Population health in Namibia: an analytical approach

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This thesis is submitted for the degree of Doctor of Philosophy

Declaration

This thesis is submitted for the degree of Doctor of Philosophy. This thesis is the result of my own work and includes nothing which is the outcome of work done in collaboration except where specified in the text. This work is not under consideration for a degree or diploma or other qualification at the University of Cambridge or any other University or similar institution. Parts of the work described in this thesis have been published or presented elsewhere as indicated in the list of publications and presentations.

This dissertation does not exceed the 60,000 word limit (excluding figures, tables, appendices and references) set by the Degree Committee for Clinical Medicine and Clinical Veterinary Medicine.

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Summary

Background and objectives: Namibia aims to improve population health and human development. As there is limited research to date exploring the sociodemographic patterns of disease and healthcare access in the country, this thesis aimed to assess the burden of infectious and non-communicable diseases, the coverage of public health interventions and barriers to healthcare access at the population level.

Methods: Using data collected from 9,849 households and 41,646 individuals in the 2013 Namibia Demographic and Health Survey, the prevalence and sociodemographic patterns of disease and healthcare barriers were explored. Specifically, this thesis investigated the prevalence and distribution of chronic diseases, the coverage of public health interventions and access to healthcare. The determinants of these outcomes were assessed in descriptive, multivariable and spatial analyses.

Results: In this DHS population, chronic disease prevalence was high (HIV: 13.9%; hypertension: 36.9% and hyperglycaemia: 5.4%). However, co-morbidity of these conditions was low. Malaria control intervention coverage was below government target levels in high transmission areas. In relation to healthcare access, almost half of women reported at least one barrier to healthcare, including distance to health facilities and getting money for treatment. Women who were less educated, less wealthy and lived in rural areas were more likely to report distance as a problem in accessing care. Spatial analyses indicated that distance and travel time to health facilities was highly variable in rural areas, with approximately 40% of the rural population having to travel for more than an hour to reach a facility. Multivariable analyses indicated that men, those who were less wealthy and lived in rural areas lived further away from health facilities. Health insurance was associated with health service utilisation but coverage of insurance was just 17.5%, with men, wealthier and more educated populations more likely to be insured.

Conclusions: The findings presented in this thesis suggest that urban-rural and socioeconomic differences are underlying determinants of population health and healthcare access in Namibia, with rural, less wealthy and less educated populations often disadvantaged. Further research is needed to better understand disease co-morbidity, to evaluate intervention programmes, and to more intricately understand the population-level barriers to healthcare in the country so as to inform strategies to improve population health and achieve human development in Namibia.

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Publications and presentations

Publications

Publications arising for work related to this thesis

Allcock SH, Young EH, Sandhu MS. A cross-sectional analysis of ITN and IRS coverage in Namibia in 2013. Malaria Journal, 2018, 17:264. [Published] [**Chapter 5**]

Allcock SH, Young EH, Sandhu MS. Sociodemographic patterns of health insurance coverage in Namibia. International Journal for Equity in Health, 2019, 18:16 [Published] [**Chapter 8**]

Publications arising from work unrelated to this thesis

Allcock SH, Young EH, Holmes M, Gurdasani D, Dougan G, Sandhu MS, Solomon L, Török ME. Antimicrobial resistance in human populations: challenges and opportunities. Global Health, Epidemiology and Genomics, 2017. [Published]

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Presentations

Presentations arising from this thesis

Allcock SH and Sandhu MS. Malaria in Namibia: determinants of insecticide-treated net ownership and use in a pre-elimination setting. Royal Society of Tropical Medicine and Hygiene Challenges in Disease Elimination Conference, 2016. Presented 12 – 16 September 2016. [Poster Presentation] [**Chapter 5**]

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Presentations arising from work unrelated to this thesis

Serov A, Barrett-Hague C, Grant J, and **Allcock SH (Editor).** Global strategies for addressing antibiotic resistance in the context of sustainable development. Polygeia Annual Conference 2017. Presented 25 November 2017. [Oral Presentation]

Abbreviations

95% CI	95% Confidence Intervals
ART	Antiretroviral therapy
BMI	Body mass index
CGIAR-CSI	CGIAR consortium for spatial information
CRS	Coordinate reference system
DEM	Digital Elevation Model
DHS	Demographic and Health Survey
EA	Enumeration area
FPG	Fasting plasma glucose
GADM	Database of Global Administrative Areas
GDP	Gross domestic product
GIS	Geographical Information System
GLC2000	Global land cover 2000
GPS	Global positioning satellite
HAQ	Healthcare Access and Quality
HIV	Human immunodeficiency virus
ICC	Intraclass correlation coefficient
IQR	Interquartile range
IRS	Indoor residual spraying
ITN	Insecticide-treated net
LLIN	Long-lasting insecticide-treated net
LMICs	Low- and middle-income countries
MAP	Malaria Atlas Project
mHealth	Mobile health
MoHSS	Ministry of Health and Social Services
MSP	Malaria Strategic Plan
NCD	Non-communicable disease
NIP	National Institute of Pathology
NSA	Namibia Statistics Agency
OOP	Out of pocket
PCA	Principal components analysis
*Pf*PR$_{2-10}$	*Plasmodium falciparum* Parasite Rate in those aged 2 to 10 years
PSEMAS	Public Service Employees Medical Aid Scheme

QGIS	Quantum GIS
RR	Risk Ratio
SDG	Sustainable Development Goal
SES	Socioeconomic status
SRTM	Shuttle Radar Topography Mission
SSA	sub-Saharan Africa
TB	Tuberculosis
THE	Total health expenditure
UHC	Universal Health Coverage
USAID	United States Agency for International Development
WHO	World Health Organization

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1. Introduction

1.1 Overview

Namibia is an upper-middle income country located in the south of sub-Saharan Africa (SSA). The country has made notable social and economic gains following independence but inequalities still remain. Namibia aims to improve population health and human development as part of its national development goals [1].

Improvements in population health and human development will require the support of an effective health system that is able to accommodate the healthcare needs of the population, is affordable and is physically accessible to all. However, in Namibia, barriers to healthcare access exist, both at the health system level and at the population level. Whilst system-level barriers to healthcare in Namibia have been reported [2-6], the population-level factors that influence healthcare access in Namibia are less well understood. This thesis aims to use a population-based approach to better understand the burden of disease, access to public health interventions and the determinants of healthcare barriers in Namibia and thereby inform further research as well as health policy and planning for scaling-up the coverage of healthcare in the country.

1.2 Background and history of Namibia

Both geographical and political factors have shaped the distribution of the population in Namibia today, which influences the location of essential services, including healthcare providers, and impacts upon access to them. These factors are likely to affect economic and human development in Namibia and, as such, provide important context for understanding health, disease and healthcare access in Namibia.

1.2.1 Population and environment

Namibia has a small population of around 2.5 million people (2016) [7] who are distributed across the country's vast landscape of around 842,000 Km^2 [1]. The country is divided into 13 administrative regions (**Figure 1.1**). Namibia has one of the lowest population densities in SSA, with an average of around three people per Km^2, compared to an average of 45 people per Km^2 across SSA [1, 8]. The population is highly clustered in areas such as Windhoek, Walvis Bay, Swakopmund and northern areas around Outapi, Oshakati and Oshikango (**Figure 1.2**). Approximately 90% of the population inhabit less than 10% of the country's surface area [9].

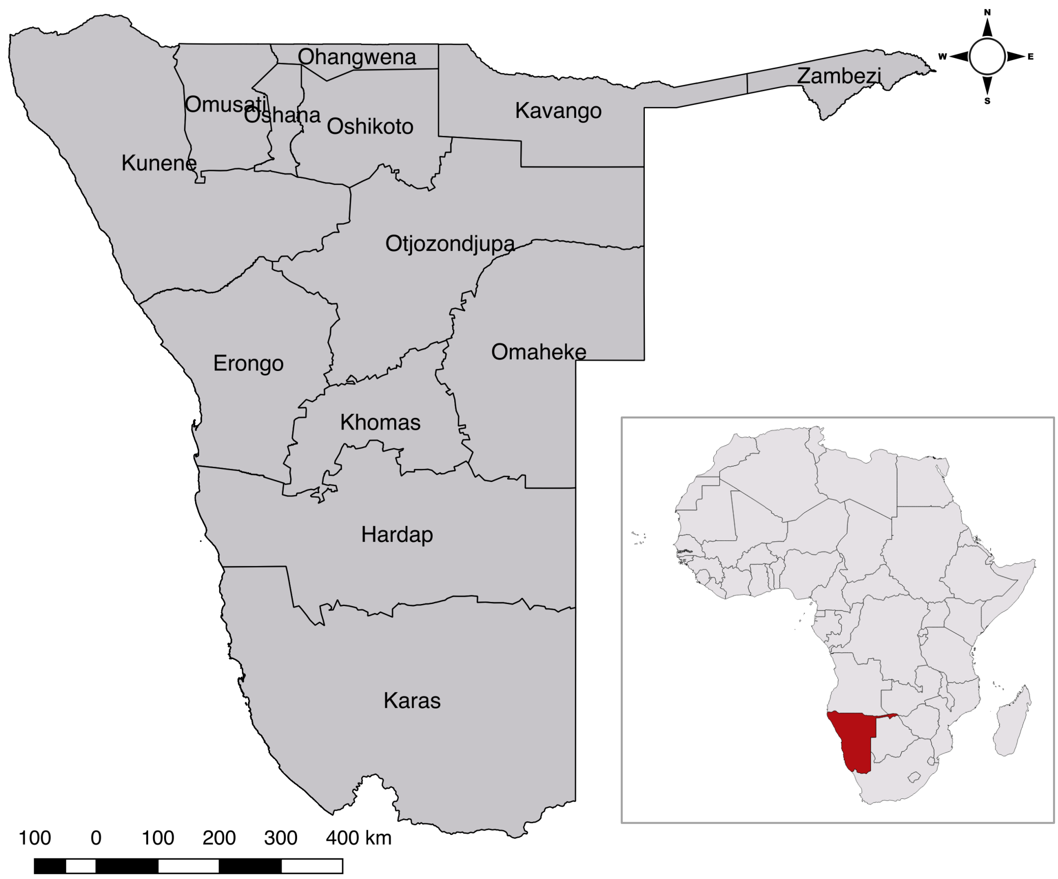


Figure 1.1: Map of Namibia's 13 administrative regions.

Large areas of the country are accounted for by the Namib, Kalahari and Karoo deserts, making a substantial proportion of the landscape uninhabitable for humans [1]. Annual rainfall in Namibia is highly variable and less than 10% of the country receives enough rainfall to support crop growth, most of which is in the north [1]. Aside from geographical constraints and the availability of natural resources, other factors that influence population distribution include employment prospects, the availability of transport infrastructure and access to water and other essential services [10].

With clustering of the population in the more habitable areas, there are long distances to travel between settlements. Consequently, there can be certain remote communities that are severely disadvantaged in terms of their ability to access resources and infrastructure including healthcare.

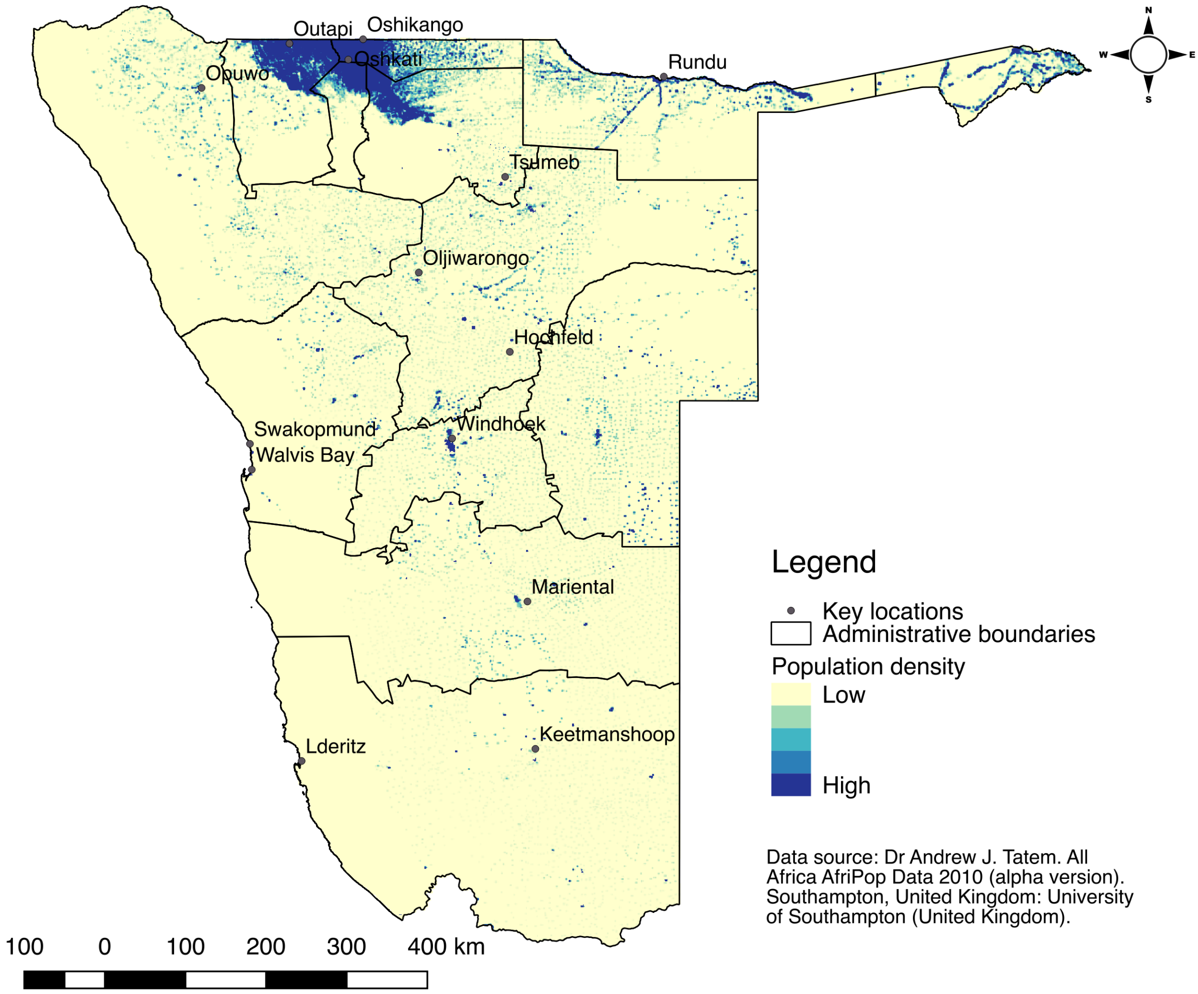


Figure 1.2: Population density in Namibia in 2010. Data source: AfriPop 2010 (alpha version) Namibia [9].

1.2.2 Political history of Namibia

Population distribution and land use in Namibia has been further shaped by Namibia's political history. In 1884, Namibia was colonised by Germany; in the following years, the 'Great War of Resistance' (1904-1908) resulted in the devastation of many of Namibia's indigenous populations [1, 11, 12]. Land was expropriated, indigenous groups were banned from owning cattle and, within the 'Police Zone', were forced into labour [1, 11, 12]. **Figure 1.3** shows the reorganisation of land in Namibia following colonisation by Germany, with much of the land once occupied by indigenous populations reallocated for European farming. By 1911, around 20% of the land was used for commercial farming [10].

Following World War I, the League of Nations provided South Africa with a mandate to govern Namibia and, in 1948, the 'apartheid' system was introduced in Namibia [1]. The productive farmland was transferred to white Afrikaans populations and there was further removal of Namibia's indigenous populations from their settlements and reorganisation of land [1, 11]. By 1955, commercial farming occupied an estimated 47% of the land [10].

Namibia gained independence from South Africa in 1990 but the drastic restructure of Namibia's landscape throughout the periods of German rule and, later, apartheid is still apparent in the organisation of settlements in Namibia today [2]. Apartheid also directly and indirectly influenced the future geographical distribution of healthcare, particularly in northern Namibia [13]. Furthermore, apartheid contributed to inequalities in wealth and land ownership that have persisted in the country [1]. Independent Namibia faced human resource constraints and a considerable skills deficit due to a lack of education and work experience of Namibian populations [1, 12]. Consequently, Namibia continues to face challenges in human and economic development.

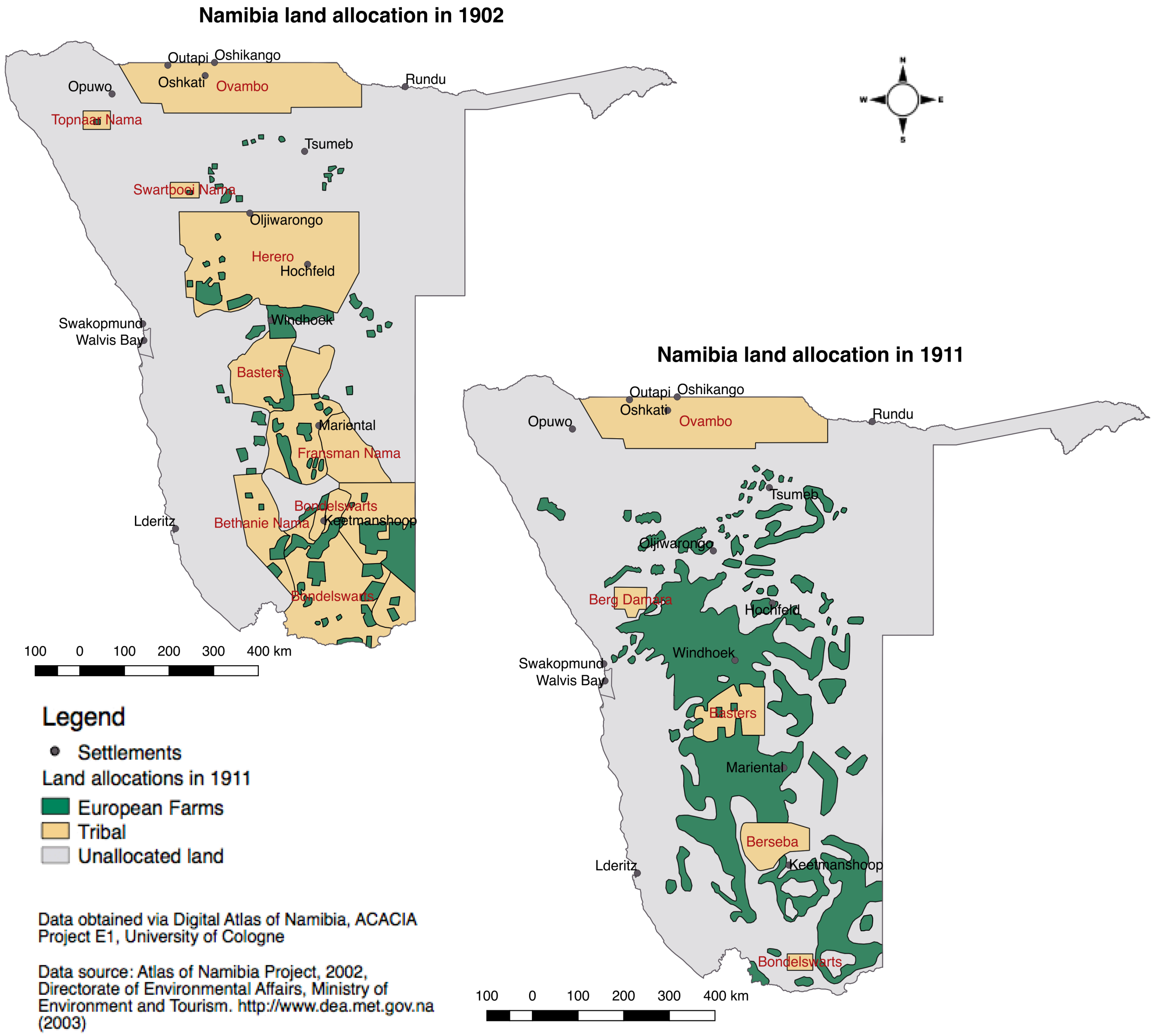


Figure 1.3: Land allocation in Namibia in 1902 and 1911 under German rule. Data obtained from the Digital Atlas of Namibia, ACACIA Project E1 [14], originally sourced from the Atlas of Namibia Project 2002, Directorate of Environmental Affairs, Ministry of Environment and Tourism [10, 15].

1.2.3 Social and economic inequalities in Namibia

Social and economic inequalities have been described in Namibia [5, 16-18]. Socioeconomic status (SES) and health are inextricably linked. Therefore, socioeconomic inequalities have the potential to affect population health and human development through a number of pathways (**Figure 1.4**). For example, education or employment could affect the ability of households to access healthcare physically, financially or socially. Education can lead to better employment prospects and earning potential, which in turn, increase household wealth and SES [19]. Wealthier households often have more disposable income to pay healthcare-associated costs and thereby gain access to health services. Socioeconomic inequalities have been found to result in differential use of health services in other countries [20-22] and poor access to healthcare may widen gaps in SES. Furthermore, poorer people often suffer worse health outcomes [23] and inequalities in wealth have been linked to lower life expectancy, greater infant mortality and other health outcomes [24, 25]. It is therefore important to understand socioeconomic inequalities in Namibia.

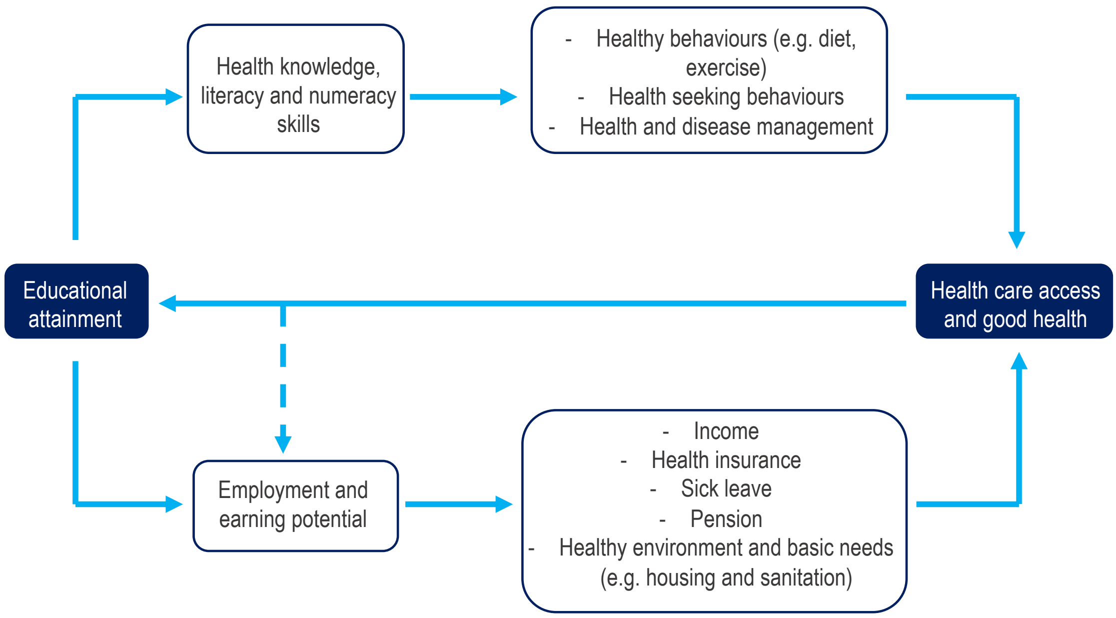


Figure 1.4: The relationship between education, socioeconomic status and health.

Wealth inequality in Namibia has been attributed to the allocation and restriction of economic resources during apartheid, as well as the large skills deficit of the Namibian population at independence [1]. Indeed, other southern African countries experienced similar inequalities following independence from colonial rule [16]. In Namibia, a dearth of skilled workers in the labour force remains and in 2014 youth unemployment was almost 40% [5, 18]. Despite much progress in Namibia's development since 1990, these socioeconomic inequalities are still a serious problem in Namibia.

Inequalities in income and wealth

Eastern and southern Africa, alongside Latin America, have the highest levels of income inequality, globally [16]. Despite being an upper-middle income country that has achieved rapid socioeconomic growth, Namibia has one of the highest income inequalities, globally (**Figure 1.5**) [5, 18]. The wealthiest 10% of households in Namibia contribute over 50% of total expenditure in the country, whilst the poorest 10% contribute only 1% [17]. Levels of poverty differ by region, ethno-linguistic groups, different levels of education and, to some extent, sex [17].

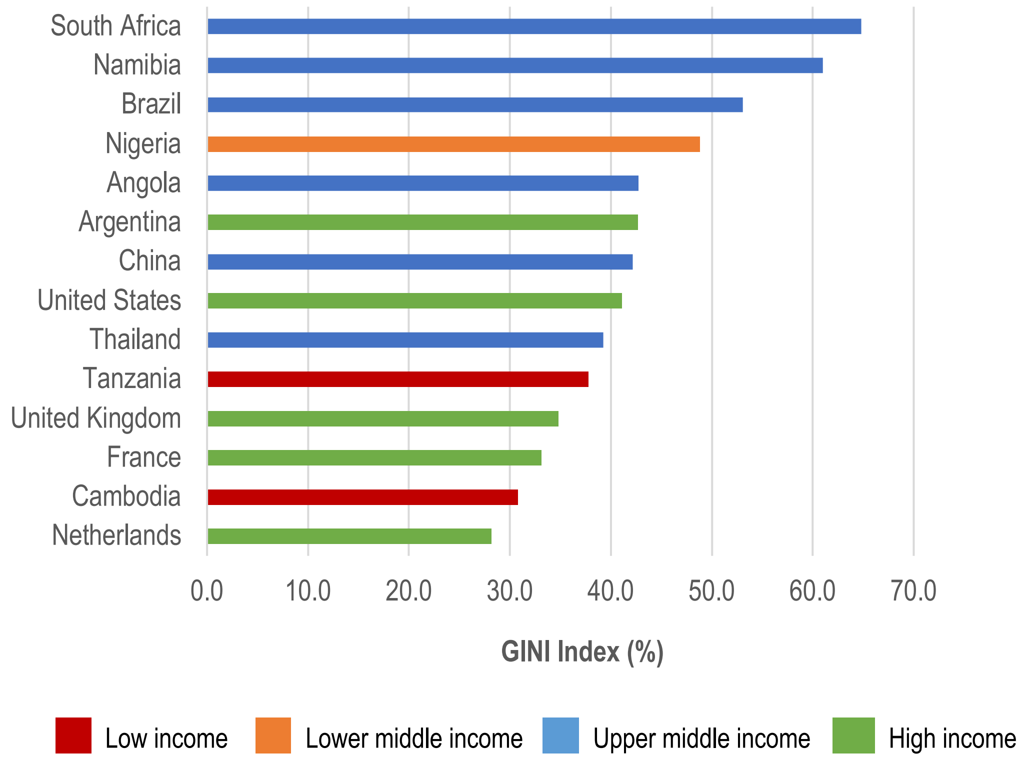


Figure 1.5: GINI index for Namibia compared to select other countries globally. Data sourced from World Bank (2009-2014) [18]. GINI index: a statistical measure of income distribution in a population whereby 0% represents perfect equality and 100% represents perfect inequality [26].

Wealth affects access to basic services such as healthcare and education, with poorer households having to dedicate the vast majority of their expenditure to cover basic needs, such as food and housing, leaving only small shares to allocate to health and education [17]. This perpetuates the cycle of inequality.

Education

Namibia also faces inequalities in educational attainment [5]. Whilst there has been political commitment and progress towards improving the education system in Namibia, the quality of education can be variable and, in rural areas, completion of primary education is low [5]. Only around half of first grade students remain in attendance by grade five of primary education [5]. Furthermore, progression from secondary to higher education is poor at around 20% and is variable by socioeconomic groups, ethno-linguistic groups and geographical location [5]. Of the small proportion of the population who attend higher education, only around half actually complete this level of education (2015), often due to lack of funding and support [5]. Education is a social determinant of health [27, 28], which is also linked to other measures of socioeconomic wellbeing (**Figure 1.4**). Therefore, it is important to understand the role of education in population health and healthcare access in Namibia.

Indigenous populations

Indigenous populations in Namibia include the San, Nama, Ovahimba, Ovatjimba and Ovatwa. Namibia's indigenous communities particularly suffer socioeconomic inequalities; more than half of the San population have no education, 77% are unemployed and 68% live in poverty [5]. The Human Development Index, a combined measure of life expectancy, education and income, is lower amongst Namibia's indigenous communities compared to Afrikaans, English and German-speaking inhabitants [29]. There are also few health data on Namibia's indigenous groups making it difficult to improve health and wellbeing in these populations [29]. The health of indigenous populations is often worse than that of the general population [30]. It is thought that access to good quality and culturally-appropriate health services amongst indigenous populations in Namibia is poor, but more research is needed to better understand healthcare access in these populations [29].

The need for increasing equality to improve population health

In order to improve population health in Namibia, the socioeconomic determinants of health must be taken into account. Access to basic needs, such as adequate housing and sanitation, as well as equal opportunities in education and employment are underlying factors in achieving health equity [23]. As such, it is important that the socioeconomic determinants of health and healthcare access are better understood in Namibia.

1.3 Health and healthcare in Namibia

In order to understand healthcare access in Namibia, it is first important to recognise the current health challenges and the resources available for healthcare in Namibia. Here, I outline the burden of infectious and non-communicable diseases (NCDs) and describe the organisation of the health system in Namibia.

1.3.1 Burden of disease in Namibia

SSA is undergoing an epidemiological transition, whereby there is a decline in infectious diseases combined with a rise in NCDs, due to ageing populations as well as the development of unhealthy lifestyles [31, 32]. Namibia has a double burden of infectious and NCDs. The country has one of the highest HIV prevalence estimates, globally, as well as an increasing burden of NCDs and their risk factors [33, 34]. In order to manage this double burden of disease, the health system will need to be well equipped to provide adequate and appropriate integrated care for these conditions.

Infectious diseases

Almost half of deaths in Namibia are attributable to communicable, maternal, perinatal and nutritional diseases [35]. However, here I describe three infectious diseases of major public health concern in the country: HIV, tuberculosis (TB) and malaria. Despite reductions in the incidence of HIV in Namibia since 2005 [33, 36], HIV/AIDS is still the leading cause of death, followed by ischemic heart disease and lower respiratory tract infections (**Figure 1.6**) [34]. In Namibia, HIV prevalence is high at 14% [37] and the number of people estimated to be living with HIV/AIDS increased from 14,000 in 1990 to 20,000 in 2016 [36]. During this time period, the number of new infections only increased overall from 5,100 to 7,400 but peaked at 20,000 new cases per year between 1996 and 1998 [36]. As such, HIV constitutes a major public health concern in Namibia and is likely to place a high demand on the health system to prevent and manage this prevalent chronic disease.

Namibia has one of the highest global incidences of TB [38]. TB is the fifth leading cause of death in Namibia and progression to active TB is often due to co-infection with HIV [34]. It is estimated that around half of TB cases are co-infected with HIV in Namibia [38, 39]. Additionally, the incidence of drug-resistant and multi-drug resistant TB is rising [39]. In 2016, there were an estimated 39 cases per 100,000 population of rifampicin-resistant and rifampicin and isoniazid-resistant TB in Namibia [40]. Therefore, TB continues to pose a threat to public health and will need to be carefully monitored to ensure treatment remains effective.

Although Namibia is one of eight southern African countries aiming to eliminate malaria by 2020 [41], the country has recently experienced a number of outbreaks [42-45], suggesting that challenges in the control and elimination of malaria still exist. Between 2000 and 2015, malaria incidence increased by more than 20% [46] and Namibia was one of only two southern African countries to have an increase in malaria incidence between 2010 and 2016 [45]. According to the 2017 WHO World Malaria Report, a notable rise in cases occurred between 2010 and 2016 increasing from 556 to 25,198 cases [45]. Consequently, malaria is still likely to demand public health resources to prevent transmission and manage infections until and after elimination is achieved in order to prevent resurgence.

[redacted]

Figure 1.6: Leading 10 causes of death in Namibia in 2017 and the percent change between 2007 and 2016. Source: Institute of Health Metrics and Evaluation [34].

In summary, whilst much progress has been made towards reducing the burden of infectious diseases, these conditions continue to constitute a major public health concern in the country. This ongoing burden points to a need for more effective evidence-based infectious disease prevention and management policies and strategies. Such strategies would need to be informed by comprehensive research on the distribution of disease in Namibian populations on a national scale.

NCDs and associated risk factors

In addition to the high burden of infectious diseases in the country, around 21% of deaths in Namibia are attributed to cardiovascular disease, 5% to cancers and 4% to diabetes [35]. Between 2000 and 2013, there was a rise in deaths attributable to stroke, ischemic heart disease and diabetes [33]. High blood pressure, high fasting plasma glucose and high body mass index (BMI) are among the leading risk factors contributing to death and disability combined (**Figure 1.7**) [34]. Whilst health spending on NCD treatment and management in Namibia has increased, there is limited financing for NCD prevention [47]. An estimated 39.1% of the population in Namibia is overweight, 16.8% are obese and 29.7% are physically inactive [35]. This high prevalence of cardiometabolic and behavioural NCD risk factors will likely continue to drive the increasing burden of NCDs in Namibia if not addressed.

[redacted]

Figure 1.7: Leading risk factors for death and disability combined in Namibia in 2016 and the percent change between 2005 and 2016. Source: Institute of Health Metrics and Evaluation [34].

As NCDs are becoming an increasingly prominent public health concern in the country, the health system will need to dedicate resources to the prevention and management of these conditions. Importantly, the health system will need to provide effective integrated care and management of infectious and NCDs as they continue to co-exist in Namibian populations. However, there is a severe lack of research into the co-morbidity of infectious and NCDs in Namibian populations. It will therefore be important to better understand if and how these disease conditions converge in Namibian populations in order to inform future health policy and planning.

1.3.2 Healthcare provision in Namibia

When Namibia gained independence in 1990, the country inherited a health system that was hospital-oriented and focused on curative care. Prior to independence, Namibian populations had poor access to healthcare and medical resources due to the racial segregation of the country's health system [1], which also disproportionately served urban areas [48]. Since gaining independence, Namibia's health system has undergone a number of reforms to move away from the inherited racially segregated health system [48]. However, poverty and inequality continue to affect access to healthcare and other services at the population-level [17]. Furthermore, due to the sparse geographical distribution of the population, some more remote and rural areas may be underserved by the health system and there is a need to identify these populations, build health service capacity and strengthen healthcare infrastructure to improve the adequacy and availability of care to reach these populations.

Public versus private healthcare

Namibia has a public and private health sector. The public health sector operates at a central, regional and district level [48]. Health service provision is decentralised, whereby the 13 regional directorates manage health service delivery in the 34 districts [49]. The public sector is the predominant healthcare provider in terms of health system financing, service delivery and coordination [3]. This is typical of sub-Saharan African countries, with healthcare dominated by public health providers [50]. In 2009, the public sector in Namibia comprised 34 hospitals (tertiary care), 44 health centres (secondary care) and 265 clinics (primary care) [3]. Referral hospitals are located in Oshana, Kavango and Khomas, with Windhoek hospital being the national referral hospital [3]. In 2009, there were 844 private facilities [3]. The private sector has two arms: the not-for-profit and the for-profit. The for-profit sector is predominantly urban and serves around 15% of the population [3, 49, 51]. The not-for-profit sector is largely supported by international aid and non-governmental organisations [3] and, together with the public not-for-profit sector, serves approximately 85% of the population [51].

In 2009, around 30% of public and private facilities combined had regular water and electricity supplies and most facilities charged user fees [3]. Around 80% of facilities offered basic child health services, but long waiting times were considered to be an issue [3]. Family planning was available at 90% of facilities, 80% provided antenatal care services, and almost all facilities could carry out HIV testing [3]. Private providers generally had better facilities than other providers; for example, water, electricity and other amenities [3].

Health financing

Improving population health is one of the Namibian Government's priorities and total health expenditure (THE) as a percent of Gross Domestic Product (GDP) in Namibia is comparatively high within SSA [52]. In 2015, Namibia's health expenditure accounted for 8.9% of GDP, compared with the SSA average at 5.5% of GDP [52, 53]. However, socioeconomic challenges hinder government efforts to strengthen the country's health system [3].

Healthcare in Namibia is funded through government funding, prepaid private expenditure, out of pocket (OOP) expenditure and donor funding [47]. Per capita spending on health and health service utilisation, including antenatal care and skilled attendance at birth, is comparatively high relative to other countries in the World Health Organization (WHO) Africa region [47, 54]. In 2014/15, 64% of THE was provided by the Namibian Government, which equated to around 13% of government expenditure for the fiscal year [47]. In the same period, 30% of healthcare was funded privately (by employers and households) and 6% was provided by donors [47]. The majority of THE is spent in private facilities (37%) and 32% of health funds are spent in public hospitals (**Figure 1.8A**) [47]. However, the majority of government funds are allocated to public hospitals (63%), followed by private hospitals (7%). A quarter of health funds are spent on infectious diseases, followed by reproductive health (22%) and NCDs (21%)(**Figure 1.8C**) [47].

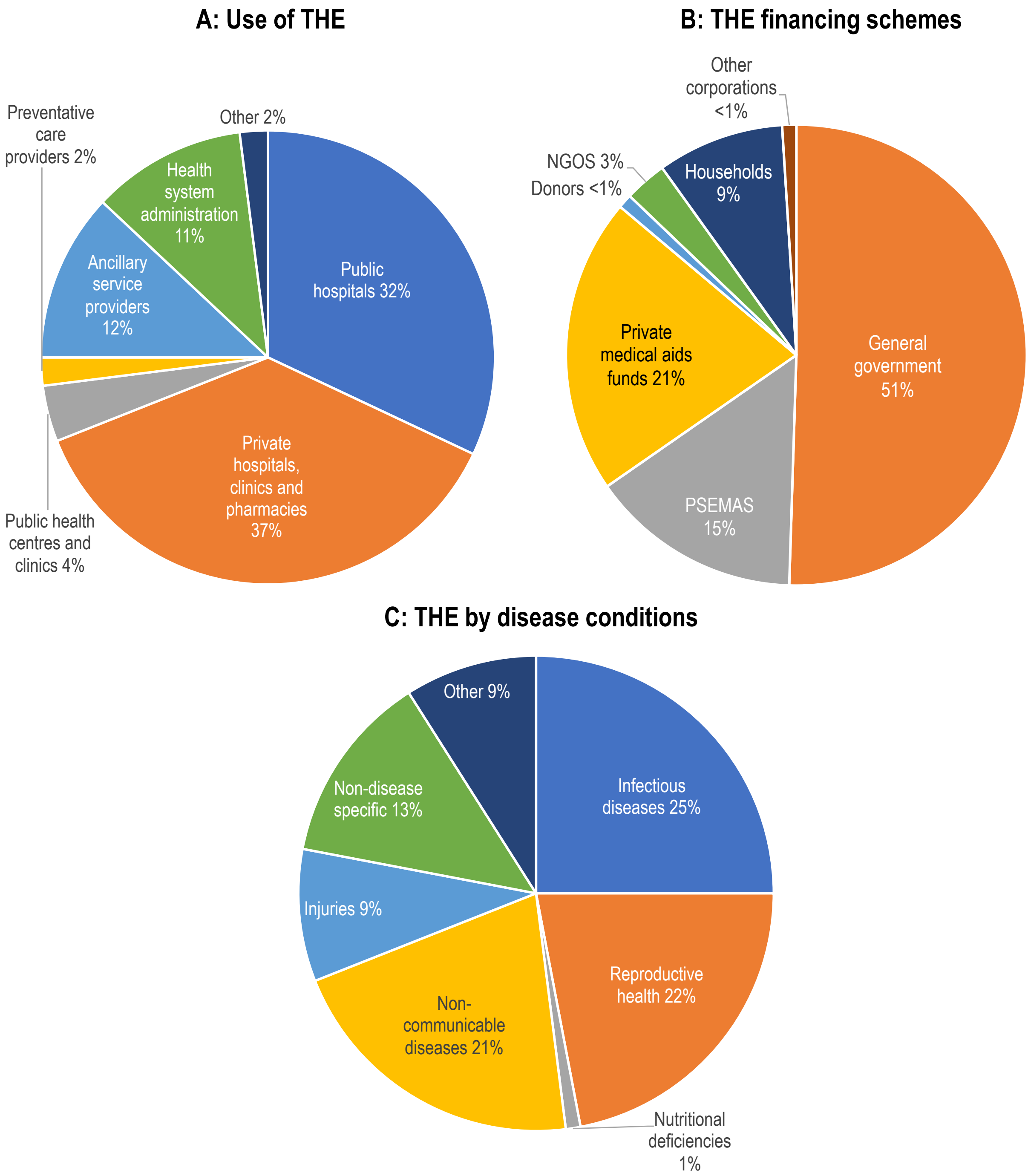


Figure 1.8: Health financing in Namibia | A: The use of THE by different types of service providers | B: Financing schemes that contribute to THE | C: The allocation of THE to care for different disease conditions. THE: Total health expenditure. Adapted from: Namibia Health Accounts Report 2014/15 [47].

Namibia's population receives healthcare through different financing schemes. General government financing accounts for 51% of health spending and this scheme involves the pooling of financial resources for healthcare (**Figure 1.8B**) [47]. Public sector financing is via the Public Service Employees Medical Aid Scheme (PSEMAS), which accounts for 15% of health spending [47]. Private medical aid funds account for a further 21% of health spending, which involves voluntary pre-payments from households, which contribute to the risk pool [47]. As such, there is risk pooling through general government financing, private medical aid funds and PSEMAS but private medical aid funds and PSEMAS do not involve much cross-subsidisation between the rich and poor [47]. Together PSEMAS and private medical aid funds account for 36% of THE but only cover around 18% of the population, leaving the remaining 64% of THE to cover 82% of the population [47]. Importantly, this 82% of the population include more disadvantaged populations, including a large proportion of the unemployed [47]. The structure of health financing in Namibia is illustrated in **Figure 1.9**.

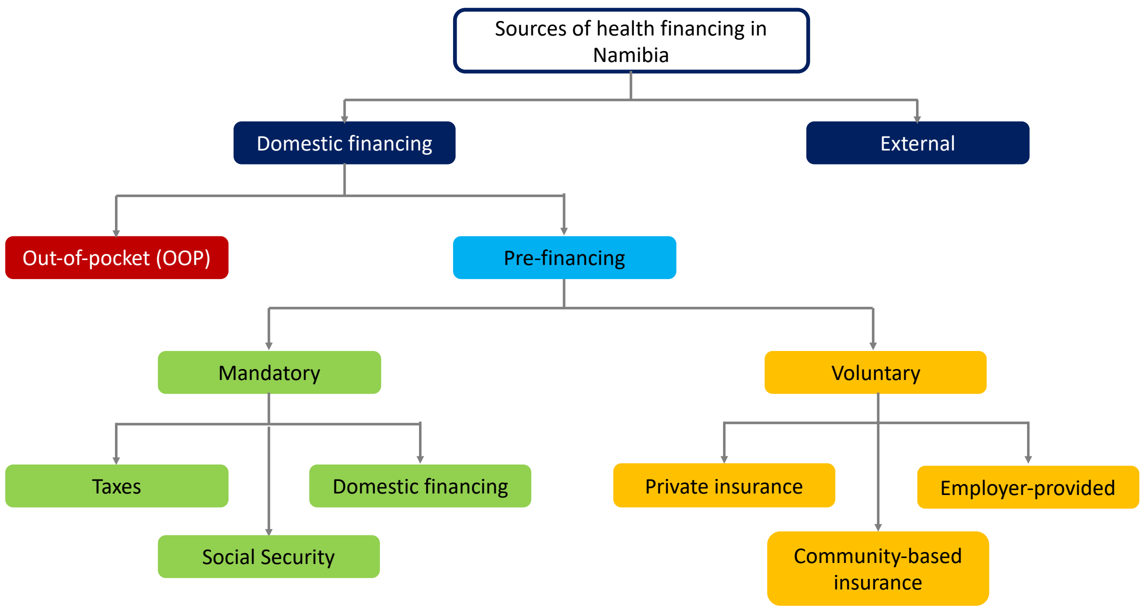


Figure 1.9: Health financing in Namibia. The breakdown of domestic financing by out of pocket and pre-financing expenditure and the multiple components that comprise pre-financing in Namibia. External financing refers to donor funds that, together with domestic financing, make up total health expenditure.

1.4 Barriers to healthcare access

In order to improve population health and human development, countries need high quality, effective health systems that are accessible to the populations they serve. However, barriers to healthcare access can occur at the system- and population-level.

1.4.1 Access to healthcare

Universal Health Coverage (UHC) is defined by the WHO to be where "…all people obtain the health services they need without suffering financial hardship when paying for them" [55]. In 2017, the WHO and World Bank "Global Monitoring Report on Tracking Universal Health Coverage" found that around half of the global population do not have access to essential health services and that around "100 million people are pushed into extreme poverty each year because of out-of-pocket health expenses" [4]. It is estimated that 8.6 million deaths per year could be averted if UHC is realised and the quality of health systems is improved [56].

There are multiple definitions of healthcare access [57] but, for the purpose of this thesis, healthcare access will be defined as the ability of individuals with a need for care to seek and obtain an appropriate and adequate quality of care, without suffering financial hardship in order to pay for it. This thesis considers five pillars of healthcare access, which include the **availability** of resources; **adequacy** of the quality of care; geographical **accessibility** of facilities and providers; **appropriateness** of the care relative to the population needs and the **affordability** of care [58].

Healthcare access is a function of system- and population-level factors, which are widely referred to in the literature as supply- and demand-side factors (**Figure 1.10**) [57, 59, 60]. Supply-side factors are internal to the health system and thus can be improved by the health system and those that finance it. These factors may affect uptake of healthcare by patients and the quality of care received [60, 61]. Demand-side factors are those which are external to the health system, dependent on the user and their circumstances. Demand-side factors determine the ability to use health services at the population-level and may include geographical location and transport options, perceptions of ill health and the importance of healthcare, and socioeconomic position that influences the ability to afford care [57, 60, 61]. These supply and demand factors are, undoubtedly, interlinked; demand will be low without good provision of services and, conversely, providing good quality of care is futile if populations are not able to physically access or afford care. Where UHC has not yet been realised, healthcare access can be improved through capacity building and health system strengthening on the supply-side, or through strategies to reduce or circumvent barriers to healthcare from the demand-side [60].

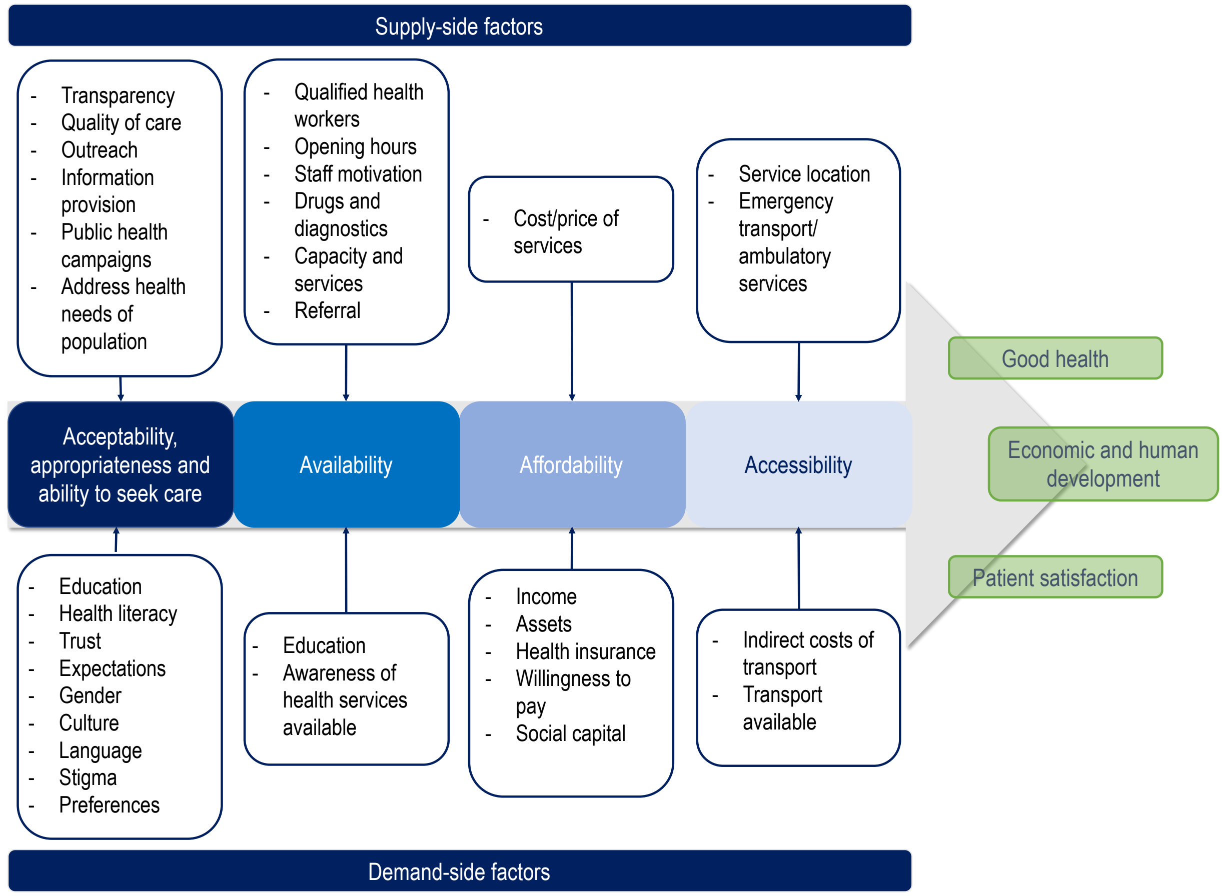


Figure 1.10: Access to healthcare conceptual framework, showing the supply- and demand-side factors that contribute to different dimensions of healthcare access. Adapted from [57, 60, 61].

Access to healthcare is particularly limited in low- and middle-income countries (LMICs). In many LMICs, the foundations of healthcare access are challenged by socioeconomic as well as physical barriers to healthcare access and the need for care is therefore often not reflected in actual use of health services [61, 62]. Millions of people in LMICs suffer conditions for which effective interventions exist [59, 63]. The underutilisation of health services relative to need for care in LMICs undermines health and human development in these countries. As such, there is a need to better understand the obstacles faced at the individual and aggregate level in the context of seeking healthcare, specific to different countries.

SSA and Southern Asia have the lowest levels of health service coverage globally [4]. The Healthcare Access and Quality (HAQ) index, a measure of access to a range of health services and their quality, was found to be lowest in SSA, with Namibia classified to be in the third lowest HAQ decile (**Figure 1.11**) [64].

[redacted]

Figure 1.11: Healthcare Access and Quality (HAQ) index. Adapted from Global Burden of Disease (GBD) 2016 Healthcare Access and Quality Collaborators 2018 [64].

At the population level, it is often the poorer individuals in LMICs who are most affected [61]. The advent of the Sustainable Development Goals (SDGs) in 2016 brought about renewed efforts to improve global social, economic and environmental development by 2030. SDG3, to "ensure healthy lives and promote wellbeing for all at all ages", sets a number of health targets, including "access to quality essential health-care services" and "access to affordable essential medicines and vaccines" [65]. However, healthcare gains in LMICs are often undermined by weak health infrastructures, a lack of trained personnel and human resources, shortages in drug supplies and poor health service provision and management [66-68]. Consequently, there is a need to strengthen health systems and better understand barriers to healthcare access at the population level in order to facilitate progress towards UHC and the SDGs.

1.4.2 Barriers to healthcare access in Namibia

Accessibility of health services

In LMICs, one of the most widely reported barriers to healthcare is distance to health facilities and associated transport costs [61, 69-76]. Geographical inaccessibility is a greater challenge in rural and remote areas due to greater transport costs to reach the nearest facility and the potential for roads to become impassable in adverse weather conditions [61, 63]. It is often difficult to accurately measure geographical access to healthcare as it has many components: the distance to travel to health facilities, the mode of transport, the cost of the travel (expenses and time) and the perceptions of whether that distance is too far to travel proportionate to the healthcare need, and other individual-level factors. Therefore, it is important for Ministries of Health and Transport to appropriately understand geographical accessibility of health facilities, beyond quantifying the ratio of health facilities to the population. Geographical inaccessibility has been found to result in poor health service utilisation for maternal and child health services [71], which in turn is associated with higher maternal and child mortality [69, 77-80]. Greater distances and travel times have also been associated with lower health service utilisation for other conditions, which may result in delays in diagnosis and treatment [81-85]. Individuals' location of residence is often influenced by sociodemographic factors; therefore certain populations are especially disadvantaged when accessing healthcare. Such factors may include differences in income, education and ethnicity [86, 87]. Evidence from rural settings suggests that geographical barriers to healthcare are also likely to particularly affect less mobile populations, such as the elderly or disabled [88, 89].

In Namibia, there are a number of factors that affect the accessibility of healthcare. Namibia's small population is spread over its vast landscape, the distribution of which has been influenced by geographical factors, as well as the country's political history. In the central and southern portions of the country, outside of urban areas, population density is low [90]. By contrast, the north of the country is home to some 60% of the population [90].

It has been estimated that 21% of the population live more than 10 Km away from their nearest health facility [90], and over 70% live more than 50 Km from a tertiary care facility [91]. Namibia has a good, well maintained road network, which means settlements are well connected [10]. However, use of the road networks appears to be concentrated in certain sections [10]. There is also a lack of affordable transport options. Transport limitations also hinder the efficacy of the referral system as well as outreach and mobile services [48]. It is also possible for roads to become impassable due to flooding, resulting in the inaccessibility of health services and treatment [92]. There is a need for more fine-scale, comprehensive research on the ability of populations to physically access health services, and the population level factors that influence the ability to seek care.

Affordability of care

The affordability of healthcare is determined by the price of care set by the provider and the willingness and ability to pay of the user. The willingness to pay may also be influenced by the severity of the disease condition and the importance placed upon getting treatment by the individual.

Financial barriers to healthcare access have been well described in other sub-Saharan African countries [69, 72, 73, 93, 94]. The cost of healthcare impacts on health service utilisation [76, 95-102]. Higher SES has been associated with better access to healthcare when an individual falls ill [95-97] and delivering at a health facility during pregnancy [76, 98-102]. The need to pay for user fees OOP, means that healthcare access is often not affordable for poorer populations in LMICs. Indeed, OOP expenditures push millions into, or further into, poverty every year [4]. Whilst some have shown the removal of user fees may increase health service utilisation [103, 104], others have suggested evidence for the impact of user fees on healthcare utilisation is limited [105]. Ultimately, to achieve UHC, reductions in OOP expenditures may be achieved through compulsory prepaid risk pooling mechanisms that cross-subsidise between the wealthy and the poor and the healthy and the sick [106]. Affordability of care could also be improved through population development, such as increasing educational attainment, improving employment statistics and increasing disposable income that could be used to pay for healthcare-associated costs.

Whilst Namibia's health financing is comparatively high within SSA, financial barriers to healthcare still occur at the population level. In fact, it has been shown that in LMICs, poorer households often receive smaller shares of public health expenditure than wealthier households [50, 59, 107]. Therefore, despite Namibia's government expenditure on health, the distribution and benefit of this expenditure may not be equal at the population level. Although OOP expenditure on health in Namibia is low, accounting for 9% of THE [47], the need to pay for healthcare OOP could consume a large proportion of household expenditure for poorer households and thus may not be financially viable. Poorer households can only make limited allocations of household expenditure to health [17]. User fees vary by facility but can be around N$ 4 (US$ 0.29) in clinics and N$ 30 (US$ 2.17) at national referral facilities [108]. Whilst user fee exemptions do exist for some services (preventative services) and population groups (e.g. elderly and people with disabilities) [3], the process can be laborious and may still deter patients from seeking care [109]. Whilst care will often not be denied and the fee may be waived, payment would likely still be expected at a later date [3]. Discount and fee exemptions are not thought to be common for vulnerable groups in Namibia [3], suggesting that households may be required to make significant payments OOP that poorer households may not be able to afford. There is little research on the affordability and willingness to pay for healthcare in Namibian populations.

Availability, adequacy and appropriateness of healthcare

The 'Tracking Universal Health Coverage 2017 Global Monitoring Report' placed Namibia in the second lowest quintile of UHC, globally, based on the coverage of a number of essential health services [4]. This suggests that Namibia needs to improve the coverage of services for maternal and child health, infectious disease control and NCDs, as well build health service capacity.

Namibia has a shortage of health workers in the public sector with just two health workers per 1,000 population, below the WHO recommended 2.5 health workers per 1,000 population [2]. This especially includes doctors and nurses [2]. Historically, there have been high human resource losses in Namibia, largely due to resignations, which impact on the sustainability of the country's health system [2]. In addition to many Namibians having to travel long distances to reach the nearest available facility, long wait times have been reported in some regions, with 82% of patients having to wait for over three hours in facilities in the Hardap region [48]. The lack of staff and resources has also resulted in referrals to other clinics, which further delays treatment [48]. The lack of organisation and management of Namibia's health system has led to poor health system and infrastructure planning and maintenance [48].

It is important that the health services provided are also appropriate to the healthcare needs of the population. In Namibia, there is an unequal distribution of resources, with the regions with the greatest need thought to receive the least resources [6]. Furthermore, the availability of essential medicines is compromised due to ineffective procurement procedures, lack of storage, poor access to pharmaceutical drugs and the inappropriate, ineffective use of drugs [5]. This points to a need for disease monitoring and surveillance to ensure that resources are allocated to health facilities based on the demand for these services at each facility. Therefore, it is important to understand the healthcare needs of the population beyond national-level estimates of disease burden and how this differs by sociodemographic groups and geographical regions.

Social factors affecting healthcare access

Healthcare access can also be impeded by social factors that prevent an individual from seeking care. Such factors may include gender inequalities, for example if women feel that they need permission to seek healthcare or do not want to attend a health facility alone [69]. Other factors may include inequality in educational attainment and lack of empowerment to make decisions about one's health. Education has been related to healthcare utilisation, for example, mothers' education level has been linked to utilisation of maternal healthcare services in a number of studies in other LMICs [75, 76, 94, 99-101, 110].

Social stigma can also impact on health service utilisation. For example, barriers to access to antiretroviral treatment (ART) for HIV-positive TB patients have been identified in Windhoek, which included fear of stigma [111]. The study also reported religious issues as a barrier, with a number of patients discouraged from taking ART by the Pentecostal church, which urged healing through faith and prayer [111].

Importantly, Namibia's indigenous populations experience poor access to healthcare, with over 80% of the San population estimated to live more than 80 Km from a health facility [112]. There are also language barriers, which can result in misdiagnosis or inadequate treatment of these indigenous groups [112]. Differential challenges experienced by distinct ethnic groups have also been observed elsewhere, for example, in Tanzania, women of the Sukama ethnic group were found to be less likely to deliver at a health facility [98].

Combined with the awareness of socioeconomic inequalities in Namibia, these factors highlight the need to explore social factors that may influence healthcare access in Namibia.

1.4.3 Opportunities for research into healthcare access in Namibia

It is evident that whilst there is significant funding for healthcare in Namibia, there are supply- and demand-side challenges that need to be addressed in order to achieve UHC. Increasing the funds available for healthcare does not necessarily ensure improvements to the health system and health service provision, and certainly does not guarantee equitable improvements in access [66]. It is fundamental to understand the constraints at the population-level that prevent healthcare access. Such factors may include, but are not limited to, physical or environmental factors, public policies, such as those that influence transport infrastructure, financial and social barriers at the individual- and household-level that prevent use and climatic, environmental or genetic predisposition to disease risk [66].

Namibia presents a distinctive case to explore access to healthcare for a number of reasons. Namibia's strengths in this scenario include its small population to which health services must be delivered and good per capita health expenditure. Namibia is also politically stable and has set goals to bring about gains in economic growth, build human resource capacity, bridge gaps in education and wealth equality and improve access to care [1, 5]. Conversely, despite being an upper-middle income country, Namibia experiences substantial socioeconomic inequalities, which are likely to influence equity in healthcare access. Additionally, the country's geographical architecture, with a vast landscape and small, highly clustered population, presents an exceptional scenario in which physical access to health services is likely to be highly variable. Previous studies exploring access to healthcare in Namibia have focused on specific diseases or healthcare needs, or specific population groups [88, 92, 113-118]. More nationally-representative research is needed to understand access to healthcare more broadly.

1.5 Thesis objectives and structure

Using data from the 2013 Namibia Demographic and Health Survey, this thesis aimed to investigate a number of components of population health in Namibia, in an effort to inform future research and strategies to improve equity in health and healthcare at the population level. The themes and specific components of this thesis are outlined in **Figure 1.12**.

The first objective was to explore the distribution of the populations by sociodemographic factors, particularly focusing on socioeconomic and urban-rural differences in population distribution, given the well-described socioeconomic inequalities in Namibia. The second objective was to better understand the prevalence and distribution of HIV and cardiometabolic risk factors in a Namibian population and to assess the co-morbidity of these infectious and non-infectious conditions, due to the particularly limited existing research on NCDs and co-morbidity in the country. Given the recent rise in malaria cases, this thesis also aimed to examine the coverage of malaria control interventions, as an essential public health intervention. Next, the perceptions of healthcare access were explored to understand, from the perspective of women, what barriers are faced in accessing care. This focused on perceptions of geographical barriers to healthcare. The accessibility of health services was further investigated using objective measures of distance and travel time to health facilities. Finally, the coverage and determinants of health insurance, as a strategy to improve the affordability of care, was explored.

The sociodemographic factors associated with these components of population health were assessed, with a focus on inequalities in sex, education, wealth and urban or rural residence type, which are factors thought to influence health and healthcare access in Namibia. Understanding the sociodemographic patterns of population health may create a platform for further research to better understand the modifiable population-level factors that could improve population health in the country.

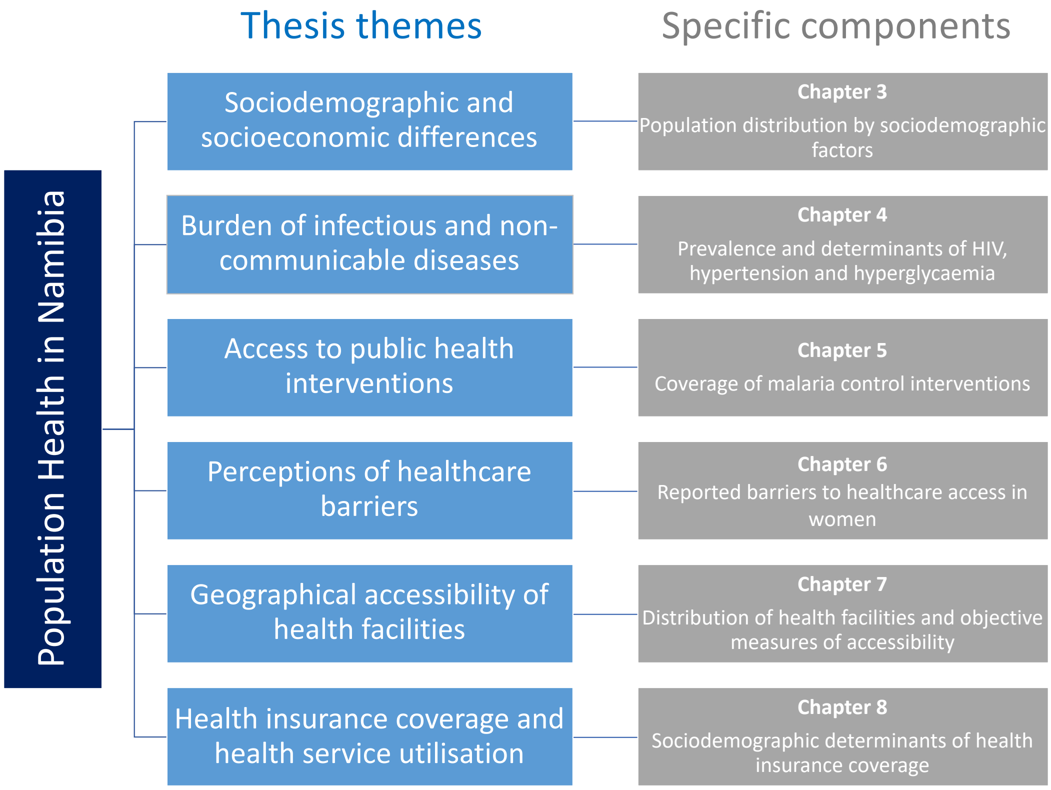


Figure 1.12: Components of population health to be explored in this thesis.

A brief overview of the subsequent chapters is outlined as follows:

- **Chapter 2** provides a detailed introduction to the Namibia 2013 DHS, including the survey design, data collection methods, the use of the data in this thesis and its strengths and limitations.
- **Chapter 3** provides an overview of the households and population surveyed in the DHS.
- **Chapter 4** explores the prevalence and distribution of HIV by sociodemographic and behavioural risk factors as well as the prevalence and distribution of cardiometabolic risk factors.
- **Chapter 5** investigates the coverage of malaria control interventions in relation to transmission intensity.
- **Chapter 6** explores the perception of barriers to healthcare amongst women, including the sociodemographic factors associated with reporting distance as a barrier to healthcare.
- **Chapter 7** estimates distance and travel time to health facilities in Namibia and explores the travel time by sociodemographic factors.
- **Chapter 8** explores the sociodemographic patterns of health insurance coverage in this Namibian population.
- **Chapter 9** provides a discussion and the conclusions of the work undertaken in this thesis.

2. Methodology of the 2013 Namibia Demographic and Health Survey

Summary

The DHS Program has conducted over 300 surveys in more than 90 countries, globally. The most recent survey conducted in Namibia was completed in 2013 and collected data on 9,849 households and 41,646 household members, including in-depth individual data on 10,018 women and 4,481 men.

The 2013 Namibia DHS data provide an opportunity for large-scale epidemiological analyses of numerous outcomes including infant and child mortality, maternal and child health, nutrition, malaria control interventions and knowledge and prevalence of HIV/AIDS and NCDs. The survey also collected geographical coordinates of survey enumeration areas, enabling spatial epidemiological analyses of DHS data.

Following data request approval from the DHS Program and download of datasets, I was responsible for the management and storage of the 2013 Namibia DHS data for the research group. I also requested and securely stored 2013 DHS GPS data for Namibia. I created relevant datasets for analyses included in this thesis and additionally combined other publicly available datasets with DHS data to broaden the scope of analyses undertaken using these data.

Although the methods of the DHS are outlined in detail elsewhere, in this chapter I present the DHS methodology relevant to analyses undertaken in Chapter 3—8 of this thesis. I also acknowledge the strengths and limitations of these data in the context of this thesis.

2.1 Background

Recent improvements in the availability of survey data relating to individuals, and their use of health services, provides a platform for research into healthcare access in a number of different countries and settings. The Demographic and Health Survey (DHS) Program is an international programme that has conducted more than 300 surveys in over 90 countries worldwide [119] and provides technical assistance to local actors to conduct large-scale surveys pertaining to population demographics, socioeconomics and health. Data collected by the Program is made available to the global research community.

The Program focuses efforts on obtaining high quality data from LMICs in an affordable way. It is primarily funded by the United States Agency for International Development (USAID), in addition to other donor and domestic sources [120]. Technical support was provided by ICF—an international consulting firm working across the Americas, Africa and the Middle East, Europe and Asia and the Pacific in a variety of fields including survey research, data science, research and evaluation, and policy development [121, 122].

The DHS orients data collection towards policy, programme planning and monitoring and evaluation [120]. The Program also aims to build the capacity of participating countries to collect and utilise data to inform programme and policy planning and supports country ownership of data and analyses [120].

In Namibia, DHS surveys have been implemented since 1992, with subsequent surveys taking place in 2000, 2006/07 and 2013. A detailed report of key findings and results is published on the DHS website for each survey. The 2013 Namibia DHS is the most recent large-scale survey of this kind in the country and provides a useful resource to explore access to healthcare. The 2013 Namibia DHS was implemented by the Namibian Ministry of Health and Social Services (MoHSS), in collaboration with the Namibia Statistics Agency (NSA) and the National Institute of Pathology (NIP) [120]. The Government of Namibia, USAID and the Global Fund provided financial support for the survey [120].

The 2013 Namibia DHS aimed to collect current data pertaining to fertility, family planning, infant and child mortality, maternal and child health, nutrition, domestic violence, and knowledge and prevalence of HIV/AIDS and non-communicable diseases. The survey also measured a number of other indicators such as blood pressure, blood glucose, anthropometric indices and tested for HIV and anaemia via blood samples. Various subsets of these data are presented in Chapters 3—8 to explore the burden of disease as well as access to healthcare and interventions in Namibia.

DHS data are available to researchers upon request. All DHS datasets available to date had already been requested and downloaded. I additionally acquired Namibia 2013 DHS GPS data and was responsible for the management and secure storage of these data. This involved generating a Standard Operating Procedure for the management and use and these data. Access was restricted to authorised research staff. I also managed the Namibia DHS data. DHS data are provided in nine separate data files, including the GPS data, which was stored separately from other DHS data. I created a dataset that merged reshaped Household Questionnaire data, Woman's Questionnaire data, Men's Questionnaire data, and HIV data. I also appended additional data to DHS datasets, including Malaria Atlas Project *Plasmodium falciparum* Parasite Rate (*Pf*PR) data and distance and travel time to health facilities derived from DHS GPS data and health facility coordinates.

Detailed methodology of the 2013 Namibia DHS is described elsewhere [120]. Here I describe the methodology of the 2013 Namibia DHS relevant to subsequent chapters in this thesis. I also outline my contribution to the creation of datasets for analysis.

2.2 Survey objectives

The specific objectives set out for the 2013 Namibia DHS are as follows:

1. To provide demographic, socioeconomic and health data to inform policy, planning and monitoring and evaluation of national health and population programmes;
2. To assess the prevalence of health outcomes, such as anaemia, high blood pressure, and high blood glucose in adults and anaemia in children;
3. To collect anthropometric measurements to understand the nutritional status of adults and children;
4. In the long-term, strengthen the local technical capacity to conduct national-level population health surveys [120].

2.3 Survey sampling strategy

The 2013 Namibia DHS was designed to provide health and demographic estimates for urban and rural areas as well as the 13 administrative regions that make up the country [120]. The 13 regions are subdivided into 107 constituencies, which are further divided into administrative units called enumeration areas (EAs) [120]. EAs are classed as either urban or rural and are defined as "geographical areas covering an adequate number of households to serve as a counting unit for the population census"[120]. A rural EA is usually a village, a section of a larger village or a group of smaller villages and an urban EA is typically a city block [120].

The sampling frame for the survey was a list of all EAs in Namibia produced by the 2011 Namibia Population and Housing Census [120, 123]. An example of the hierarchy of regions, constituencies and EAs is shown in **Figure 2.1.** The size of EAs are defined by the number of households that they contain as per the 2011 Namibia Population and Housing Census [120].

Redacted

Figure 2.1: The hierarchical structure of regions, constituencies and enumeration areas using the Khomas region as an example. Image adapted from *"An atlas of Namibia's population: monitoring and understanding its characteristics"* produced by the Central Bureau of Statistics (2010)[124].

The sampling strategy was a two-stage stratified sample design, where the first stage involved the selection of EAs (**Figure 2.2**) [120]. The EAs in each of the 13 regions were classified as either urban or rural giving 13 urban and 13 rural strata [120]. In each stratum, EAs were selected based on a probability proportional to the EA size according to the 2011 Census [120], thereby selecting EAs proportionately to the number of households belonging to each EA. This enabled comparable sample sizes between urban and rural strata. A total of 269 urban and 285 rural EAs were selected [120].

The second stage of sample selection involved the selection of households from the EAs. Around 20 households per EA were selected. Households were selected using equal probability systematic sampling, where the probability of a given household being selected is the same as for any other household in the EA. A total of 11,004 households were selected for interview [120]. Subsets of households and eligible household members were selected for different tests and questionnaires, details of which are outlined in section 2.7. If households did not take part in the DHS, no other households were approached as alternatives.

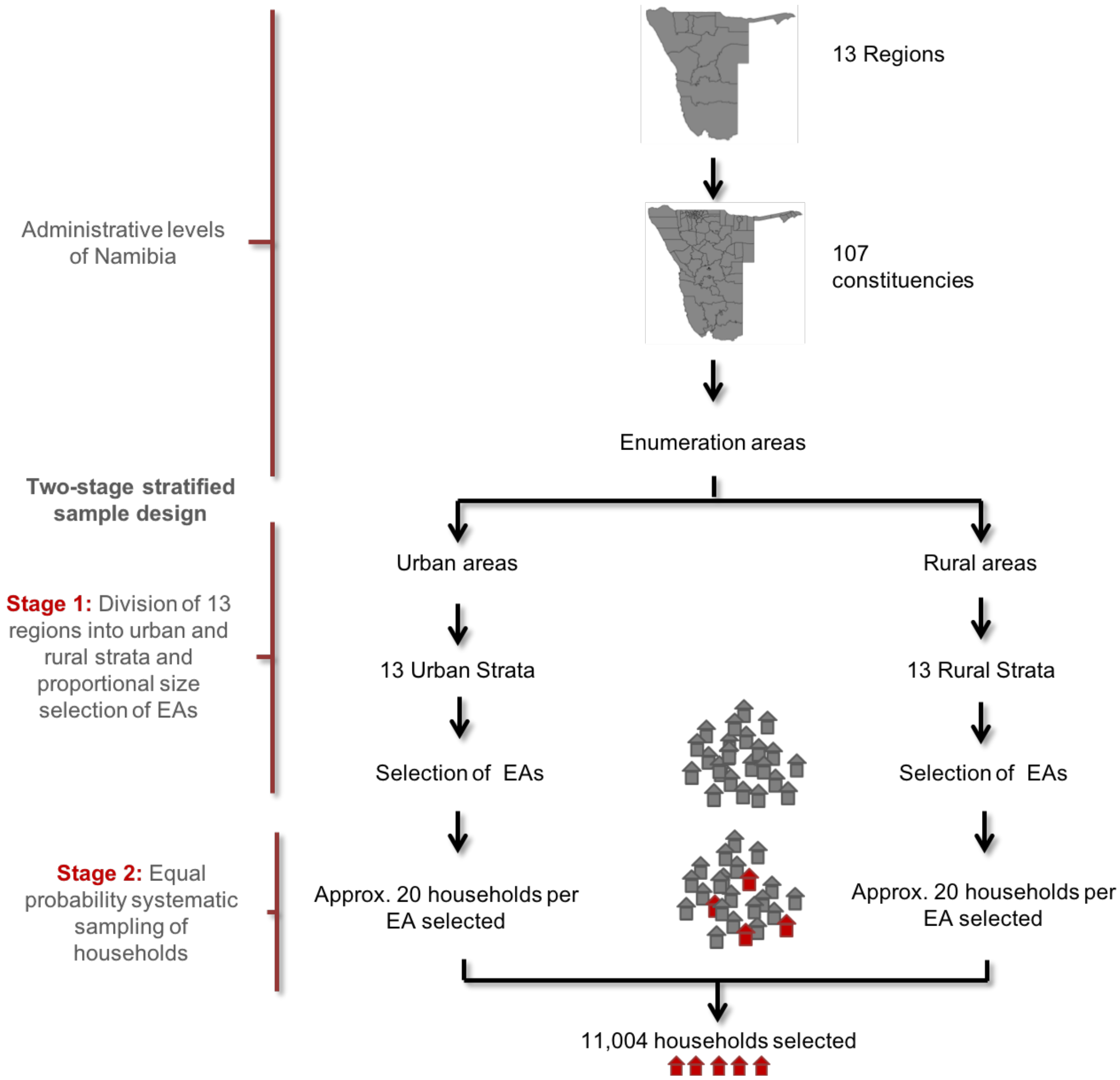


Figure 2.2: Schematic of the two-stage stratified sample design for the 2013 Namibia DHS. 13 urban and 13 rural strata refer to regions being stratified by urban and rural.

2.4 Consent structure

Informed consent was obtained by the interviewer at the beginning of each questionnaire (Household, Woman's and Man's Questionnaires). Statements were included at the beginning of each questionnaire to explain the purpose of the survey and that participation was voluntary and respondents could choose not to answer any of the questions [125]. Specifically, the statements explained the purpose of the interview or test, the duration of the interview, the procedures involved, the potential risks and benefits of taking part and provided contact details if the respondent would like more information [126]. The interviewer, not the respondent, signed to confirm informed consent was received [125]. If the respondent did not consent, this was to be indicated on the form by the interviewer. For children or adolescents to participate, consent was obtained from a guardian [126]. Consent was obtained throughout the survey for specific tests.

2.5 Privacy of respondents

In the DHS, including the 2013 Namibia DHS, attempts are made to conduct tests and interviews privately, not in the presence of other eligible individuals. Survey responses and test results are confidential. In the DHS datasets, unique IDs are used to ensure the participants are not identifiable by the user.

2.6 Data collection

The 2013 Namibia DHS recruited 250 field staff, including 31 nurses who were the health technicians. Information on the training of field staff can be found elsewhere [120]. Field staff were divided into 28 teams consisting of one supervisor, a field editor, three female interviewers, one male interviewer and a health technician [120].

Field work took place between 26 May 2013 and 30 September 2013 [120]. Data collection started in Windhoek to ensure close supervision of data collection before deployment to other regions [120]. Quality assurance procedures were carried out by regional supervisors [120]. The survey was publicised through television and print platforms between May and June 2013 [120].

2.7 Questionnaires and tests

The 2013 Namibia DHS survey followed the DHS version VI, which was adapted to cover population and health topics relevant to Namibia, informed by meetings with government ministries in Namibia, non-governmental organisations and international donor parties [120]. The DHS data were collected through three different questionnaires: the Household Questionnaire, the Woman's Questionnaire and the Man's Questionnaire (**Figure 2.3**) [120]. Each questionnaire was produced in English and was translated into six local languages: Afrikaans, Rukwangali, Oshiwambo, Damara/Nama, Otjiherero and Silozi [120]. The questionnaires were also translated back into English to check for accuracy [120].

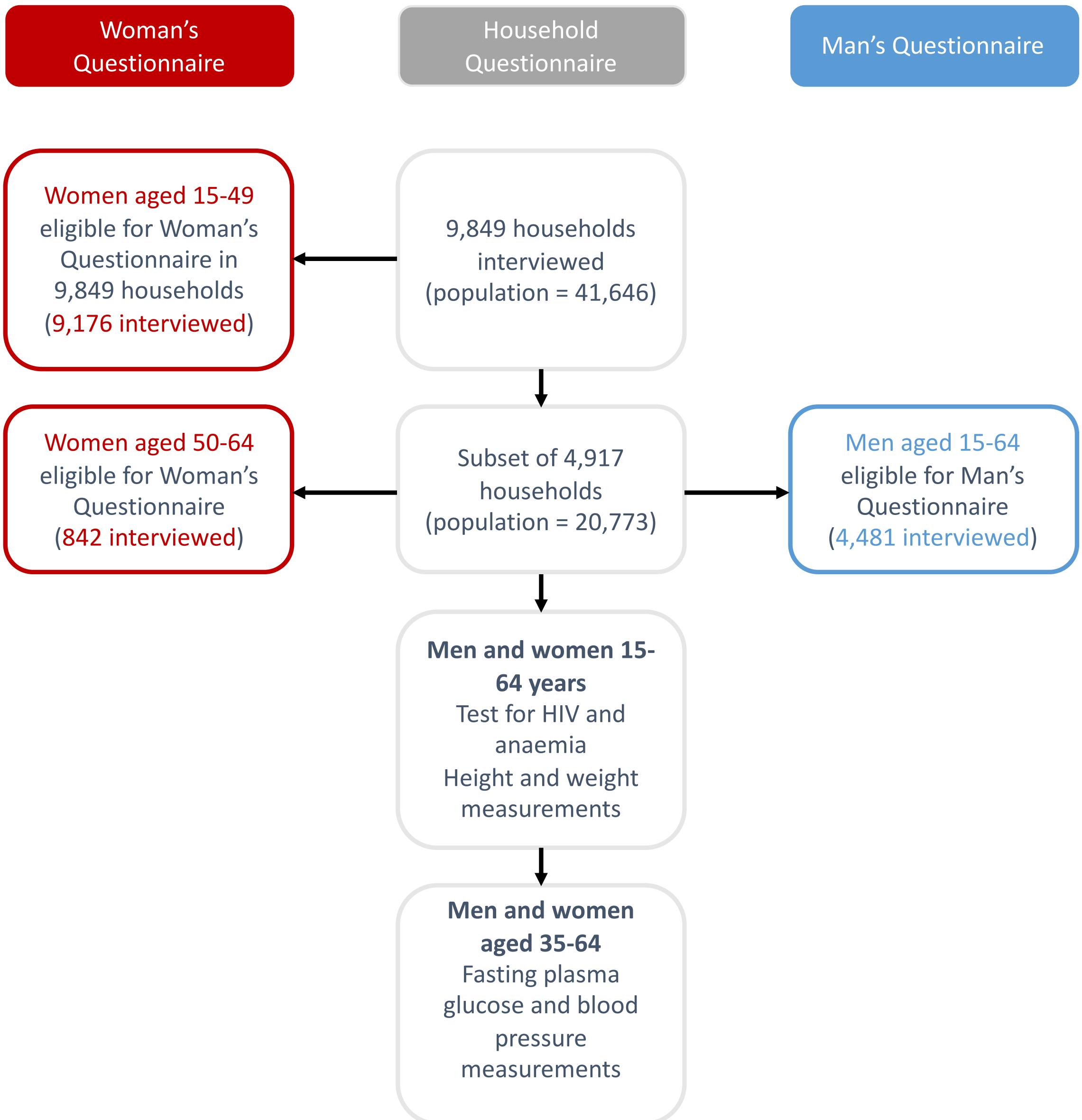


Figure 2.3: Overview of households and individuals surveyed in the DHS.

2.7.1 The Household Questionnaire

The Household Questionnaire was administered to all participating households (N=9,849). The proportion of response is outlined in **Chapter 3**. Sociodemographic and health Information on each household member was collected. One household member answered questions on behalf of all other household members. Each household member was assigned a line number through which they could be identified in answers to certain questions; for example, the line number of the individual who sought care. Questions relating to knowledge and attitudes towards malaria and malaria preventative measures, health expenditure, household assets and household structure were also included, amongst others, in the Household Questionnaire.

Through this questionnaire individuals who were eligible for the Woman's and Man's Questionnaires were identified. A subset of half of the households (n=4,917) were selected for the collection of anthropometric and biomarker data (**Figure 2.3**) [120]. Individuals in these households eligible for the collection of this information are listed in **Table 2.1**.

Table 2.1: Individuals eligible for the collection of anthropometric and biomarker data in the Household Questionnaire

Tests and measurements	Age
Height and weight measurements	15-64 years 0-59 months
Anaemia test	15-64 years 6-59 months
HIV test	15-64 years
Blood pressure	35-64 years
Blood glucose	35-64 years

2.7.2 The Woman's Questionnaire

In all surveyed households, eligible women aged 15–49 years could answer the Woman's Questionnaire. In half of the selected households, women aged 50–64 years were also eligible to answer this questionnaire (**Figure 2.3**) [120]. This questionnaire asked questions relating to education, birth history and child mortality, knowledge and use of family planning methods, antenatal care, delivery and postnatal care, vaccinations and childhood illness, marriage, sexual activity, awareness of sexually transmitted infections, maternal mortality, domestic violence, barriers to healthcare and other health issues [120].

2.7.3 The Man's Questionnaire

The same half of survey households where women aged 50–64 were eligible for the Woman's Questionnaire, men aged between 15 and 64 years living in these households were invited to take part in the Man's Questionnaire (**Figure 2.3**) [120]. The Man's Questionnaire answered questions under similar themes as in the Woman's Questionnaire but was shorter as it did not include questions on maternal and child health [120].

2.7.4 HIV testing

In the same half of households, men and women aged 15–64 years were eligible for HIV testing. Blood samples for HIV testing were obtained from consenting individuals by health technicians [120]. The blood collection procedure and data confidentiality was explained to the participants and they were made aware that they would not be informed of their HIV test result [120]. However, respondents were given information about HIV/AIDS and a list of places they could seek counselling and further testing [120].

Blood sample collection involved three to five finger-prick blood samples collected on filter paper to which a unique barcode label was attached [120]. If the participant did not consent to their sample being stored for possible future testing, this was recorded in the Household Questionnaire and on the filter paper [120]. An identical barcode was attached to the Household Questionnaire and to the sample transmittal form [120]. Samples were left to dry overnight and were transported the following day to the National Institute of Pathology (NIP) for HIV testing [120].

At the NIP, samples were logged to the CSPro HIC Test Tracking System and stored at -20°C [120]. The HIV testing algorithm is outlined in **Figure 2.4**. The samples were screened first using the Vironostika® Ag/Ab combination assay [120]. Retests were carried out on all positive samples and 10% of negative samples using Enzygnost® HIV Integral II assay–a fourth-generation enzymelinked immunosorbent assay (ELISA) to confirm the result [120]. Samples with discordant results were re-tested with the first two tests and if remained discordant were tested using a third assay – the Inno-Lia HIV I/II Score line immunoassay [120]. The result of this test was taken as the final result. If the results of this test were indeterminate, the sample was recorded as indeterminate [120]. HIV typing was carried out using the Inno-Lia HIV I/II Score line immunoassay for all positive results [120]. HIV results were stored with the barcode as the unique identifier, which allowed the data to be linked to individual data from the questionnaires [120].

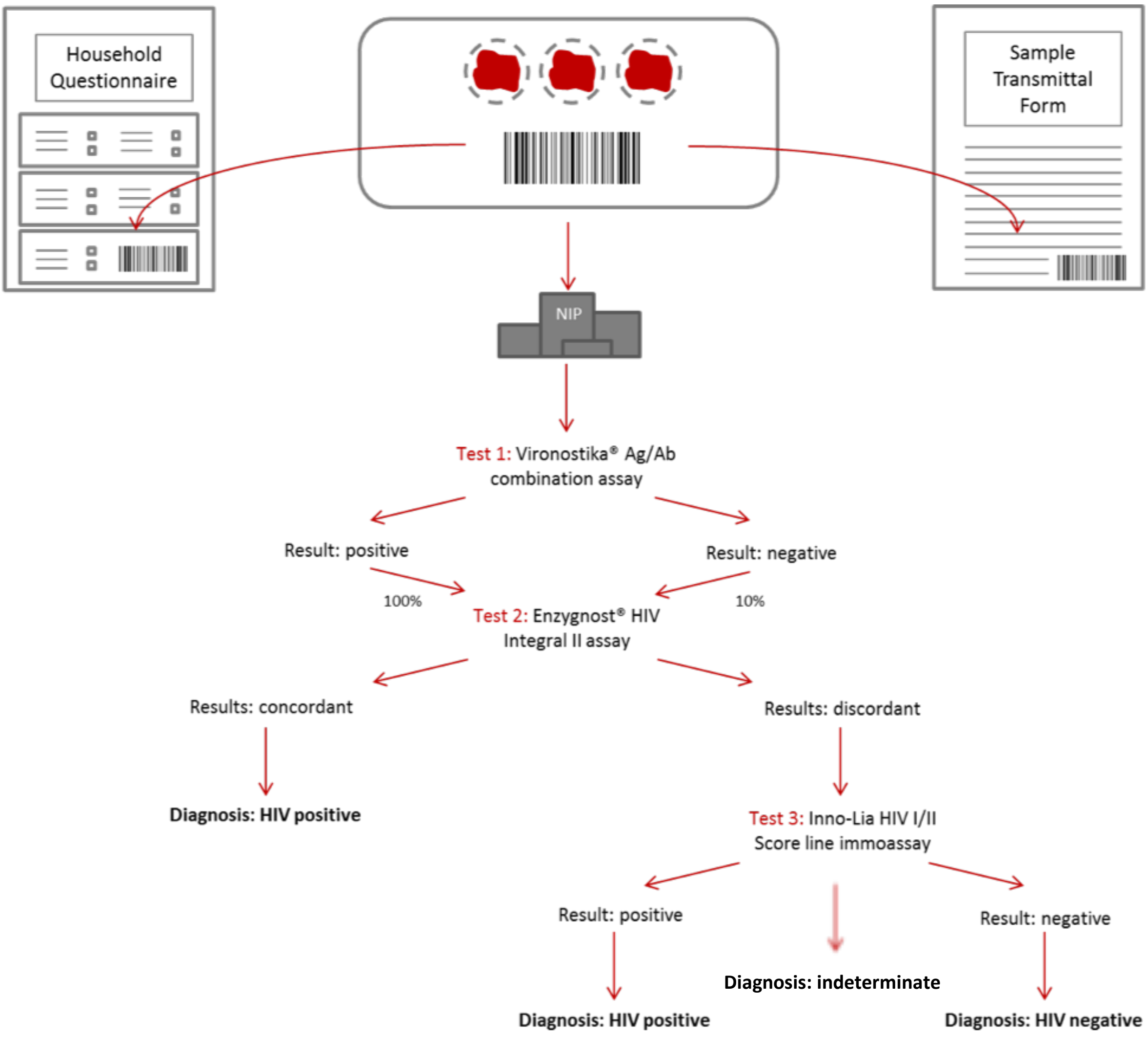


Figure 2.4: Sample collection and testing algorithm for HIV.

2.7.5 Blood pressure testing

In the same half of households, individuals aged 35–64 were eligible to have their blood pressure and blood glucose measured. Blood pressure measurements were taken using Life Source UA-767 Plus digital devices [120], which have automatic upper-arm inflation and automatic pressure release. Three blood pressure measurements were taken; the first was discarded and the average of the other two measurements was calculated and recorded [120]. However, if there were only two readings, the second measure was taken as the average and if there was one reading this was taken as the average [120]. Diastolic and systolic blood pressure measurements were recorded in millimetres of mercury (mmHg). Respondents with an abnormal measurement were advised to visit a health facility [120].

2.7.6 Blood glucose testing

The blood glucose measurement in the 2013 Namibia DHS was a fasting blood glucose measurement. Participants were asked to fast overnight and the last eating and drinking time was recorded before the measurement was taken [120]. A finger-prick blood sample was obtained and tested using the HemoCue Glucose 201 RT system [120]. Blood glucose measurements were recorded in millimoles per litre (mmol/L).

2.8 Data processing

The 2013 Namibia DHS data processing staff consisted of data processing personnel, data operators, a questionnaire administrator, office editors, secondary editors, network technicians, data processing supervisors and a coordinator. Data entry and editing was carried out using CSPro software at the National Statistics Agency Data Processing Centre in Windhoek. Data processing ended in January 2014.

2.9 Development of the wealth index

2.9.1 Overview and aims of the wealth index

The DHS wealth index uses information on household assets collected as part of the Household Questionnaire to determine a household's wealth relative to other households [127]. The wealth index is a measure of economic status (not socioeconomic status) [127]; it does not include indicators relating to education and occupation. The index is constructed differently for each DHS country in terms of the indicators that are included to calculate the index. The general methodology for calculating the index is, however, the same. The wealth index can be used to explore the ability of households or individuals to pay for health services and to understand the distribution of various services by differing levels of wealth [127].

2.9.2 Construction of the wealth index

The wealth index is constructed using principal components analysis (PCA), which is a method commonly used to derive indices of SES [128]. It is a statistical technique that reduces a number of correlated variables into uncorrelated components, which are linear weighted components of the original variables [129]. These components explain the variation in the original dataset. After the first component, each component explains additional but less variation [129].

The first PCA is carried out for variables in the DHS, which are collected for purposes other than determining the wealth index e.g. household structure and assets. This is followed by a second PCA, which adds specific variables particularly related to non-urban measures of wealth, for example, ownership of farm animals and agricultural land [128]. A third stage involves the generation of separate wealth indexes for urban and rural households under the assumption that measures of wealth and the weight of certain assets will differ between urban and rural areas [128]. The variable relating to farm animals was later discarded due to showing a non-linear relationship with the national, urban and rural wealth indexes [128].

The PCA score coefficients for each variable are listed and two columns are produced for whether the household has or does not have the item in question. The mean of the item is subtracted from 1 and 0: from 1 to create a score for if the household has the item and from 0 for if the household does not [128]. This number is then divided by the standard deviation (SD) and then multiplied by the PCA score for that item [128].

Score for if the household <u>has</u> the item:

$$\frac{1-\bar{x}}{SD} \times PCA\ score$$

Score for if the household <u>does not have</u> the item:

$$\frac{0-\bar{x}}{SD} \times PCA\ score$$

The household assets used to construct the wealth index for the 2013 Namibia DHS are listed in **Appendix 1**, which also contains the results of the PCA analysis. A single composite wealth score is generated from the national, rural and urban indices [130]. A regression was performed with the national score as the outcome and urban or rural residence type as the exposure [130]. The output constants and coefficients are used to create a combined score, which accounts for differences in wealth by residence type [130]. Wealth quintiles are subsequently generated from the wealth index.

2.10 Survey weights

Although the DHS is intended to be nationally-representative, non-proportional allocation of the sample to different regions or selection bias from differences in proportion of responses may mean that estimates are not generalisable to the broader population [120]. To account for this, the DHS calculates sampling weights [131]. Sample weights are appropriate for descriptive analyses, including prevalence estimates [131]. They are not appropriate for use in regression analyses or other analyses that explore the relationship between variables [131]. As such, for the primary analyses of this thesis, unweighted analyses are presented, with weighted prevalence estimates reported for relevant descriptive analyses in **Appendix 2.**

2.11 GPS data

2.11.1 Methods of GPS data collection in the DHS

Like many other DHS surveys, the 2013 Namibia DHS collected GPS data. GPS stands for Global Positioning Satellite. Detailed methods of the collection of GPS data in the DHS are described elsewhere [132] but are summarised here.

GPS receivers are used to determine geographical location using satellites. There are different types of GPS receivers; the DHS uses recreational receivers, which are accurate to 15 meters or less and often to around 5 metres [132]. GPS data in the DHS is collected for each EA, not for each household, to enable confidentiality of participants [132]. Coordinates are obtained in longitude and latitude [132]. Where possible, readings are taken in open spaces to reduce the likelihood of being obscured by large obstacles [132].

Once collected, GPS data are downloaded onto a Geographical Information System (GIS). Where duplicates occur, the point taken first is usually kept and assumed to be the correct point [132]. Points are also checked for any obvious errors, for example if they appear to have been collected in a different location than expected, by checking against administrative boundaries [132]. The data are also checked for missing entries [132].

2.11.2 Using GPS data

The GPS coordinates are randomly displaced in order to ensure participant confidentiality. In urban areas, EA locations are displaced by up to 2 Km [133]. In rural areas, this is greater at up to 5 Km, with 1% of rural EAs displaced by up to 10 Km [133]. It is not possible to determine which EAs were displaced by up to 10 Km. Once displaced, the coordinates are checked to ensure that they still fall within the correct administrative boundaries [133].

The random displacement of GPS points means that it is difficult to accurately measure the distance between the EA and other points of interest, for example the nearest health facility. There are multiple methods to account for EA displacement, depending on the aim and type of analysis being conducted [133]. The specific methods chosen to account for displacement are outlined in the relevant subsequent chapters.

2.11.3 Limitations of GPS data collected in the DHS

GPS data collection has certain limitations. First, the accuracy of the receiver depends upon the number of satellite signals it receives and the strength of the signal itself [132]. The signal can also be obscured by large obstacles such as buildings or mountains, which may reduce the accuracy of the recording. Furthermore, human error can be introduced, which may be difficult to detect.

2.12 Obtaining and storing DHS datasets

DHS datasets were previously requested and downloaded from the DHS website. I additionally requested access to the 2013 Namibia DHS GPS data. Following approval from the DHS Program, GPS data were downloaded and stored in a highly secure, managed access file. DHS survey data were stored at a lower level of security on a managed access drive with access by multiple users.

2.13 Management of DHS data

DHS survey data are provided in a number of data files, which contain different recodes of the Household, Woman's and Man's Questionnaire data. A description of these recode files can be found in **Table 2.2.** The first two letters of the file name refer to the country, the second two refer to the type of data file, the numbers refer to the phase and number of the survey, and the last two letters refer to the type of software program needed to open the file (FL denotes that the file contains an ASCII file and dictionaries).

Table 2.2: Description of the 2013 Namibia DHS datasets

Recode file name	Description	Populations	Origin Questionnaire
NMAR61FL	HIV Test Results Recode	Results of HIV test results for all those tested	N/A
NMBR60FL	Births Recode	All births to interviewed women	Woman's Questionnaire
NMCR60FL	Couple's Recode	Interviewed couples	Woman's and Man's Questionnaires
NMHR60FL	Household Recode	Household level data including a list of household members and data about them	Household Questionnaire
NMKR60FL	Children's Recode	Children under 5 years of interviewed women	Woman's Questionnaire
NMIR60FL	Individual Recode	Interviewed women	Woman's Questionnaire
NMMR60FL	Male Recode	Interviewed men	Man's Questionnaire
NMPR60FL	Household member recode	People in in the household	Household Questionnaire

For this thesis, a dataset was created that combined the reshaped Household, Woman's, Man's and HIV datasets. This enabled the investigation of individual-level traits in the context of household level factors and data collected on that individual in the household questionnaire. It also allowed HIV results to be linked to individual and household level indicators that may be important HIV risk factors.

Further, I appended additional datasets to the DHS data to broaden the scope of these analyses. Additional datasets and their applications are outlined in detail in relevant chapters but are described briefly in **Table 2.3.**

Table 2.3: Additional datasets used in conjunction with DHS data

Dataset	Data source	Description	DHS dataset applied to	Relevant chapter
Regional *Pf*PR$_{2-10}$ data and *Pf*PR$_{2-10}$ raster file for Namibia in the year 2013	Malaria Atlas Project (MAP) [134]	*Plasmodium falciparum* Parasite Rate in those aged 2-10 years	NMHR60FL–Namibia DHS 2013 Household Recode	Chapter 5
Public Health Facilities in Namibia	Namibian Ministry of Health and Social Services (MoHSS)	GPS coordinates of public health facilities	DHS GPS data	Chapter 7
Distance to nearest health facility	Derived from public health facility data and DHS GPS data	Euclidean (straight-line) distance from DHS EAs to health facilities	Merge of Household Recode, Individual Recode (Woman's Questionnaire), Men's Recode and HIV Test Results Recode	Chapter 7
Travel time to health facility	Derived using Access Mod 5.0 software	Travel time to health facility, accounting for road speed, elevation and land cover	Merge of Household Recode, Individual Recode (Woman's Questionnaire), Men's Recode and HIV Test Results Recode	Chapter 7

2.14 Strengths and limitations of the 2013 Namibia DHS

The 2013 Namibia DHS is a useful resource for understanding population health and demographics in the country. The 2013 Namibia DHS is a nationally representative survey, with a large sample size of 9,849 households. The 2011 Population and Housing Census in Namibia identified 465,400 households [135], therefore the households surveyed in the DHS account for approximately 2% of this total. There were a total of 2,058,100 people identified in the census as living in conventional households, including 1,065,600 women and 992,500 men. The DHS household population of 41,646 therefore also represented approximately 2% of the total population. In the Woman's Questionnaire, the DHS covered an estimated 0.9% of the female population and in the Man's Questionnaire the DHS covered around 0.5% of the male population.

However, the DHS report states that the sample was not proportionately allocated to each region. Furthermore, differential proportions of response can influence the national representativeness of the sample. Sample weights can be applied to obtain representative estimates. This thesis primarily focuses on the prevalence and determinants of heath and healthcare access. In this context, and given the previous literature on specific aspects of healthcare access, the large sample size of the DHS was expected to be sufficient for statistical detection of effect sizes similar to those reported in previous studies. The large sample size reduces the likelihood that the outcomes observed will be affected by chance. Furthermore, as the proportion of response was high, the risk of error from sampling bias is low.

Another advantage of the DHS is that the surveys are standardised, allowing comparisons with other countries. It also enables comparisons of surveys conducted at different time points in the same country. In Namibia, it is possible to explore how prevalence of disease has changed between 1992, 2000, 2006/07 and 2013, for example. However, such analyses are limited due to different survey populations taking part at different time points. Additionally, the surveys have been developed over time; thus different versions have been used at various time points, limiting the comparability of surveys.

One limitation of the DHS for exploring disease outcomes is that the survey was cross-sectional, thus does not enable the temporality of associations to be assessed. Cross-sectional studies are, however, useful for investigating disease prevalence at one point in time and can allow the investigation of exposures that may be associated with the outcome of interest, even if causation cannot be determined. This is useful for the design of future research studies to better understand the causal pathway. Cross-sectional studies can also be useful for informing health system planning and evaluating the success of control programmes, for example exploring the coverage of interventions at a particular time point.

Data collection in the form of surveys can result in systematic error being introduced. Errors in reporting may arise when household members are answering questions on past events or are providing information on other household members; for example, as part of the Household Questionnaire, questions were asked to one household member about the other household members. Information on other household member's age, education level and whether a household member slept under a mosquito net the night before the survey, are some examples of such questions. This may result in the misclassification of household members, which, if differential, could bias prevalence and effect estimates. However, it is possible to correct information such as age and education based on individual survey responses for some individuals.

A further disadvantage of these DHS data is that HIV status was not fed back to participants of the survey. Although participants were informed of this and consented to have their blood taken and tested for HIV on this basis, in a country like Namibia with a high HIV prevalence, where HIV is also the leading cause of death and a major public health concern, it would have been beneficial to have provided a diagnosis, further screening or treatment as a result of a positive HIV test, especially given the scale and reach of the survey. This could have helped participants manage their own health but also potentially prevented onward transmission.

Overall, the DHS provides an opportunity to undertake large-scale epidemiological analyses in Namibia. In the context of this thesis, the DHS is a useful resource for exploring prevalence of disease outcomes, access to healthcare and intervention coverage at a single time point at the national level. Furthermore, the DHS is useful for investigating the coverage of malaria control interventions at the end of control programme implementation for the year 2013, prior to major outbreaks of malaria in the country in subsequent years. It provides a means to explore inter-regional differences in outcomes of interest and the GPS component facilitates sophisticated geospatial analyses of nationally-representative data. Combined with government health facility data, it is possible to explore barriers to healthcare, using the most recent nationally-representative data on Namibian populations.

2.15 The use of DHS data in this thesis

Data from the 2013 Namibia DHS are used in subsequent chapters 3 to 8 to explore disease burden and access to healthcare and interventions, with a view to informing further research and policies for health system strengthening.

3. Overview of the DHS population

Summary

Introduction: This chapter explores the representativeness of the 2013 Namibia DHS relative to the Namibian 2011 census population, the distribution of survey household by different characteristics and the sociodemographic characteristics of the household population and individual survey respondents. Given the socioeconomic inequalities reported in Namibia, I also explore the urban-rural, regional and population distribution of socioeconomic indicators.

Methods: Data from the 2013 DHS on 9,849 households constituting a population of 41,646 individuals, in addition to data collected from 10,018 women and 4,481 men in the individual questionnaires, were included in these analyses. I also present information from the 2011 Population and Housing Census and AfriPop data on Population Density in 2010. I conducted descriptive analyses of household facilities, assets, and population demographics.

Results: The distribution of the DHS EAs was reflective of the population density in Namibia. Over 90% of invited households and women and 85% of invited men responded to the survey. Urban-rural and regional differences in wealth were observed, with rural areas and the regions of Kavango, Ohangwena, Zambezi and Oshikoto being the poorest. At the population level, wealthier populations and those in urban areas had higher levels of education. The proportion of the population educated to secondary and higher education decreased with age (from 1 to 95 years), suggesting that educational attainment has improved in the population over time. Unemployment was higher in rural areas, in less wealthy households and in less educated populations.

Conclusion: The DHS is a useful resource to explore population health and demographics, given its large sample size, representativeness and variety of themes under which data were collected. The distribution of the population by wealth, education, employment and residence type suggests that careful consideration should be given to these factors in further analyses using these data.

3.1 Introduction

The most recent DHS conducted in Namibia took place in 2013. The survey explored a number of social, economic and health-related outcomes, at the national level. The 2013 Namibia DHS collected data pertaining to a variety of topics, thus constituting a useful tool to understand population health outcomes and their determinants.

Few have used the 2013 Namibia DHS data for large-scale epidemiological analyses and the Namibia DHS Report 2013 provided only descriptive analyses of DHS data. Throughout this thesis I used these data to explore the burden of disease, barriers to healthcare and intervention access and their determinants. In this chapter, I provide an introduction and overview of the DHS households and participants. This included an assessment of the distribution and representativeness of the population, the location of selected study EAs and descriptive statistics of household facilities, structure and assets, and population demographics. This chapter aimed to introduce the households and populations that are explored further in subsequent chapters.

This chapter also aimed to assess the distribution of households and individuals by key socioeconomic indicators, namely education, wealth and employment. There has been growing attention given to understanding the nexus of inequality, poverty and health in the context of sustainable development. Socioeconomic inequality has the potential to impact on health as well as human development and economic growth, poverty and political stability [16]. Given Namibia's substantial income inequality, variations in educational attainment and a high percentage of unemployment [5, 17, 136], it is important to understand the distribution of these socioeconomic factors in the DHS population, as well as the differential distribution of these factors by urban and rural residence type and by region. As these factors are likely to impact on health outcomes, intervention coverage and healthcare access, these findings are used to inform subsequent analyses in this thesis.

The specific aims of this chapter are:

i. To explore the distribution of the DHS population relative to the national census population;
ii. To describe household characteristics and assets and how they differ between urban and rural dwellings;
iii. To investigate the sociodemographic characteristics of DHS populations from the household and individual surveys;

iv. To assess the distribution of individuals and households by socioeconomic indicators and how these factors differ by residence type and region.

3.2 Methods

3.2.1 Data sources

These analyses used data from the 2013 Namibia DHS. Details relating to the DHS background and methods are described elsewhere [120] and are outlined in detail in **Chapter 2**. In brief, the 2013 Namibia DHS collected demographic and health information on household members via three questionnaires: the Household Questionnaire, the Woman's Questionnaire and the Man's Questionnaire. All participating households took part in the Household Questionnaire. All consenting eligible women aged 15–49 years in these households answered the Woman's Questionnaire. In half of households, consenting eligible women aged 50–64 years also took part in the Woman's Questionnaire, alongside consenting eligible men aged 15–64 years who completed the Man's Questionnaire. In this half of households, individuals aged 15–64 years could also consent to height and weight measurements, anaemia testing and an HIV test. Those aged 35–64 years could consent to fasting blood glucose and blood pressure measurements.

Data on 9,849 households, 41,646 individuals from the household population, 10,018 women and 4,481 men were included in these analyses. Namibia DHS GPS data for survey EAs were also used in these analyses. AfriPop data for the year 2010 were used to present population density in Namibia [9].

3.2.2 Statistical methods

All statistical analyses were carried out in Stata 14.0 (StataCorp: College Station, TX, USA). Continuous variables are presented as means and standard deviations (SDs). All categorical variables are presented as a number and percentage. *P* values were generated using chi-squared tests for categorical variables and Student's T-test for continuous variables.

The Household, individual Woman's and individual Man's datasets were combined for this analysis. Age was corrected in the household data from the individual surveys where possible. Age groups were defined in five-year intervals with the exception of those aged over 75 years that were grouped in one category to reduce the number of parameters. Where the education level of individuals who had taken part in the Woman or Man's Questionnaires did not match that in the household dataset, their education was corrected to reflect the education level from the individual datasets. Individuals who had missing information or "don't know" for age, sex or education were dropped. As such, a subset of 41,322 individuals were explored in the combined dataset, except where otherwise stated. Education level reflects the highest level of education attended [137], but does not necessarily mean that the level of education was completed.

The 2013 Namibia DHS did not collect data on ethnicity. However, it is possible to use data collected on the main language spoken in the home as a proxy for ethnicity. Data on the main language spoken in the home was collected as part of the Woman's and Man's Questionnaires. As such, additional analyses exploring the prevalence of health and healthcare access outcomes by ethnicity and associated multilevel analyses can be found in **Appendix 3**. For these analyses, the ethnicity variable was created by recoding the variable for the main language spoken in the home into five groups: Afrikaans, Damara/Nama, Herero, Oshiwambo and "other", which included small populations of English, San, Kwagali and Lozi. This classification of individuals by ethnicity in Namibia has also been used by Craig *et al.* [138].

Spatial analyses were conducted using Quantum GIS (QGIS) 2.14.1. Shapefiles of administrative boundaries for Namibia were obtained via DIVA GIS [139]. EA coordinates were provided by the DHS program following data request approval. All maps presented in this chapter are displayed in CRS WGS84 therefore scale bars are approximate.

3.3 Overview of DHS participants

3.3.1 Enumeration Areas

The location of the EAs selected for the 2013 Namibia DHS are shown in **Figure 3.1A**. The majority of EAs were located in the northern regions, across Ohangwena, Oshana, Oshikoto and Omusati, with some other noticeable clusters of EAs in the Kavango, Zambezi, Erongo and Khomas regions. The distribution of selected EAs is reflective of population density (**Figure 3.2**).

A total of 550 EAs were included in the survey, 267 of which were urban and 283 were rural. Each EA contained up to 22 households. EAs with the largest populations were located along the northern border, with EAs containing a total of 150–170 individuals from EA households, collectively (**Figure 3.1B**). Across the majority of other EAs along the northern border they contained more than 90 people from survey households. Further south in the country, EA populations were smaller with many EAs containing 50–90 people from the survey households. This is, again, reflective of population density.

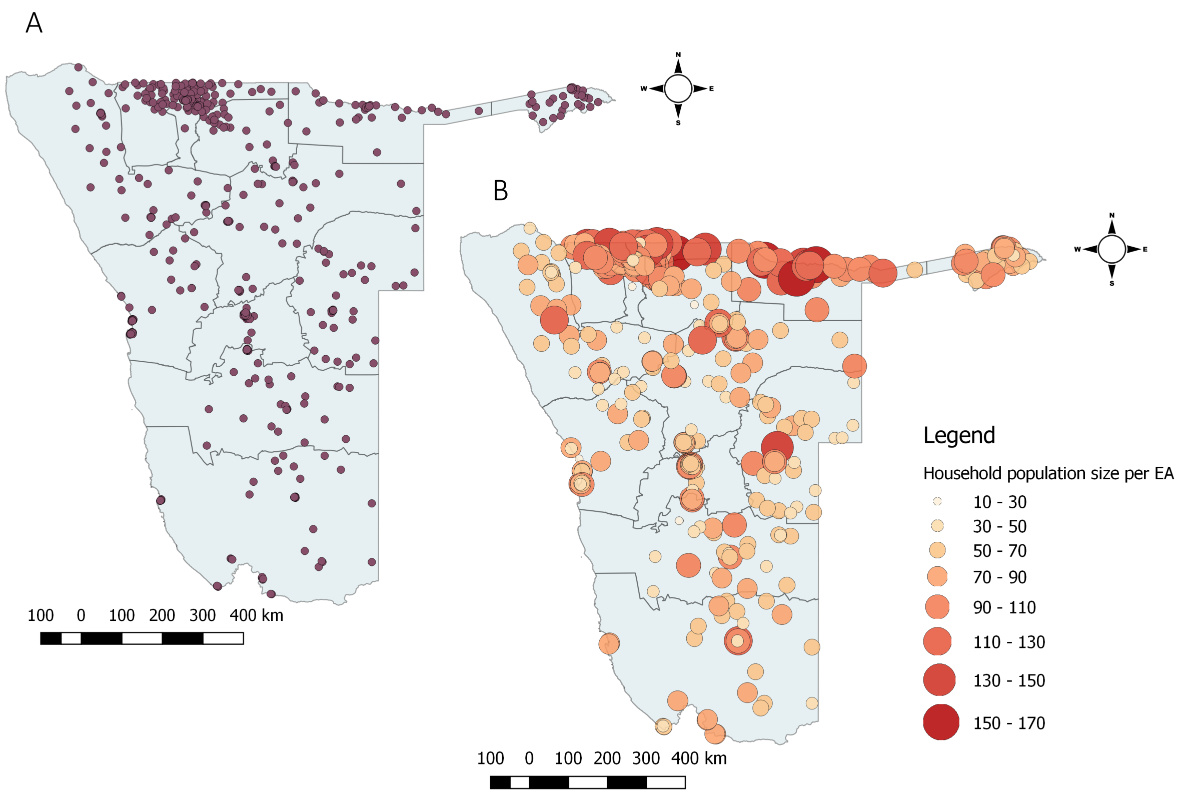


Figure 3.1: Geographical distribution of EAs and EA population size | A: Distribution of DHS EAs **| B:** Population in each EA based on the number of individuals in survey households collectively.

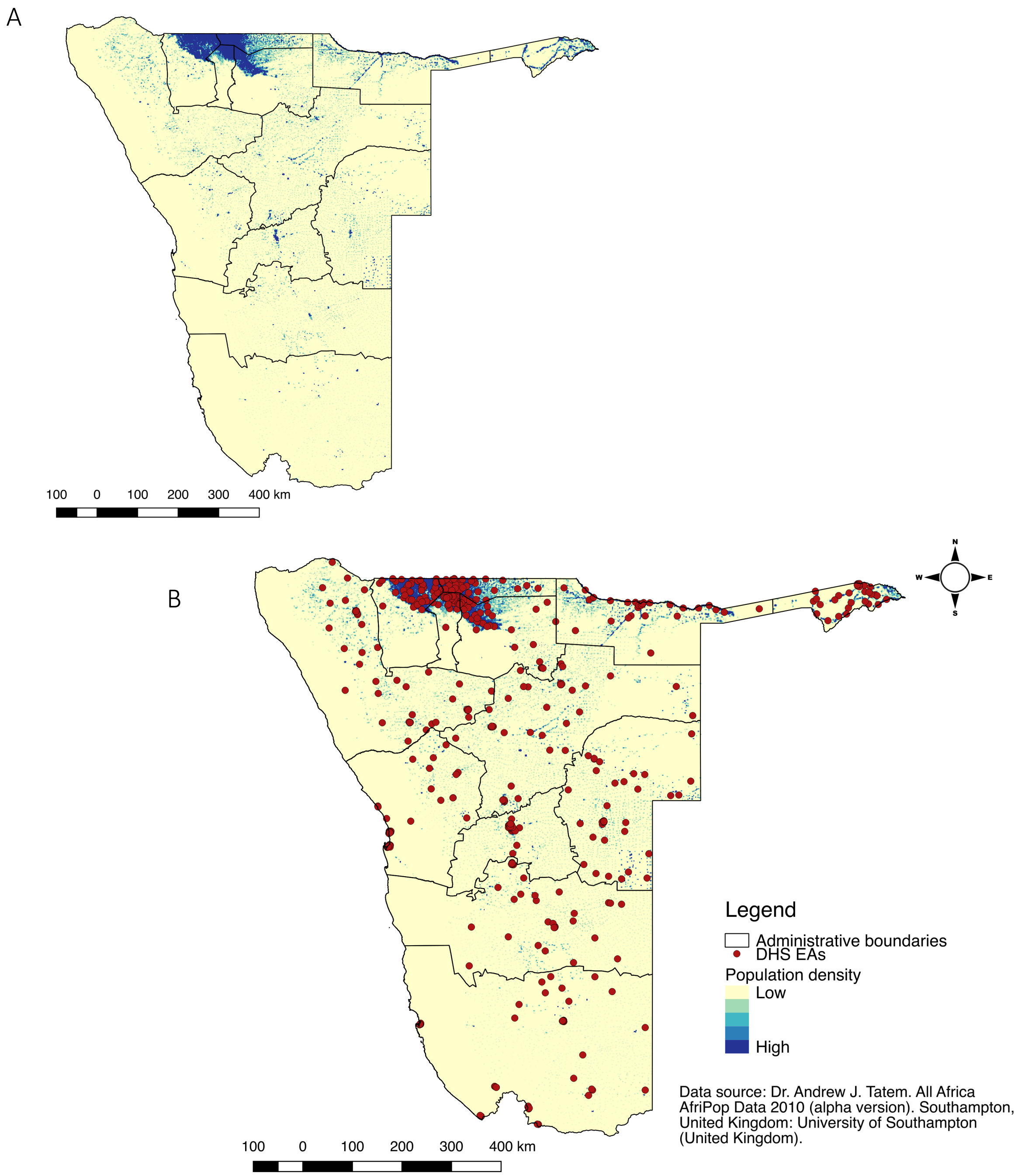


Figure 3.2: DHS EAs relative to Namibia population density | A: Population density in Namibia in 2010 **| B:** Population density overlaid with DHS Enumeration Areas**.** Population density data source: Afripop 2010 (alpha version) Namibia [9].

3.3.2 Survey response

The proportions of response for the various questionnaires have been reported elsewhere and are summarised in **Table 3.1** [120]. The proportion of invited households that responded to the survey was 97% [120]. Of the 11,004 households identified for the survey, 10,165 (92%) were occupied and, of those, 9,849 (97%) were interviewed. In 9,849 households, 9,940 women aged 15–49 were selected for the Woman's Questionnaire. In a subset of 4,917 households, 842 women aged 50–64 and 4,481 men aged 15–64 were interviewed. Of those invited to take part in the survey, 92% of women aged 15–49, 91% of women aged 50–64, and 85% of men responded [120].

Table 3.1: Proportion of households, men and women that responded to the 2013 Namibia DHS

	Invited	Interviewed	Response (%)
Households	11,004	9,849	97
Women			
Aged 15 – 49	9,940	9,176	92
Aged 50 – 64	921	842	91
Men (aged 15 – 64)	5,271	4,481	85

The primary reason for not completing the Woman and Man's Questionnaire was that the respondent was not home at the time of the survey (**Figure 3.3**). This absence was higher amongst men compared with women (9.5% vs 4.6%), possibly explaining the difference in proportion of responses between men and women.

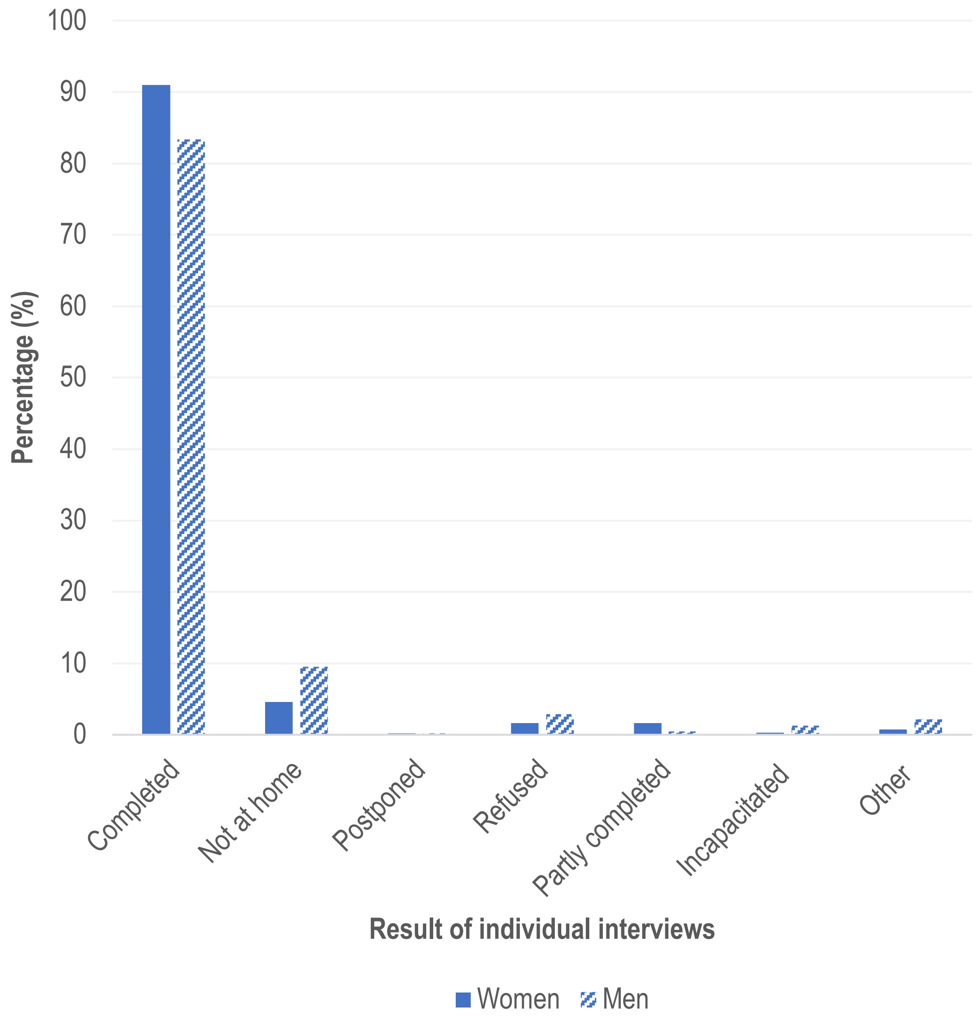


Figure 3.3: Result of individual Woman's and Man's survey interviews. N with available information was 6,177 women and 5,512 men.

3.3.3 Survey population

The 2013 Namibia DHS was designed to be nationally-representative. **Figure 3.2B** shows that the location of DHS EAs was broadly reflective of population density. This indicates that the spatial representativeness of the DHS population relative to population density.

The highest proportion of surveyed households were located in the Erongo region (>10%), followed by Khomas and then Karas and Otjozondjupa (**Figure 3.4**). The higher proportions of households surveyed appear to be located in the central regions of the country, which is surprising given that the highest population density is in the northern regions (**Figure 3.2A**). Aside from Khomas, the largest populations were in the Ohangwena and Omusati regions, where only 6–8% of households were surveyed.

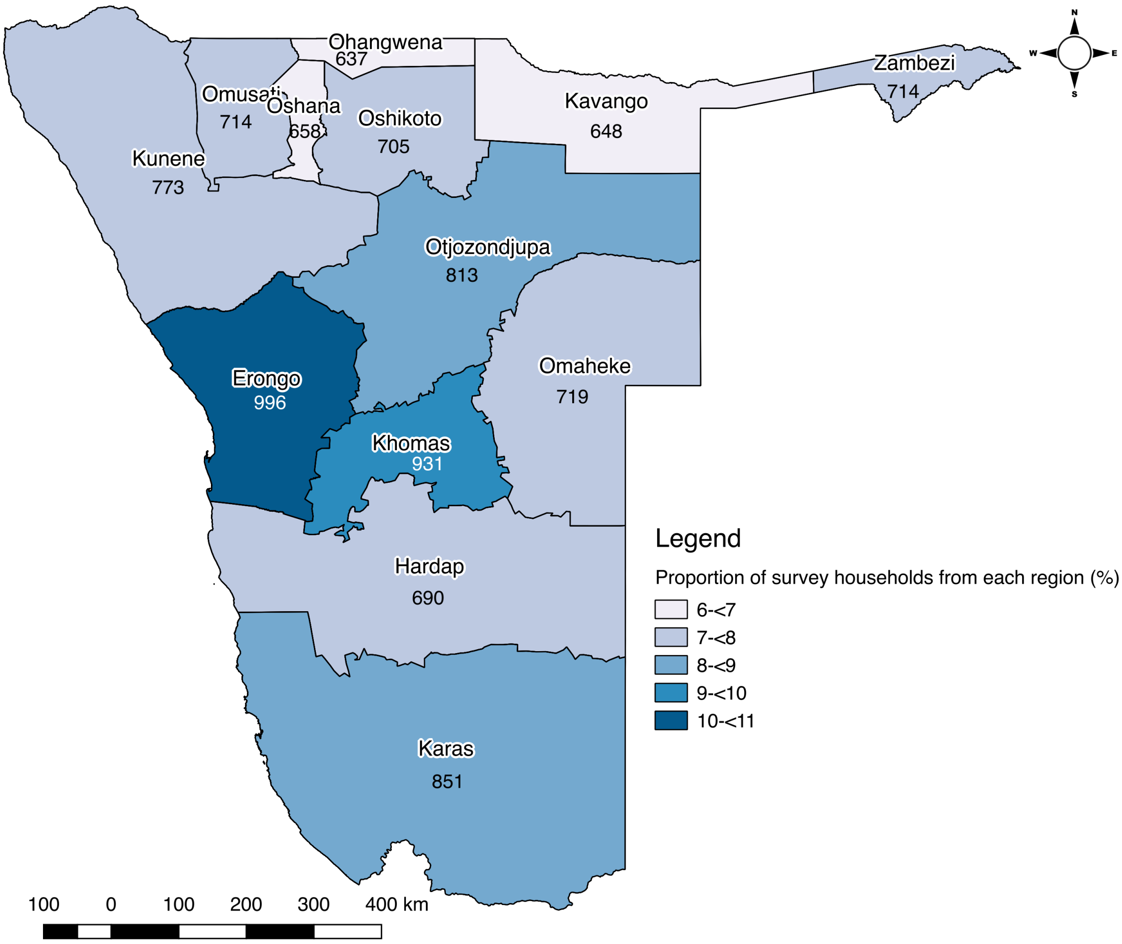


Figure 3.4: The number and distribution of total households surveyed per region. The number of households surveyed per region and the proportion of households accounted for by each region.

3.3.4 Household facilities

The majority of households had three to five rooms for sleeping in (33.8%)(**Table 3.2**). In rural areas most households had three to five rooms, whilst in urban areas the majority had one room for sleeping in. Most households had no toilet facility (47.5%), with 70.9% of rural households reporting that they had no toilet facility. By contrast, in urban areas most households had a flush toilet (67.5%). Shared toilet facilities were reported in 29.0% of all households and this was more common in urban areas (30.8% vs 24.8% in rural areas). The majority of all households reported that drinking water was piped into their yard (51.5%) and 36.1% had water piped into the dwelling. A higher proportion of urban households had water piped into the dwelling than rural households (53.7% vs 19.7%). Most rural households sourced their drinking water from a public tap. Most households had a separate room for their kitchen and this was consistent between urban and rural households (*p*<0.001).

Table 3.2: Household facilities by residence type				
Household facilities	**Urban** No. (%)	**Rural** No. (%)	***p***	**Overall** No. (%)
Rooms for sleeping				
0	1 (0.0)	4 (0.1)	<0.001	5 (0.1)
1	1,673 (35.3)	1,622 (32.1)		3,295 (33.6)
2	1,464 (30.9)	1,172 (23.2)		2,636 (26.9)
3-5	1,540 (32.5)	1,768 (35.0)		3,308 (33.8)
6-9	53 (1.1)	421 (8.3)		474 (4.8)
10+	10 (0.2)	68 (1.4)		78 (0.8)
Total	*4,741 (100.0)*	*5,055 (100.0)*		*9,796 (100.0)*
Toilet facility				
Flush	3,213 (67.5)	861 (17.0)	<0.001	4,074 (41.4)
Pit latrine	401 (8.4)	557 (11.0)		958 (9.7)
No facility/bush/field	1,073 (22.5)	3,600 (70.9)		4,673 (47.5)
other	76 (1.6)	63 (1.2)		139 (1.4)
Total	*4,763 (100.0)*	*5,081 (100.0)*		*9,844 (100.0)*
Toilet facility shared with other households				
No	2,556 (69.3)	1,113 (75.3)	<0.001	3,669 (71.0)
Yes	1,135 (30.8)	366 (24.8)		1,501 (29.0)
Total	*3,691 (100.0)*	*1,479 (100.0)*		*5,170 (100.0)*
Drinking water source				
Piped into dwelling	2,558 (53.7)	997 (19.7)	<0.001	3,555 (36.1)
Piped into yard/plot	713 (15.0)	796 (15.7)		1,509 (51.5)
Public tap/standpipe	1,310 (27.5)	1,102 (21.7)		2,412 (24.5)
Tube well or borehole	16 (0.3)	922 (18.2)		938 (9.5)
Protected/unprotected well	12 (0.3)	591 (11.7)		603 (6.1)
other	155 (3.3)	665 (13.1)		820 (8.3)
Total	*4,764 (100.0)*	*5,073 (100.0)*		*9,837 (100.0)*
Separate room for kitchen				
No	777 (22.4)	142 (6.3)	<0.001	919 (16.1)
Yes	2,686 (77.6)	2,099 (93.7)		4,785 (83.9)
Total	*3,463 (100.0)*	*2,241 (100.0)*		*5,704 (100.0)*

P value corresponds to a chi-squared test

3.3.5 Household assets

As may be expected, the majority of rural households reported owning agricultural land (61.5%)(**Table 3.3**). In urban areas, just 18.9% owned agricultural land. The majority of rural households also owned livestock or farm animals (71.1%). Ownership of other household assets were proportionately higher in urban areas than rural areas: more households owned a radio (74.8 vs 63.2%, $p<0.001$), more than three times as many households owned a television (68.4 vs 20.6%, $p<0.001$), almost five times as many households owned a telephone (15.7 vs 3.7%, $p<0.001$), and bicycle, motorbike and car ownership was also higher in urban areas ($p<0.01$).

Table 3.3: Household assets and possessions

Household assets	Urban	Rural	*p*	Overall
	No. (%)	No. (%)		No. (%)
Owns agricultural land				
No	3,863 (81.1)	1,957 (38.5)	<0.001	5,820 (59.1)
Yes	900 (18.9)	3,122 (61.5)		4,022 (40.9)
Total	*4,763 (100.0)*	*5,079 (100.0)*		*9,842 (100.0)*
Owns livestock/ farm animals				
No	3,622 (76.0)	1,466 (28.9)	<0.001	5,088 (51.7)
Yes	1,142 (24.0)	3,614 (71.1)		4,756 (48.3)
Total	*4,764 (100.0)*	*5,080 (100.0)*		*9,844 (100.0)*
Other household possessions*				
Radio	3,562 (74.8)	3,213 (63.2)	<0.001	6,775 (68.8)
Television	3,258 (68.4)	1,047 (20.6)	<0.001	4,305 (43.7)
Telephone	717 (15.1)	187 (3.7)	<0.001	904 (9.2)
Refrigerator	3,141 (66.0)	959 (18.9)	<0.001	4,100 (41.7)
Bicycle	749 (15.7)	598 (11.8)	<0.001	1,347 (13.7)
Motorbike	119 (2.5)	83 (1.6)	0.003	202 (2.1)
Car	1,601 (33.6)	931 (18.4)	<0.001	2,532 (25.8)

P value corresponds to a chi-squared test

*numbers represent households with these possessions and percentages are the proportion of households interviewed with each possession relative to overall households interviewed

Household assets were used to generate the wealth index (**Appendix 1**) [127, 128], and therefore vary in their distribution by wealth quintile. Wealth also differed by urban and rural residence type (*p*<0.001). The number of rural households decreased with increasing wealth quintile, whilst the number of urban households increased with increasing wealth quintile (**Figure 3.5**). This suggests that, overall, urban households were wealthier than rural households.

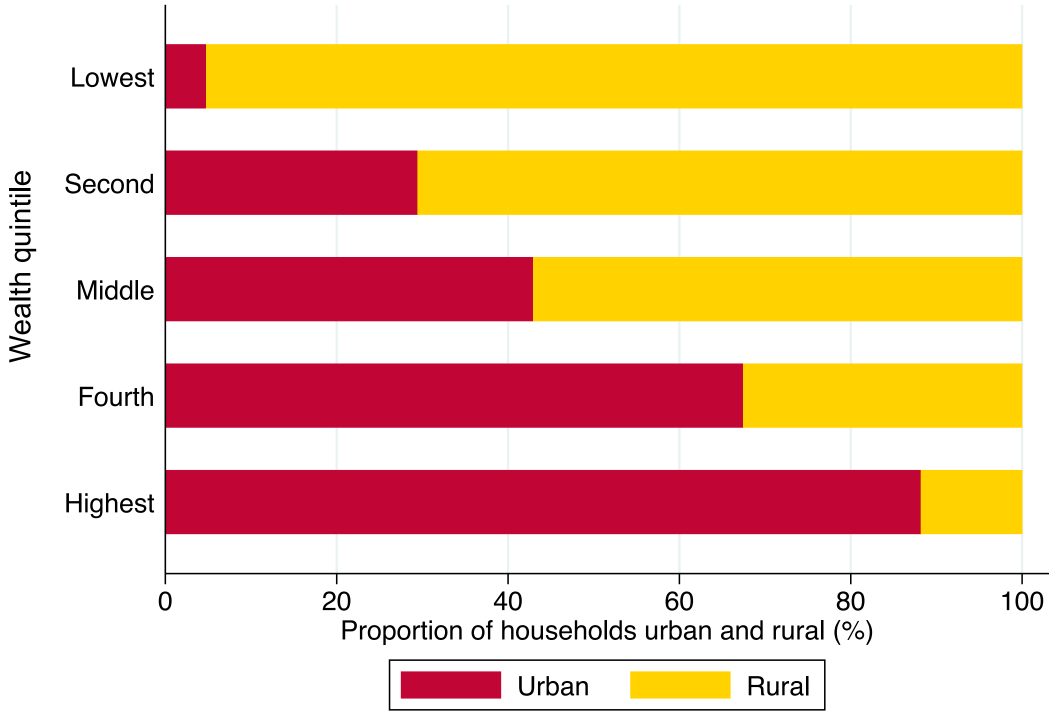


Figure 3.5: Differential distribution of urban and rural households by wealth quintile (N=9,849).

Regional differences in wealth were also observed (*p*<0.001)(**Figure 3.6B**). The wealthiest regions were Erongo, Khomas, Hardap and Karas, which are four of the most southern regions of the country. More than 45% of the households in Erongo and Khomas were in the highest wealth quintile. In Hardap and Karas, more than 30% of households were in the highest wealth quintile. The poorest regions were Kavango, Ohangwena, Zambezi and Oshikoto, with more than 47% of households in Kavango and Ohangwena being in the lowest wealth quintile. In Zambezi, 36.1% of households were in the lowest quintile and in Oshikoto 28.5% of households were in this quintile. Furthermore, in six regions (Zambezi, Kavango, Kunene, Ohangwena, Omusati and Oshikoto) more than 50% of households were in the lowest two quintiles. By contrast, in Erongo, more than 80% of households were in the highest two quintiles and in Hardap, Karas, Khomas and Otjozondjupa more than 50% were in the highest two quintiles.

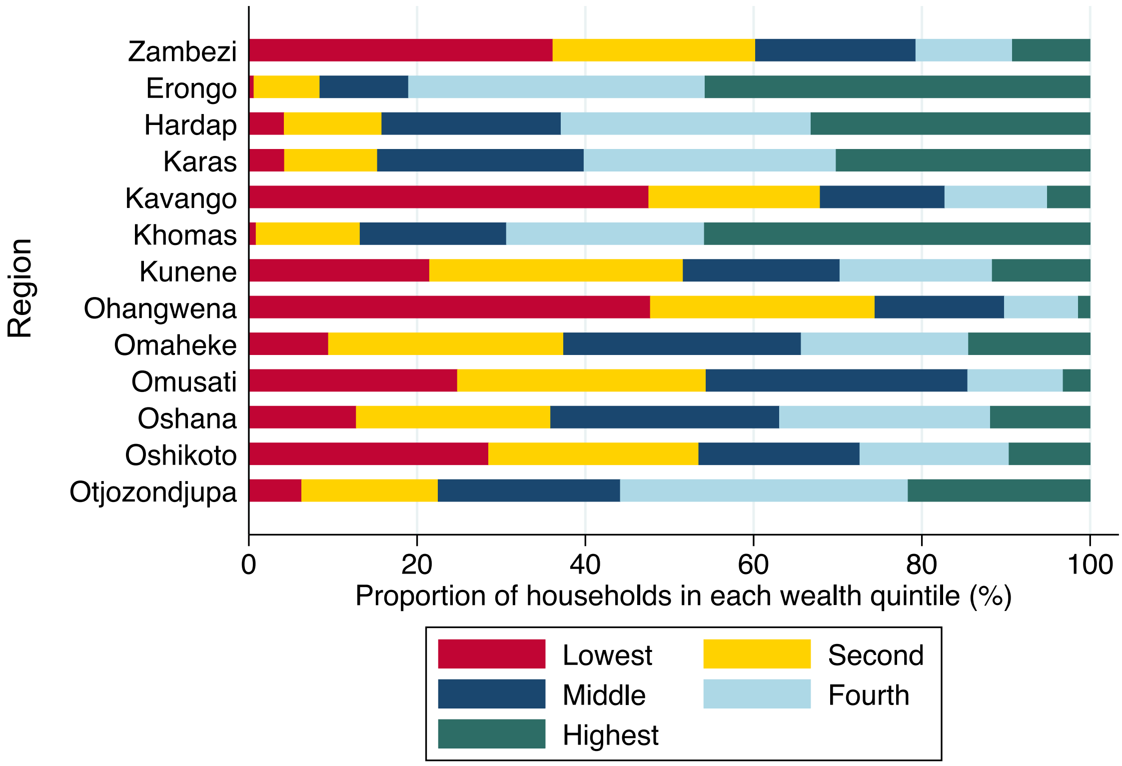


Figure 3.6: Distribution of households by wealth quintile for each region (N=9,849).

Households were also differentially distributed by residence type across regions (p<0.001)(**Figure 3.7**). Regions that were also the most wealthy (Erongo, Khomas, Hardap and Karas) were also the most urban. In Erongo and Khomas, 88.8% and 95.4% were urban, respectively. The most rural regions were Omusati (93.0% rural), Ohangwena (86.8% rural) and Oshikoto (84.0% rural). This is reflective of the regional urban-rural distribution observed in the Namibia 2011 Population and Housing Census [135].

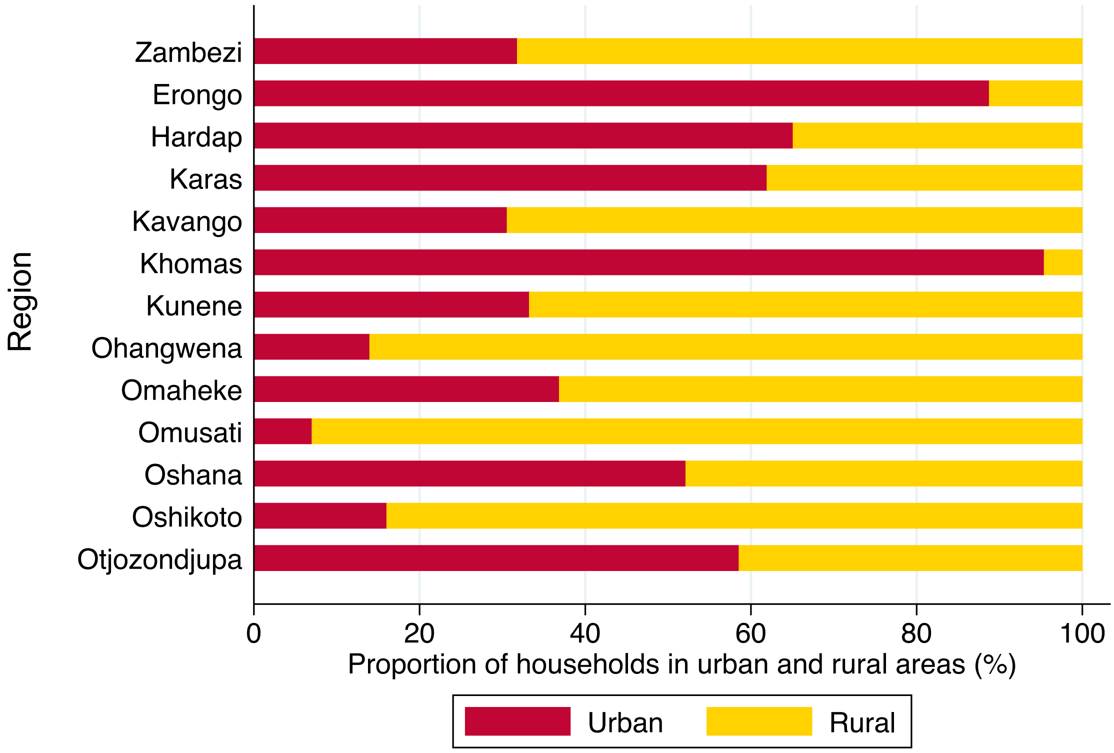


Figure 3.7: Distribution of households by residence type for each region (N=9,849).

3.3.6 Household composition

In the 9,849 households surveyed, there was an average of 4.2 (± 2.9) members per household, with a maximum number of 25 household members reported (**Table 3.4**).

Table 3.4: Household population

Total number of households	Mean number (SD) of household members	Minimum number of household members	Maximum number of household members
9,849	4.2 (2.9)	1	25

The majority of heads of households were male (57.5%), which was consistent in urban and rural areas (**Table 3.5**). Most of all, urban and rural households had 6–10 household members, followed by one household member (p<0.001).

Table 3.5: Household composition

Household composition	Urban No. (%)	Rural No. (%)	*p*	Overall No. (%)
Sex of head of household				
Male	2,800 (58.8)	2,864 (56.3)	0.016	5,664 (57.5)
Female	1,966 (41.3)	2,219 (43.7)		4,185 (42.5)
Number of household members				
1	861 (18.1)	905 (17.8)	<0.001	1,766 (17.9)
2	837 (17.6)	734 (14.4)		1,571 (16.0)
3	713 (15.0)	662 (13.0)		1,375 (14.0)
4	700 (14.7)	607 (11.9)		1,307 (13.3)
5	559 (11.7)	565 (11.1)		1,124 (11.4)
6 - 10	990 (20.8)	1,363 (26.8)		2,353 (23.9)
11 - 15	89 (1.9)	217 (4.3)		306 (3.1)
16 - 20	14 (0.3)	24 (0.5)		38 (0.4)
>20	3 (0.1)	6 (0.1)		9 (0.1)

p value corresponds to a chi-squared test

3.3.7 Household population demographics

The total number of household members listed in the Household Questionnaire was 41,646 across the 9,849 households. However, a subset of 41,611 individuals with complete information on age and sex were explored here. **Figure 3.8** shows the distribution of the household population by sex and age group. Among both men and women, the majority of the population were aged under five years and the population decreased with increasing age. This age distribution is indicative of population growth.

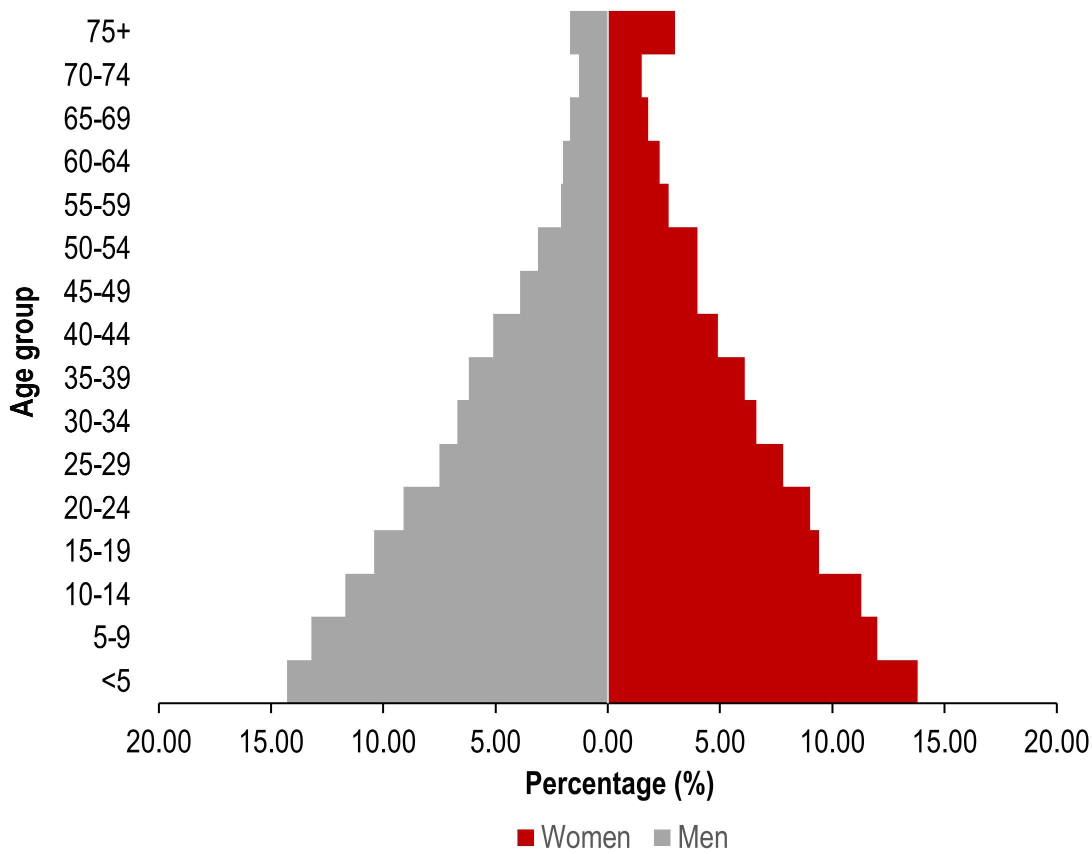


Figure 3.8: Population pyramid of household members by age and sex (n= 41,611).

A total of 41,254 individuals had information on age, sex and education, not including those who answered “don’t know” for education in the Household Questionnaire. The greatest proportion of men were educated to primary level (34.1%) and the majority of women were educated to secondary level (35.0%)(**Table 3.6**). Just 4.8% of men and 4.7% of women were educated to higher level. There was an equal distribution of men and women by wealth quintiles (19.0 – 21.5% in each quintile). There was no significant difference in the distribution of men and women by residence type (*p*=0.191).

Table 3.6: Background characteristics of the household population by sex

Sociodemographic Characteristics	Men	Women	*p*	Overall
Mean age (± SD)	24.2 (19.4)	26.2 (20.9)	<0.001	25.2 (20.2)
Education level No. (%)				
No education	5,939 (29.9)	5,923 (27.7)	<0.001	11,862 (28.8)
Primary	6,774 (34.1)	6,982 (32.6)		13,756 (33.3)
Secondary	6,188 (31.2)	7,487 (35.0)		13,675 (33.2)
Higher	950 (4.8)	1,011 (4.7)		1,961 (4.8)
Wealth quintile No. (%)				
Lowest	3,702 (18.7)	4,145 (19.4)	0.004	7,847 (19.0)
Second	4,054 (20.4)	4,237 (19.8)		8,291 (20.1)
Middle	4,250 (21.4)	4,332 (20.2)		8,582 (20.8)
Fourth	4,097 (20.6)	4,592 (21.5)		8,689 (21.1)
Highest	4,738 (18.9)	4,097 (19.1)		7,845 (19.0)
Residence type No. (%)				
Urban	8,862 (44.6)	9,692 (45.3)	0.191	18,554 (45.0)
Rural	10,989 (55.4)	11,711 (54.7)		22,700 (55.0)
Total	19,851 (100.0)	21,403 (100.0)		41,254 (100.0)

n=41,254 with information on age, sex, and education (individuals who answered don’t know for education were also excluded) | SD: standard deviation | *p* value corresponds to a chi-squared test for categorical variables and Student’s t-test for continuous variables

3.3.8 Surveyed population demographics

The populations surveyed in the Woman's and Man's Questionnaires are shown in **Figure 3.9.** A total of 10,018 women and 4,481 men aged 15–64 years were interviewed (n=14,499). The majority of both women and men were in the youngest age group: 15–19 years. The proportion of both women and men decreased with increasing age group, suggesting population growth.

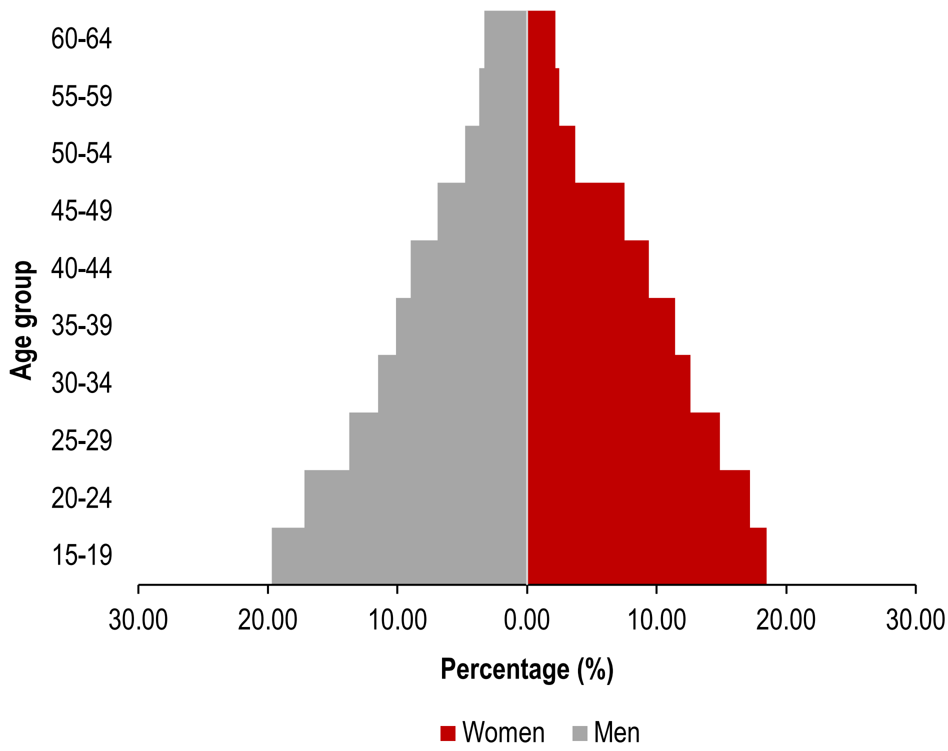


Figure 3.9: Population pyramid for individuals surveyed in the Woman's and Man's Questionnaires (n=14,499).

The majority of both men and women were educated to secondary level at 55.3% and 62.3%, respectively (**Table 3.7**). There was a slightly lower proportion of men and women in the lowest wealth quintile at 15.0% and 16.4%, respectively, with 23.2% and 23.5% in the fourth wealth quintile, respectively. There was a fairly equal distribution of men and women by residence type; a function of survey design.

Table 3.7: Background characteristics of men and women interviewed in the Man's and Woman's Questionnaires, respectively (n=14,499)

Sociodemographic Characteristics	Men	Women	*p*
Mean age (± SD)	31.9 (12.9)	31.4 (12.0)	0.016
Education level No. (%)			
No education	495 (11.1)	725 (7.2)	<0.001
Primary	1,176 (26.2)	2,300 (23.0)	
Secondary	2,478 (55.3)	6,241 (62.3)	
Higher	332 (7.4)	752 (7.5)	
Wealth quintile No. (%)			
Lowest	670 (15.0)	1,639 (16.4)	0.003
Second	866 (19.3)	1,822 (18.2)	
Middle	1,009 (22.5)	2,048 (20.4)	
Fourth	1,039 (23.2)	2,353 (23.5)	
Highest	897 (20.0)	2,156 (21.5)	
Residence type No. (%)			
Urban	2,224 (49.6)	5,163 (51.5)	0.034
Rural	2,257 (50.4)	4,855 (48.5)	
Total	4,481 (100.0)	10,018 (100.0)	

SD: standard deviation | *p* value corresponds to a chi-squared test for categorical variables and a Student's t-test for continuous variables

3.3.9 Sociodemographic characteristics of individual and household survey populations combined

By combining the Household, Woman's and Man's datasets it was possible to explore the sociodemographic characteristics of 41,646 individuals aged up to 95 years of age. Of these, 41,611 individuals had information on age and sex. The population was distributed towards the younger age groups in both men and women and the proportion of the population in each age group decreased with increasing age (**Figure 3.10**).

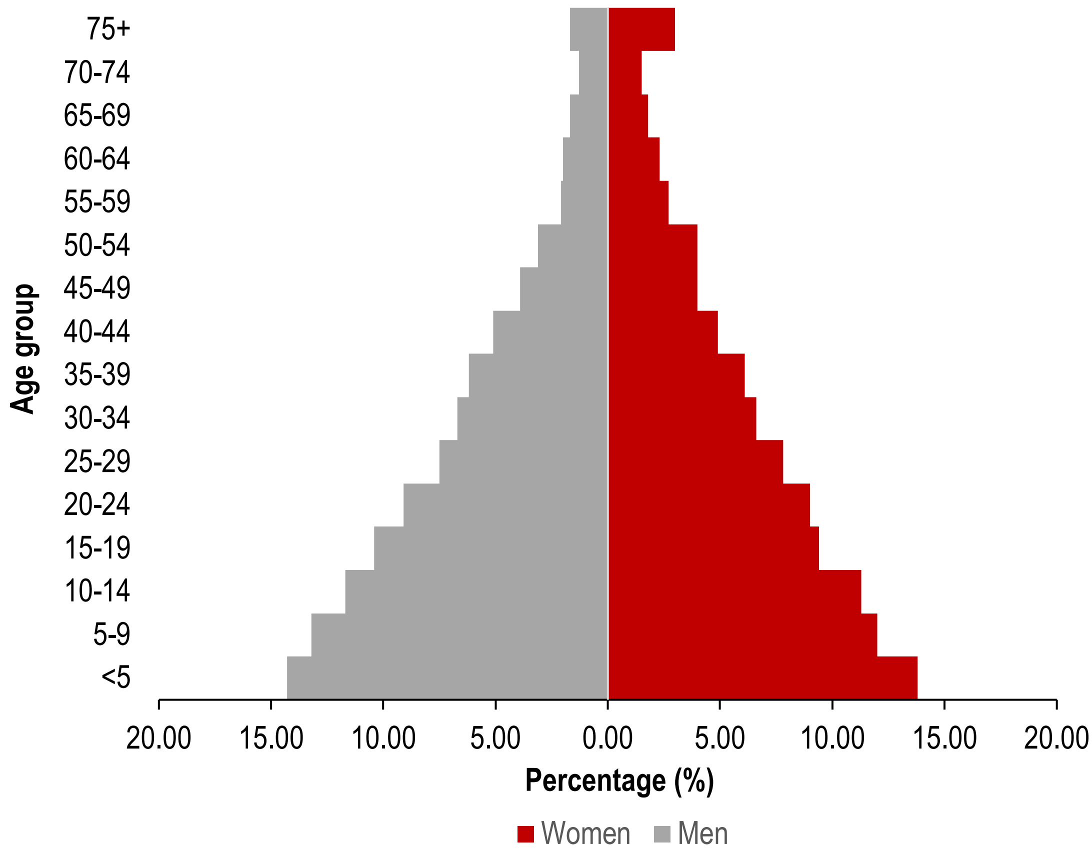


Figure 3.10: Population pyramid of the distribution of men and women by age group (n=41,611).

A total of 41,322 individuals had complete data on age, sex and education, with education corrected based on the individual survey data. The population was evenly distributed by sex, with 48.1% of the population being men and 51.9% being women (**Table 3.8**). This was also broadly reflective of the population distribution in the 2011 Population and Housing Census [135]. Around a third of the population were educated to primary and secondary level (33.2% and 33.4%, respectively), 28.7% had no education and 4.8% were educated to higher level. As expected, the population was evenly distributed by wealth quintile, with around 20% of the population in each quintile. Around half of the population was urban and rural (45.0% urban and 55.0% rural), which was again reflective of the population distribution in the 2011 Population and Housing Census (43% urban and 57% rural) [140]. Similar trends in the distribution of the population by sociodemographic factors were also observed in men and women.

Table 3.8: Sociodemographic characteristics of DHS population

Sociodemographic characteristics	Overall No. (%)	Men No. (%)	Women No. (%)	*p*
Sex				
Men	19,881 (48.1)	—	—	
Women	21,441 (51.9)	—	—	
Education level				
No education	11,863 (28.7)	5,940 (29.9)	5,923 (27.6)	<0.001
Primary	13,697 (33.2)	6,724 (33.8)	6,973 (32.5)	
Secondary	13,782 (33.4)	6,259 (31.5)	7,523 (35.1)	
Higher	1,980 (4.8)	958 (4.8)	1,022 (4.8)	
Wealth quintile				
Lowest	7,866 (19.0)	3,707 (18.7)	4,159 (19.4)	0.004
Secondary	8,302 (20.1)	4,061 (20.4)	4,241 (19.8)	
Middle	8,597 (20.8)	4,256 (21.4)	4,341 (20.3)	
Fourth	8,704 (21.1)	4,108 (20.7)	4,596 (21.4)	
Highest	7,853 (19.0)	3,749 (18.9)	4,104 (19.1)	
Residence type				
Urban	18.589 (45.0)	8,880 (44.7)	9,709 (45.3)	0.208
Rural	22,733 (55.0)	11,001 (55.3)	11,732 (54.7)	
Total	41,322 (100.0)	19,881 (100.0)	21,441 (100.0)	

n=41,322 individuals from the household, Woman's and Man's surveys combined with information on age, sex and education | *p* value corresponds to chi-squared test

The population was differentially distributed by levels of education, across wealth quintiles (p<0.001)(**Figure 3.11**). With increasing levels of wealth, the proportion of the population in each quintile that had no education and primary education reduced. Conversely, with increasing levels of wealth, the proportion of the population in each quintile with secondary and higher education increased. Simply, education levels were higher in wealthier households. This suggests a relation between education and wealth in this DHS population.

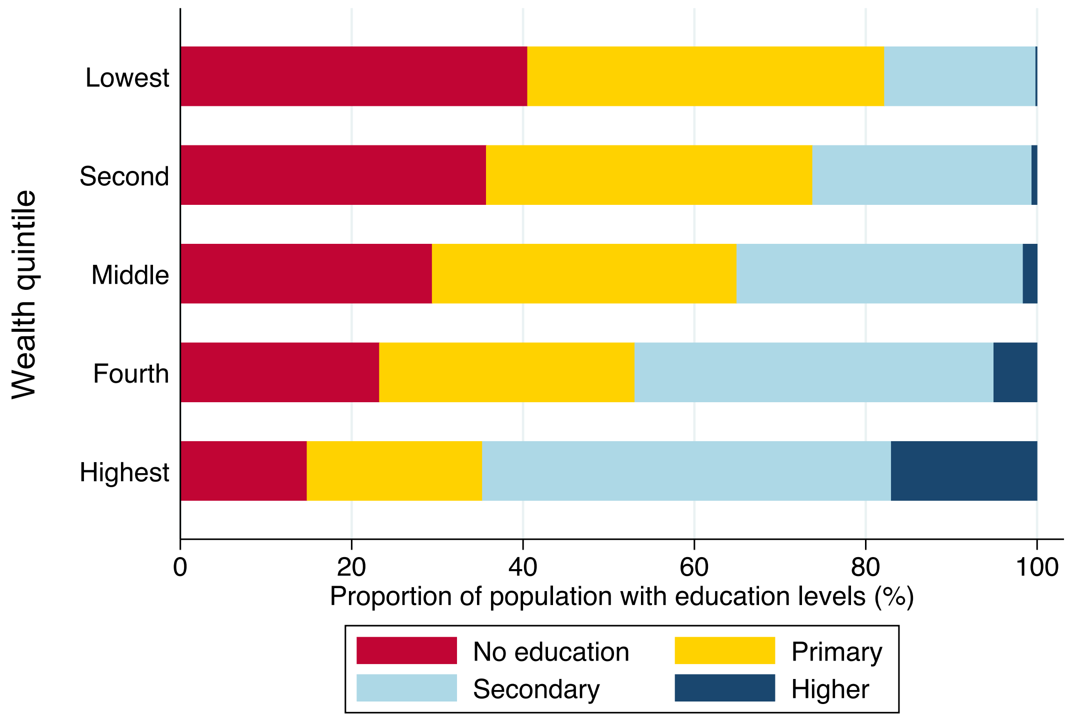


Figure 3.11: Population distribution by education within wealth quintiles (n=41,322).

As may be expected, all children under the age of five had no education and those aged 5–9 years had no education or primary education ($p<0.001$)(**Table 3.12**). The proportion of individuals with secondary education increased with age. This suggests that the proportion of the population reaching secondary education has improved over time, with younger populations having greater educational attainment. Similarly, in those aged over 15 years, the proportion of the population with no education increased with age, reaching more than 50% in those aged over 75 years compared with just 3.7% of those aged 15–19 and 5.7% of those aged 20–24 years.

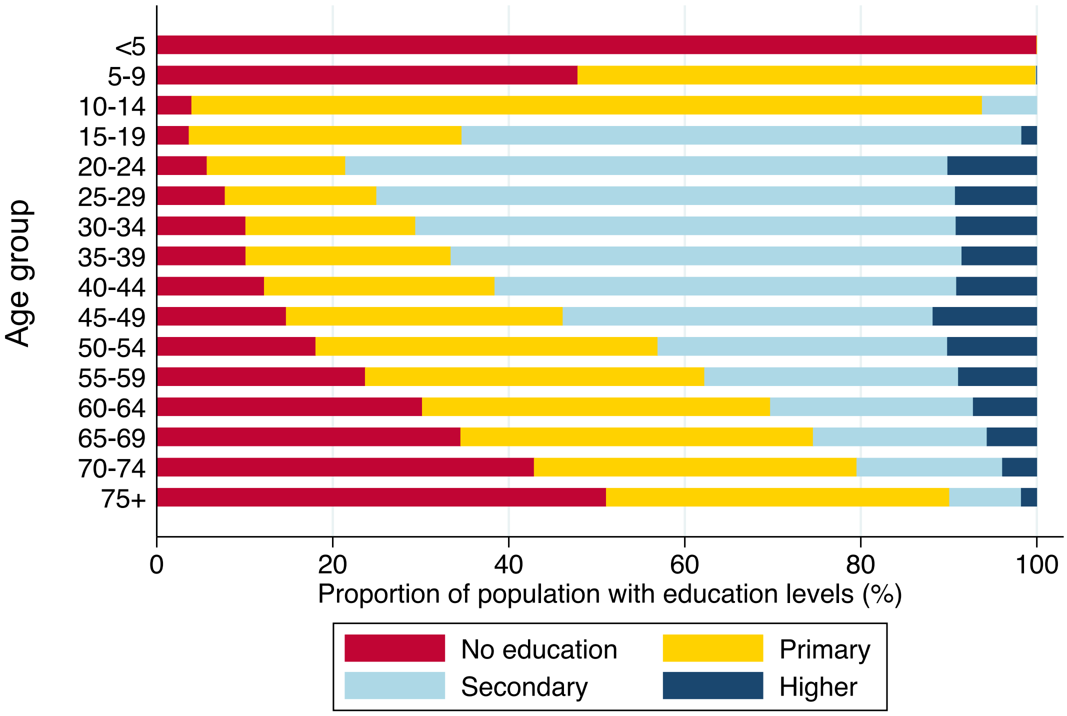


Figure 3.12: Distribution of the population by education level across age groups (n=41,300; 22 missing age information).

As education level increased, the proportion of the population that was urban increased and the proportion of the population that was rural decreased (*p*<0.001)(**Figure 3.13**). Of individuals with no education, 65.9% were rural, of those with primary education 63.6% were rural. By contrast, 58.4% with secondary education were urban and over 75% of individuals with higher education lived in urban areas. This suggests that educational attainment is greater in urban areas compared with rural areas in Namibia.

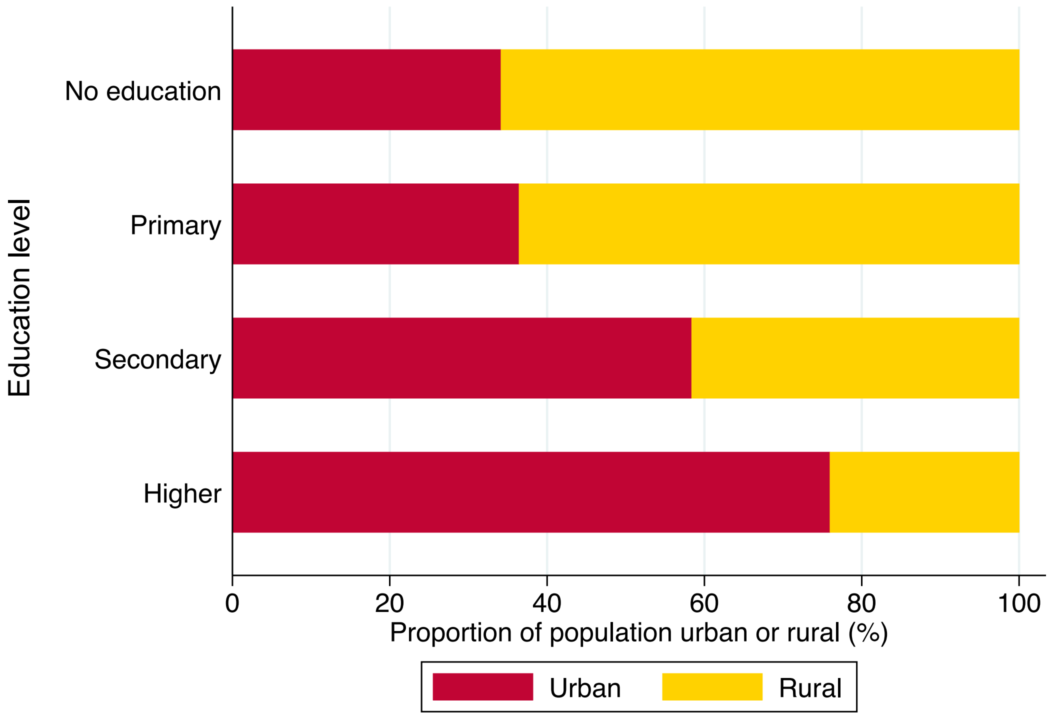


Figure 3.13: Population distribution by residence type across levels of education (n=41,322).

Regional differences in educational attainment were also observed (p<0.001). Higher education was greatest in the Khomas region (16.6%), followed by Erongo and Oshana (**Figure 3.14**). Higher education in other regions was less than 5%. Kunene had the highest prevalence of no education at 50.6%, followed by Omaheke and Kavango. These inter-regional differences in educational attainment somewhat reflect the interregional differences in wealth (**Figure 3.6**).

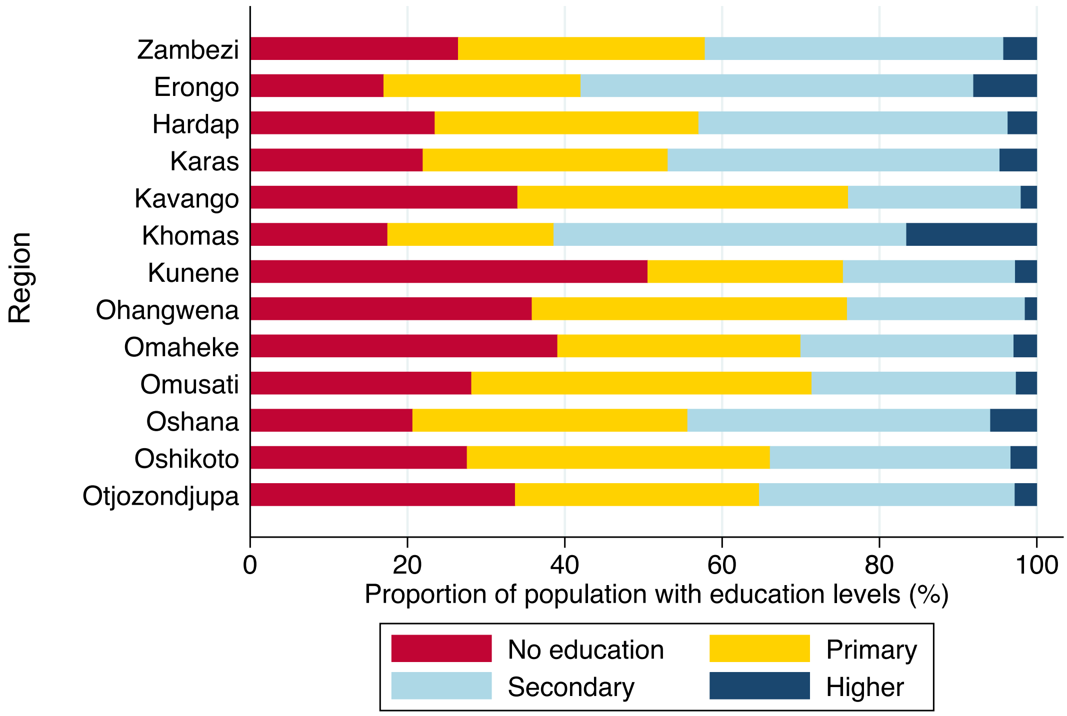


Figure 3.14: Population distribution by education across the 13 regions (n=41,322).

In a subset of 14,457 individuals who also had information on occupation, 50.3% were unemployed. Unemployment was higher in younger and older age groups (15–19 and 60–64 years) and was lowest in those aged 30–44 years (p<0.001)(**Figure 3.15**).

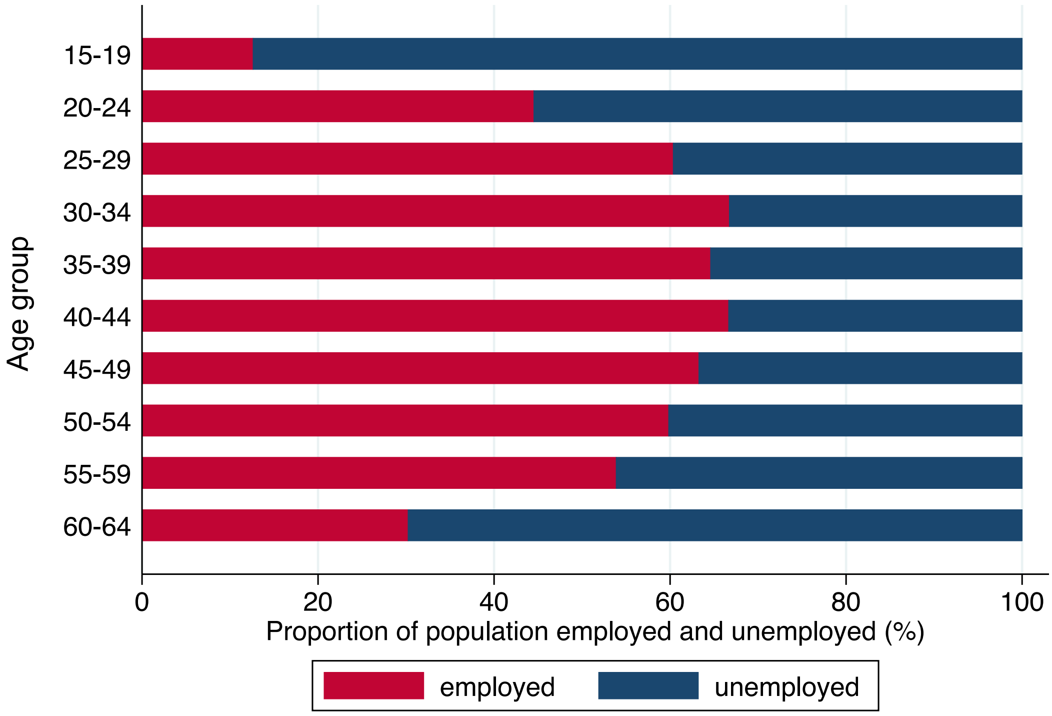


Figure 3.15: Distribution of the population by employment status across different age groups (n=14,456, n=1 dropped due to age <15 years).

Unemployment decreased the higher the level of education (p<0.001)(**Figure 3.16**). Amongst those with no education and primary education, unemployment was 58.9% and 57.2%, respectively.

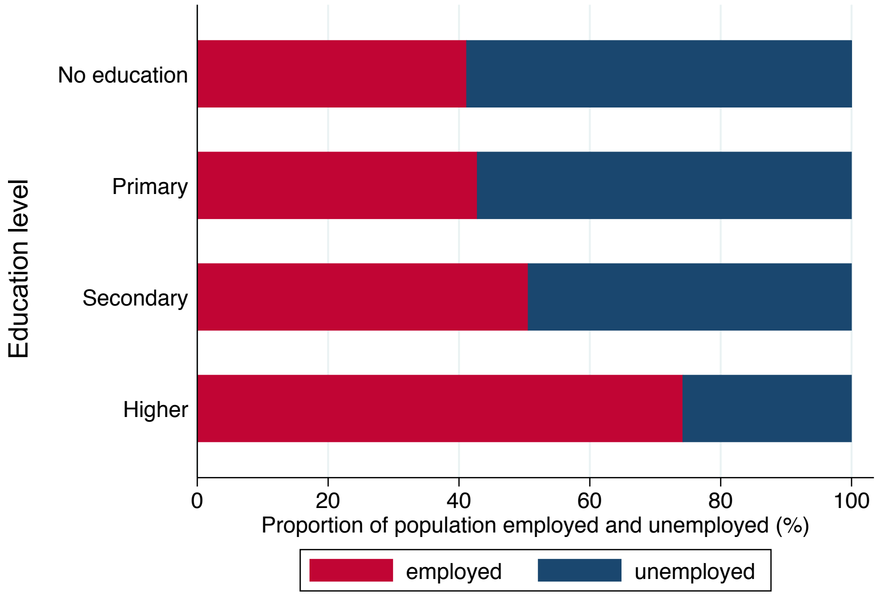


Figure 3.16: Distribution of the population by employment status across different levels of education (n=14,457).

Employment increased with higher levels of wealth with the highest unemployment in the lowest wealth quintile at 69.2% (p<0.001)(**Figure 3.17**).

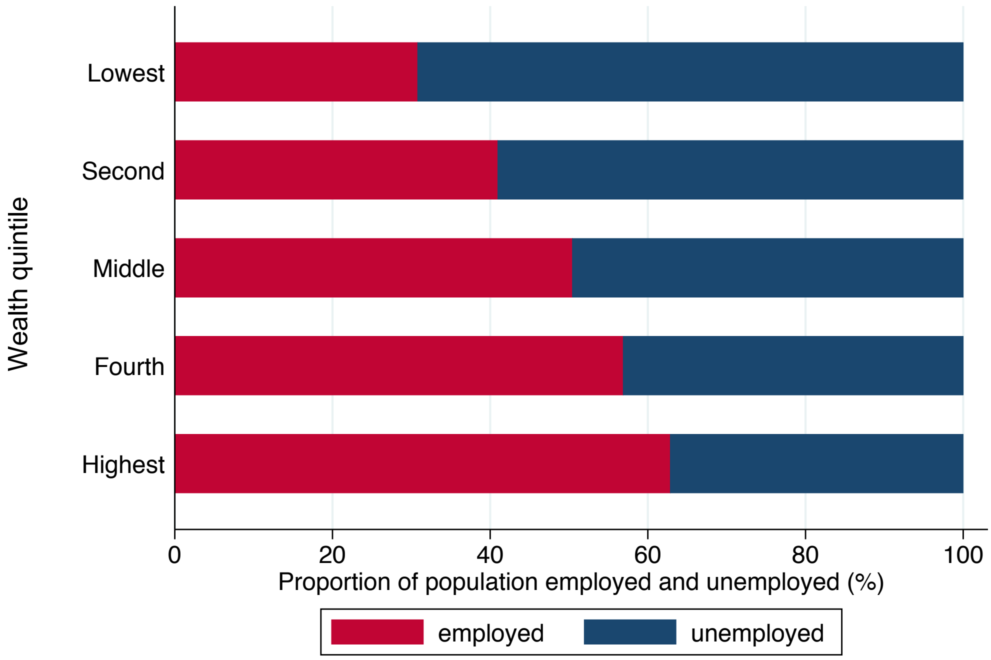


Figure 3.17: Distribution of the population by employment status across different levels of wealth (n=14,457).

Unemployment was higher in rural areas compared with urban areas (60.8% vs 40.2%, $p<0.001$). Inter-regional differences in unemployment were also observed ($p<0.001$)(**Figure 3.18**). Unemployment was highest in Omusati at 72.0%, followed by Ohangwena, Kavango and Zambezi. Conversely, employment was highest in Karas, Erongo and Khomas, again reflective of inter-regional differences in wealth.

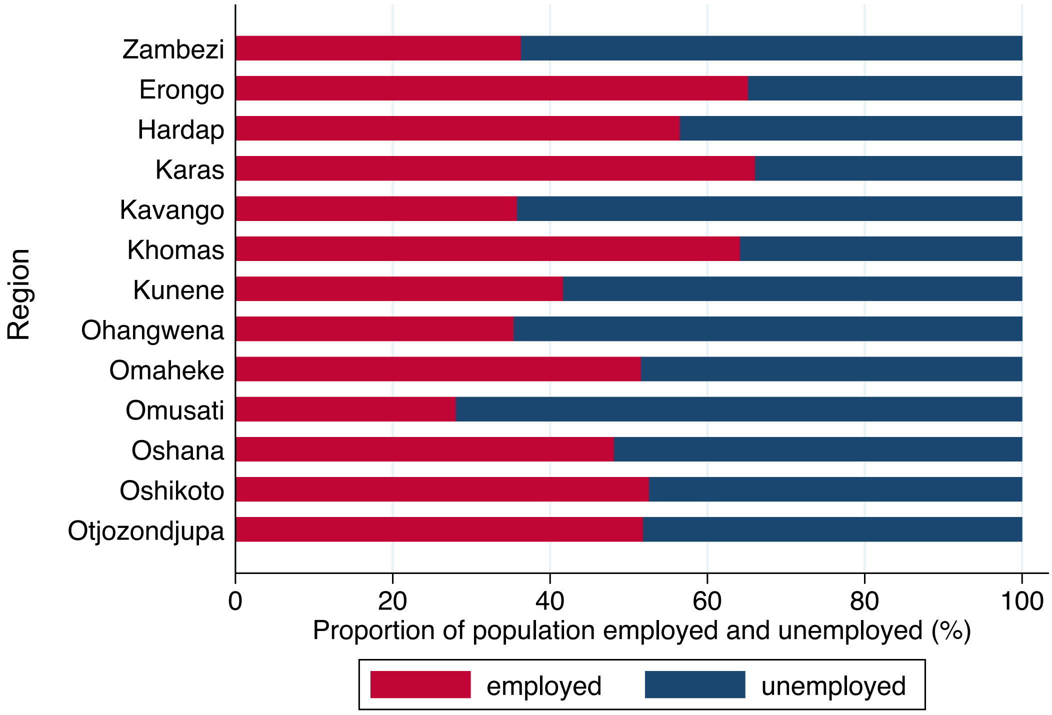


Figure 3.18: Distribution of the population by employment status across regions (n=14,457).

Additionally, I used language as a proxy for ethnicity (**Figure 3.19**). **Figures 3.20 – 3.22** show the distribution of the population in different ethnic groups by education, wealth and employment status. In this subset of 14,492 individuals, the majority of the population were in the Oshiwambo ethnic group (43.4%), with 21.3% in the "other" category, 15.2% in the Damara/Nama group and 10.9% in the Afrikaans group and 9.2% in the Herero ethnic group (**Figure 3.19**). This is reflective of population demographics in Namibia [141].

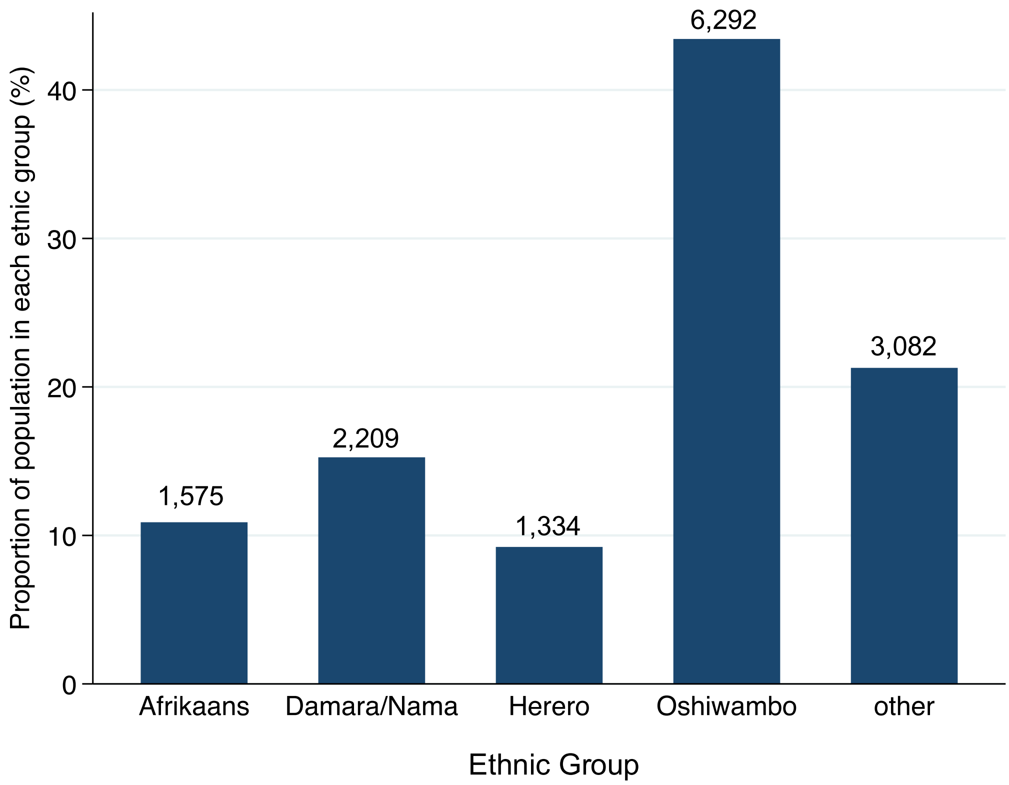


Figure 3.19: Distribution of the population by ethnic group (n=14,492). Numbers refer to number of individuals in each ethnic group.

Comparing the distribution of the population by ethnic groups for each level of education (**Figure 3.20**), the Herero population accounted for a higher proportion of those with no education and only small percentages of those with other levels of education, particularly higher education. Similarly, the Damara/Nama population accounted for 21.3% of those with no education and just 6.6% of those with higher education. By contrast, the Afrikaans population accounted for less than 2% of individuals with no education but almost 20% of the population with higher education. The distribution of the population by ethnicity amongst wealth quintiles was similar, with the exception of the Afrikaans population (**Figure 3.21**). The Afrikaans population accounted for just 0.6% of the lowest quintile but 33.1% of the population in the highest quintile.

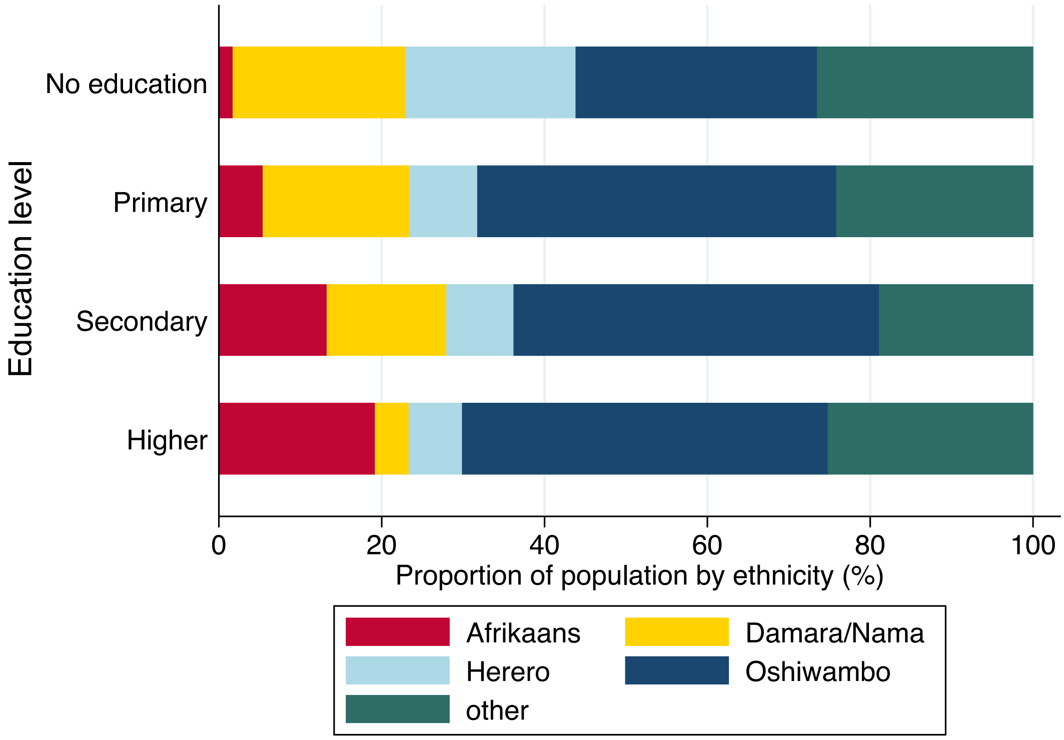


Figure 3.20: Distribution of individuals by ethnicity for each level of education (n=14,492).

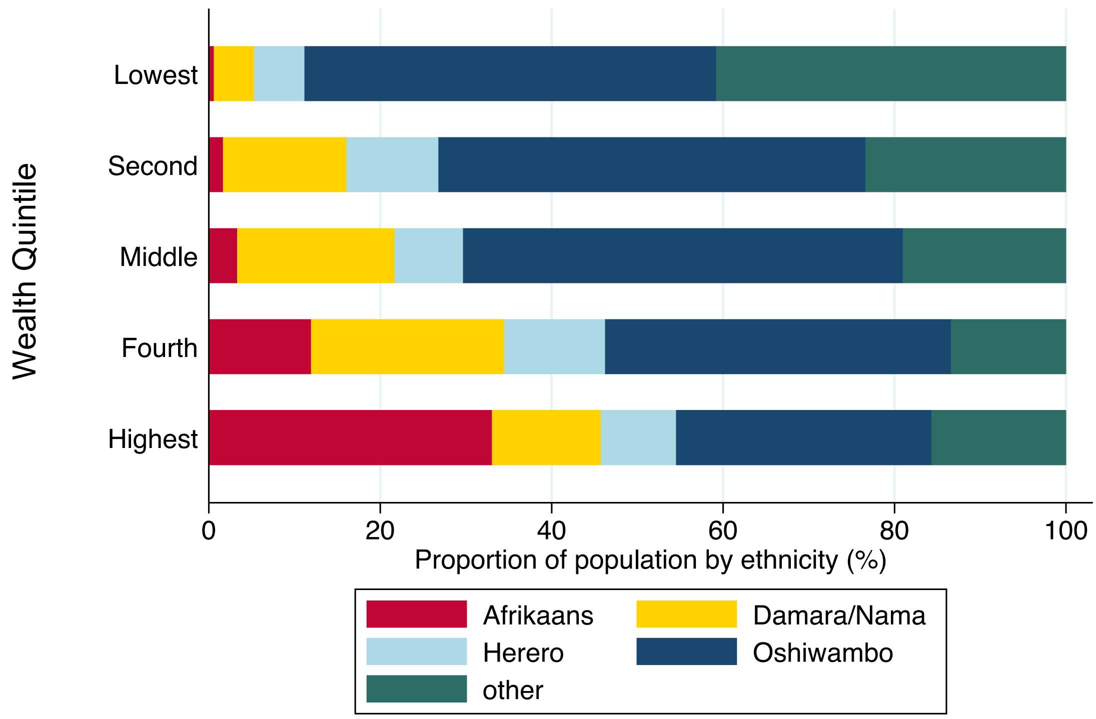


Figure 3.21: Distribution of individuals by ethnicity for each level of wealth (n=14,492).

Employment also differed by ethnic group, with 65% of the Afrikaans population employed, whilst just 43.3% of the Herero were employed. Importantly, employment was not high in any ethnic group, reflective of the country-level high unemployment rate.

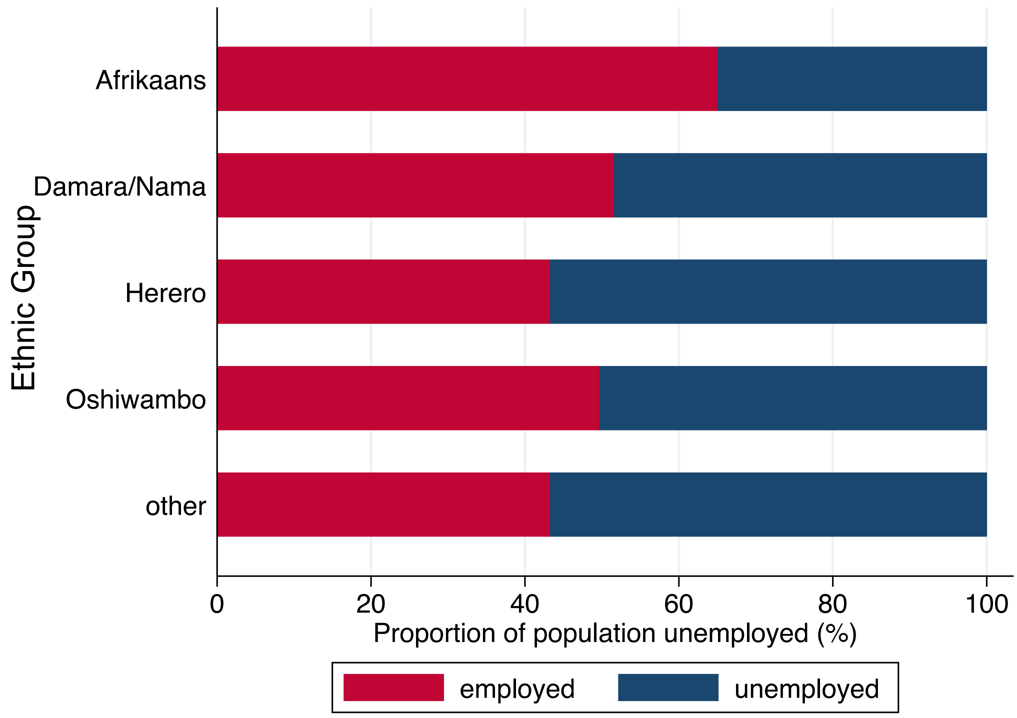


Figure 3.22: Proportion of individuals in each ethnic group employed and unemployed (n=14,492).

3.4 Discussion

Overall, the 2013 Namibia DHS provides a comprehensive, nationally-representative, large-scale dataset to explore a number of health and sociodemographic indicators. Urban-rural differences in household assets and facilities, as well as variations in household wealth and individual education level were observed. Higher levels of education were observed in wealthier and urban households and patterns of educational attainment by region were reflective of regional wealth. Employment was higher amongst more educated individuals, wealthier households and also reflected regional variations in wealth. Collectively, these findings point to socioeconomic inequalities in this Namibian population, which may be expected given the country's high income inequality, variable educational attainment and high unemployment [5, 17, 136]. It will be important to explore the impact of these socioeconomic factors in further analyses investigating the population-level determinants of healthcare access in this DHS population.

3.4.1 Sociodemographic distribution of the DHS population

Household facilities varied greatly by urban and rural residence type, with indication that urban households had better physical structure than in rural areas. In rural areas, 70.6% of households had no toilet facility and just 19.7% had piped water into the dwelling. Urban-rural differences were also observed in the context of household wealth, with urban households being predominantly wealthy compared to rural households, which were distributed towards lower wealth quintiles. This suggests that rural households were poorer than their urban counterparts and that living standards were also lower in rural areas. These findings are consistent with those of Sahn and Stifel (2004), who explored urban-rural inequality in 24 sub-Saharan African countries and found inequalities in living standards and poverty between urban and rural areas [142].

Regional differences in wealth were also observed, with Erongo, Khomas, Hardap and Karas being the most wealthy and Kavango, Ohangwena, Zambezi and Oshikoto being the poorest regions. These variations in wealth are not surprising given the high income inequality reported in the country [17]. Understanding such regional and urban-rural differences in wealth is important context for subsequent analyses in Chapters 4–8, exploring the sociodemographic determinants of health outcomes and healthcare access in Namibia.

Differences in the distribution of the population by education and wealth were also observed. Less than 5% of men and women were educated to higher level, suggesting higher educational attainment is low in Namibia. Whilst 31.2% of men and 35.0% of women reached secondary education, overall 28.8% of the population did not have any education, although this was largely in younger populations under 10 years of age and in older populations. When education was explored by age, it appeared that the level of educational attainment was greater in lower age groups (over the age of 15 years) compared with older age groups. This suggests that educational attainment has improved over time. The population distribution by education levels differed between the household survey and the individuals surveys. Whilst in the household population around a third of the population were educated to primary and secondary level, in the individual surveys, 55.3% of men and 62.3% of women were educated to secondary level. This was due to the age of the individuals surveyed (15–64 years), which excludes the populations with the highest levels of no education (those aged under 15 years and over 65 years of age). Differences in education by sex were not observed.

Educational attainment also appeared to be related to household wealth. The proportion of individuals with no education was greater the lower the household wealth quintile and, by contrast, the proportion of individuals with secondary or higher education increased the higher the wealth quintile. This suggests that wealthier populations are likely to be more educated, and vice versa. Education and wealth are inextricably linked; higher levels of education may lead to greater employment prospects and earning potential [27, 28]. Differences in education enrolment by wealth have been observed across SSA, and the situation in Namibia was similar to that observed in other southern African countries [16].

Education also differed by residence type, with the majority of those without education or just primary education belonging to rural households and the majority of those with secondary or higher education belonging to urban households. This relationship may be explained by urban-rural differences in wealth but could also be inherent to the factors that characterise urban and rural areas. For example, urban areas may have more schools available as well as shorter distances to travel to get there. Rural populations in Namibia have to travel further to reach services such as schools [143]. Urban-rural differences in education have been observed across SSA [142].

Another socioeconomic indicator explored was employment status. Half of the population with information on occupation were unemployed. This is slightly higher than other national estimates that have been reported in similar age groups [5, 136]. However, when stratified by age group, estimates were more similar to other estimates in younger age groups [136]. One reason for this could be that employed individuals may have been at work and therefore not present to take part in the survey. As response was high, the absence is unlikely to affect the results. This could also be explained by potential different classifications of retired populations. The prevalence of unemployment decreased the higher the level of wealth and education, suggesting that these factors are likely to be associated with employment. Furthermore, inter-regional differences in employment were observed and reflected regional differences in wealth. This is perhaps also representative of the urban-rural differences in employment as unemployment was higher in rural areas, and the regions with the highest unemployment were predominantly rural. Similarly, in SSA, urban populations typically have higher formal sector earnings [16].

3.4.2 Limitations

The strengths and limitations of the Namibia 2013 DHS data are outlined in **Chapter 2**. Other limitations include discrepancies between datasets. In the Household Questionnaire, the information provided on individual household members may not be accurate. Where possible, age and education information can be corrected using data collected in the individual Woman's and Man's Questionnaires. However, it is not possible to correct this information for the majority of household members.

3.4.3 Implications

Based on these findings, I expect further analyses of the DHS data to broadly reflect the geographical distribution of the population in Namibia. It is likely that outcomes of interest may differ by education, wealth and residence type due to the differential distribution of the DHS population by these sociodemographic factors. However, this is also likely to be reflective of broader socioeconomic patterns across the country. It will be important to adjust for these factors when exploring the association between other sociodemographic factors and outcomes of interest. In subsequent chapters, various subsets of the DHS population are used to explore outcomes of interest and methods for inclusion and exclusion of individuals and households are outlined in each chapter.

3.4.4 Conclusions

Overall, the 2013 Namibia DHS provides a useful resource for national-level estimates of population health outcomes and a variety of health indicators in Namibia. In this thesis, DHS data collected in Namibia in 2013 are used to explore the prevalence and distribution of health outcomes (HIV, hyperglycaemia and hypertension), the coverage of interventions for malaria, barriers to healthcare reported by Namibian women, the geographical accessibility of health facilities in the country and the coverage of health insurance in Namibian populations. Together, these analyses aim to better understand access to healthcare in Namibia, which may help to inform health service planning and provision in the country.

4. Prevalence and distribution of chronic diseases and their risk factors in Namibia

Summary

Introduction: Chronic diseases such as HIV, diabetes and cardiovascular diseases are amongst the leading causes of death in Namibia. However, the prevalence, co-morbidity and sociodemographic distribution of these disease conditions have not been well described in Namibia. A better understanding of the prevalence and distribution of these chronic conditions provides important context as to the healthcare needs of the population. Therefore, this chapter aims to explore the prevalence, distribution and determinants of HIV, hypertension and hyperglycaemia and the co- and multi-morbidity of these conditions in the 2013 Namibia DHS population.

Methods: Data on 8,406 individuals aged 15–64 years who were tested for HIV were used to explore the prevalence and determinants of HIV. Data on 3,247 individuals aged 35–64 years with blood pressure and blood glucose measurements were used to explore the prevalence and determinants of hypertension, hyperglycaemia and other proximal and distal cardiometabolic risk factors. The prevalence of co- and multi-morbidity of HIV, hypertension and hyperglycaemia was assessed in a subset of 3,172 individuals aged 35–64 years. Univariable and multivariable mixed effects Poisson regression analyses were conducted to explore the sociodemographic and behavioural factors associated with these chronic diseases.

Results: The prevalence of HIV was 13.9% (16.6% in women and 10.6% in men). Women were more likely to have HIV (RR: 1.59; 95% CI: 1.38 – 1.83; p<0.001) and those with higher education and those in the highest wealth quintiles were less likely to be HIV-positive. The prevalence of hyperglycaemia was 5.4%, whilst 36.9% of the population had hypertension. By contrast to HIV, women were less likely to be hypertensive (RR: 0.86; 95% CI: 0.78 – 0.95; p=0.002). Education and wealth were inversely associated with hypertension. Co- and multi-morbidity of HIV with hypertension and hyperglycaemia was low (HIV and hypertension: 6.1%; HIV and hyperglycaemia: 0.9%). Rural populations were less likely to have more than one chronic disease condition (RR: 0.62; 95% CI: 0.43 – 0.90; p=0.012).

Conclusion: In this DHS population, HIV and hypertension prevalence was high but the co-morbidity of these chronic diseases was low. The sociodemographic patterns of HIV and hypertension differed, with the exception of urban and less educated populations, which were at a higher risk of both conditions. Further research is needed to better understand the risk factors for co-morbidity of these chronic conditions in Namibian populations.

4.1 Introduction

Namibia is an upper-middle income country in southern Africa with a population of around 2.5 million people (2016) [7]. Whilst life expectancy has increased and under-five mortality declined between 1990 and 2016, Namibia faces a high burden of infectious and NCDs that are major contributors to death and disability in the country [34, 35]. Like many other sub-Saharan African countries, Namibia is undergoing an epidemiological transition, with a shift from infectious to non-infectious diseases [31, 47]. Understanding the prevalence, distribution and co-morbidity of infectious and NCDs, and their risk factors, provides important context on the potential demand and need for health services in Namibia. This may help to inform the planning of regional and national health service provision and resource allocation within health systems, to better manage this double burden of disease in the country.

4.1.1 HIV

HIV is the leading cause of death and disability in Namibia [34] and it is estimated that around 230,000 adults and children are living with HIV/AIDS in the country [144]. HIV is a viral infection, which results in the immunosuppression of the individual, making them vulnerable to opportunistic infections. HIV prevalence in Namibia is estimated to be 14%; as such, Namibia has the fifth highest burden of HIV, globally [37]. Tackling HIV/AIDS in Namibia is an important element of the country's Vision 2030 [1] as it poses a pertinent challenge to development, not only due to the effect of the disease on infected individuals but also the impact on their carers and other members of their household. HIV can impact on SES, whereby HIV-infected individuals and their households may lose wealth due to medical expenses or loss of income as a result of the illness [145-148]. HIV also disproportionately affects women from a biological and sociocultural perspective [149, 150]. In addition to sociodemographic risk factors, behavioural HIV risk factors have been identified in other LMICs, which include marital status, age at first sexual encounter and the number of lifetime sexual partners [151-155]. There has been limited research on the sociodemographic and behavioural determinants of HIV in Namibia to date.

4.1.2 NCDs

As well as a high burden of infectious diseases, Namibia faces a growing burden of NCDs, including cardiometabolic diseases. Cardiometabolic diseases are a set of conditions that include cardiovascular diseases, such as ischemic heart disease and metabolic disorders, such as diabetes. Cardiometabolic diseases share common proximal risk factors including hypertension, hyperglycaemia and adiposity (waist circumference and BMI) [156, 157]. Distal risk factors include physical inactivity, smoking and low fruit and vegetable consumption [158]. Furthermore, having multiple cardiometabolic risk factors has been found to increase the risk of cardiovascular disease and type 2 diabetes [156, 157].

In 2016, cardiovascular disease accounted for 21% of all deaths in Namibia and diabetes accounted for 4% [35]. Ischemic heart disease is the third leading cause of death in Namibia and diabetes is the 8th leading cause [34]. Hypertension prevalence has been estimated to be 38.0% in an urban Namibian population [159], and until a 2018 publication using DHS data, there was a lack of national prevalence estimates for hypertension [138]. Additionally, it has been estimated that around 40% of the population are overweight, 17% are obese and 30% are physically inactive [35]. There is a lack of epidemiological research exploring the prevalence and distribution of cardiometabolic risk factors in Namibian populations.

4.1.3 Double burden of disease

With a high burden of both infectious and non-communicable disease conditions, Namibia experiences a double burden of disease. Across a number of LMICs, there is evidence for the convergence of infectious diseases and NCDs in the same high-risk populations, such as rural-to-urban migrants [160-163]. This increase in co-morbidity of infectious and NCDs in SSA is facilitated by rapid urbanisation and rural-to-urban migration, which consequently results in a change in lifestyle and an increase in risk factors for both NCDs and infectious diseases [164, 165]. Such risk factors may include a transition towards sedentary lifestyles, an increase in dietary fat, sugar and salt intake, overcrowded living conditions and riskier sexual behaviours [164]. Additionally, due to antiretroviral therapy being scaled-up, the survival of people living with HIV/AIDS has increased, and these populations are at an increased risk of other chronic conditions [166].

There is also evidence for interactions between NCDs and infectious diseases. For example, diabetes has been found to increase the risk of active TB and treatment failure [167-169] and HIV has been associated with increased morbidity and mortality in individuals with cardiovascular disease, which may be modified by antiretroviral therapy [170-173]. This underscores the need to understand the double burden of disease to inform the provision of integrated care of chronic infectious and NCDs in LMICs [174]. There is a lack of existing research into the co-morbidity of infectious and non-infectious diseases in Namibian populations [138]. Chronic diseases can put a high demand on health systems due to the need for long-term management [160]. To manage the dual burden of these chronic diseases health systems in many LMICs need to be strengthened [174, 175]. Understanding the burden of these chronic disease conditions is important for health policy and planning to prevent and manage these diseases in Namibia.

4.1.4 Opportunities for research in Namibia

Understanding the sociodemographic characteristics of the sub-populations at risk is important for targeting healthcare resources and informing health system planning for the prevention and management of infectious and non-communicable chronic diseases. Given the double burden of disease in Namibia, this chapter explores the prevalence and distribution of HIV, hyperglycaemia and hypertension and the sociodemographic factors associated with these conditions as well the co-morbidity of these chronic diseases.

The aims of this chapter are:

i. To explore the prevalence and distribution of selected chronic infectious and non-infectious diseases and their risk factors in the Namibian DHS population;
ii. To estimate the co-morbidity and multi-morbidity of HIV, hyperglycaemia and hypertension in this Namibian DHS population.
iii. To assess the sociodemographic and behavioural factors associated with HIV, hyperglycaemia and hypertension and having more than one chronic disease or risk factor.

4.2 Methods

4.2.1 Data sources

The methods of the 2013 Namibia DHS have been described elsewhere [176] and in **Chapter 2**. In summary, the 2013 Namibia DHS interviewed 9,849 households with a total population of 41,646 individuals. All households took part in the Household Questionnaire and women aged 15–49 were eligible for the Woman's Questionnaire. In half of DHS households (n=4,917), men aged 15–64 were eligible for the Man's Questionnaire and women aged 50–64 were eligible for the Woman's Questionnaire. In this same half of households, women and men aged 15–64 years were eligible to have their height and weight measured and were tested for HIV and anaemia. In these households, women and men aged 35–64 were eligible to have their blood pressure and blood glucose measured.

This chapter includes three separate analyses. The first explores the prevalence, distribution and determinants of HIV, the second investigates the prevalence, distribution and determinants of hyperglycaemia and hypertension and the third assesses co- and multi-morbidity of HIV, hyperglycaemia and hypertension.

The HIV analysis used data on a subset of 8,406 men and women aged 15–64 who were tested for HIV and had information on age, sex, education, wealth, occupation, residence type, marital status, number of lifetime sexual partners and age at first sexual encounter (**Figure 4.1**).

To explore the prevalence and determinants of hypertension and hyperglycaemia, a subset of 3,247 individuals who had height and weight, blood pressure and fasting plasma glucose measurements and who had data on age, sex, education, wealth, residence type were included (**Figure 4.1**). All of these individuals also had information on fruit and vegetable intake. Of these 3,247 individuals, 90 (2.8%) did not have information on smoking.

To explore co-morbidity and multi-morbidity of chronic diseases in Namibia, data on 3,172 individuals aged 35–64 years, with data on HIV status, hyperglycaemia and hypertension were used. A subset of 3,144 individuals (99.1%) had data on BMI and fruit and vegetable intake and were explored in multivariable analyses.

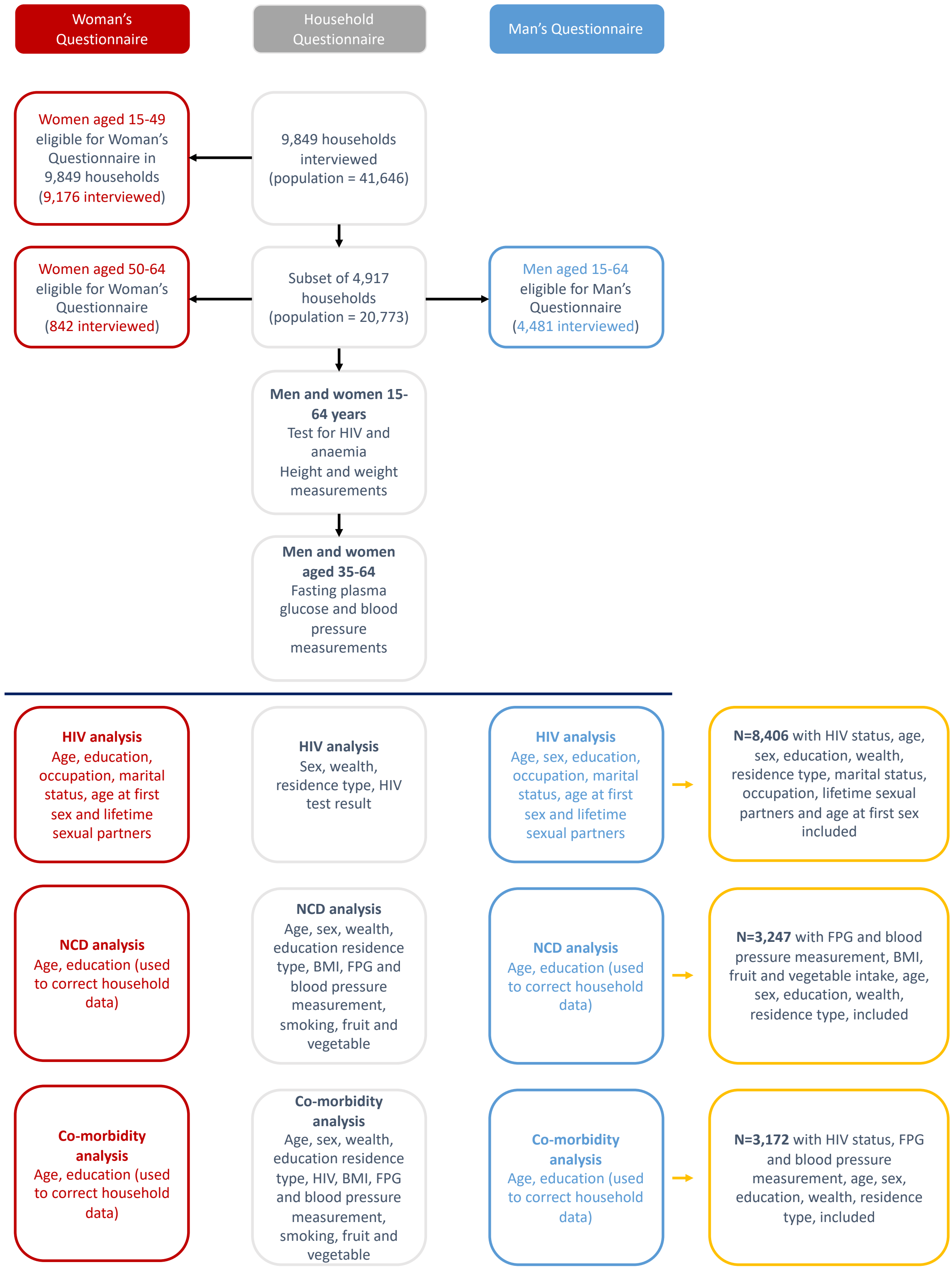


Figure 4.1: Flow chart showing the selection of households and individuals for the 2013 Namibia DHS and the inclusion criteria for each analysis presented in this chapter. BMI: body mass index | FPG: fasting plasma glucose | HIV: human immunodeficiency virus | NCD: non-communicable disease.

4.2.2 Definitions

Sociodemographic and behavioural risk factor information was based largely on self-reported measures. Sociodemographic factors included age, sex, education level, wealth quintile and residence type (urban or rural). Education level reflects the highest level of education attended [137], but does not necessarily mean that the level of education was completed.

HIV positive individuals were defined as those individuals who tested positive for HIV following a HIV test carried out as part of the DHS survey (detailed in **Chapter 2**). Sociodemographic factors assessed included sex, age, education, wealth, residence type and occupation. Behavioural factors included were age at first sexual encounter, the number of lifetime sexual partners and marital status.

BMI in Kg/m^2 was used as a measure of total body obesity. BMI was previously calculated from height and weight measurements collected as part of the DHS. Overweight as defined as 25–29.9 Kg/m2 and obesity was defined as ≥30 Kg/m^2 [177]. Hypertension was defined as a systolic blood pressure of ≥140 mmHg and/or a diastolic blood pressure of ≥90 mmHg. Hyperglycaemia was defined as fasting plasma glucose (FPG) measurement ≥7 mmol/L [178]. In additional analyses, those who had previously been told they had high blood sugar or diabetes were included in the definition of hyperglycaemia. The relevant results are presented in **Appendix 4**.

The quantifiable behavioural cardiometabolic risk factors available included smoking and low fruit/vegetable intake. Current smokers were classified as individuals who had smoked tobacco in the last 24 hours. Low fruit and vegetable intake was classified as consumption of less than five portions of fruit or vegetables per day on average.

I further explored the clustering of potential determinants of hypertension and hyperglycaemia. For hyperglycaemia, risk factors included hypertension, obesity, low fruit and vegetable intake and smoking. For hypertension, risk factors included hyperglycaemia, obesity, low fruit and vegetable intake and smoking.

Additionally, I explored the co-morbidity of HIV, hypertension and hyperglycaemia. Four scenarios were assessed: the co-morbidity of hypertension and hyperglycaemia; the co-morbidity of HIV and hypertension; the co-morbidity of HIV and hyperglycaemia and the multi-morbidity of HIV, hypertension and hyperglycaemia. Estimates were based on HIV-positive test results, FPG ≥7 mmol/L for hyperglycaemia and a systolic blood pressure of ≥140 mmHg and/or a diastolic blood pressure of ≥90 mmHg for hypertension.

4.2.3 Statistical analyses

Frequency and percentage distributions are reported for HIV, hypertension and hyperglycaemia. The distributions were assessed using a chi-squared test for categorical variables and a Student's t-test for continuous variables. All analyses were performed using Stata version 14 software package (StataCorp: College Station, TX, USA). To explore the prevalence and distribution of HIV, hypertension and hyperglycaemia, the HIV, Household, Woman's and Man's datasets were combined.

HIV

The corrected age variable (where age from the household survey was corrected in line with age reported in the individual surveys, where possible) was recoded into five-year groups, with those aged 50–64 categorised into one category. Occupation was recoded into unemployed, professional, agricultural, manual and other working status. Professional occupational status included those classed as working in technical, managerial, clerical, sales and services jobs. The "number of lifetime sexual partners" variable was recoded into those who had none, one, more than one and didn't know the number of sexual partners. The "age at first sex" variable was recoded into those who had never had sex, were under 15 years of age, were aged 15–19 years and were aged 20 years and over at the time of first sexual activity. Marital status from the individual surveys (Woman's and Man's Questionnaires) was recoded to group those who were divorced, widowed or no longer living with their partner into one category labelled "formerly/ever married".

Intraclass correlation coefficients (ICCs) were used to assess clustering of HIV status and each sociodemographic and behavioural risk factor at the household, EA and regional level. Poisson regression analyses were conducted to investigate the association between sociodemographic and behavioural factors and HIV. In Model 1, the univariable association between each exposure and HIV was assessed. In Model 2, household, EA and region were added as mixed effects to account for clustering at these levels. In Model 3, a multivariable mixed effects analysis was conducted, which adjusted for all sociodemographic and behavioural risk factors as well as household, EA and regional clustering. In Model 2 and Model 3, 95% confidence intervals (95% CIs) were generated using cluster-robust standard errors.

NCDs

When exploring the prevalence and distribution of cardiometabolic risk factors, variables for overweight, obesity, smoking and low fruit and vegetable consumption were created according to the definitions set out in section 4.2.2. The age variable was recoded into five-year groups using the corrected age from the individual surveys (Woman's and Man's Questionnaires). Although these measurements were to be carried out in individuals aged 35–64 years [120], the corrected age indicated that 7 individuals in this subset of the DHS population were aged 34 years. As these individuals had data pertaining to cardiometabolic risk factors, blood glucose and blood pressure measurements, they were included in these analyses.

I further explored the clustering of risk factors within individuals, including obesity, smoking and low fruit and vegetable intake. The prevalence of hyperglycaemia and hypertension were explored by the number of risk factors: none, one, two, three or four. Intraclass correlation coefficients (ICCs) were calculated to assess the clustering of continuous and categorical risk factors at the household, EA and regional level.

Poisson regression analyses were conducted to investigate the association between sociodemographic and behavioural factors and hyperglycaemia and hypertension, respectively. In Model 1, the univariable association between each risk factor and hyperglycaemia and hypertension was explored. In Model 2, household, EA and region were added as mixed effects to account for clustering at these levels. In Model 3, in a subset of 3,157 individuals with information on smoking, a multivariable mixed effects analysis was conducted, which adjusted for all sociodemographic and behavioural risk factors as well as household, EA and regional clustering. In Model 2 and Model 3, 95% confidence intervals (95% CIs) were generated using cluster-robust standard errors.

Co-morbidity and multi-morbidity

Additionally, I explored the co-morbidity of HIV, hyperglycaemia and hypertension in a subset of 3,173 individuals with complete data (**Figure 4.1**). I first assessed the co-morbidity of hyperglycaemia and hypertension. Second, I explored the co-morbidity of HIV with hyperglycaemia and hypertension respectively, and finally I explored the prevalence of the multi-morbidity of HIV, hyperglycaemia and hypertension.

In a subset of 3,144 individuals with complete data on HIV, hyperglycaemia, hypertension, BMI and fruit and vegetable intake, Poisson regression analyses were conducted to explore the association between sociodemographic and selected behavioural risk factors and having more than one chronic disease condition. A binary variable was created whereby individuals were categorised according to whether they had ≤1 (one or no) chronic disease condition (HIV, hypertension or hyperglycaemia) or >1 condition. In Model 1, the univariable association of age, sex, education, wealth, residence type, obesity level, fruit and vegetable intake and smoking with having more than one chronic disease was explored. In Model 2, household, EA and region were added as mixed effects to account for clustering at these levels. Model 3, which included a subset of 3,061 individuals with information on smoking, was additionally adjusted for all other risk factors as well as household EA and regional clustering in a multivariable mixed effects model.

In additional analyses (**Appendix 3**), I used language as proxy for ethnicity by recoding the variable for the main language spoken in the home into five groups: Afrikaans, Damara/Nama, Herero, Oshiwambo and "other", which included small populations of English, San, Kwagali and Lozi. In these additional analyses I explored the prevalence of HIV, hypertension and hyperglycaemia by ethnicity and the association between ethnicity and these chronic disease outcomes.

Spatial representations of regional prevalence estimates were generated in QGIS 2.14.1. Shapefiles of administrative boundaries for Namibia were obtained via DIVA GIS [139]. All maps presented in this chapter are displayed in CRS WGS84 therefore scale bars are approximate.

4.3 Results

4.3.1 Completeness of HIV data

A total of 11,689 individuals aged 15–64 years in 4,917 households were eligible for HIV testing. Of these individuals, 9,309 (79.6%) were tested for HIV, 44.1% of which were men and 56.0% were women (**Table 4.1**). An additional 2,380 individuals (20.4%) eligible for HIV testing were not tested because they were not present, refused, the sample was not tested, lost, damaged or insufficient or for other reasons. The reason for not having an HIV conducted was unknown for 502 individuals with missing data.

Table 4.1: The proportion of individuals who did and did not have a blood sample tested for HIV by sex (n=11,689)

HIV test outcome	**Men** No. (%)	**Women** No. (%)	***p***	**Overall** No. (%)
Tested (blood taken)	4,101 (44.1)	5,208 (56.0)	<0.001	9,309 (79.6)
Not tested	1,411 (59.3)	969 (40.7		2,380 (20.4)
Not present	523 (63.9)	295 (36.1)		818 (7.0)
Refused	530 (55.6)	424 (44.4)		954 (8.2)
Sample not tested*	6 (60.0)	4 (40.0)		10 (0.1)
Other	57 (59.4)	39 (40.6)		96 (0.8)
Missing	295 (58.8)	207 (41.2)		502 (4.3)

*not tested, lost, damaged or insufficient | *p* value corresponds to a chi-squared test for HIV test outcome by sex

Of the eligible individuals who did not have an HIV test (n=2,380), the most common reason for not having an HIV test was that the respondent refused (40.1% overall), followed by the fact that the participant was not present at the time of sampling (34.4% overall)(**Figure 4.2**). The reasons a HIV test was not conducted were similar in men and women.

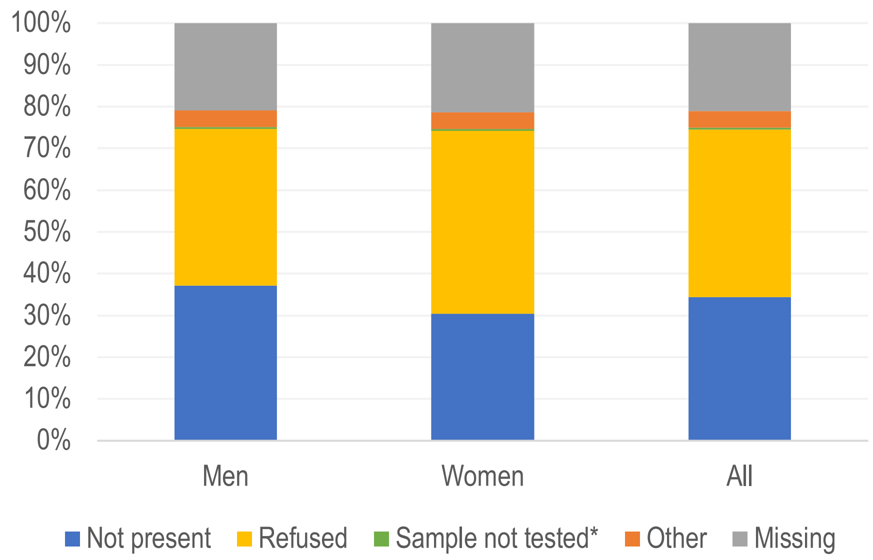


Figure 4.2: Reason HIV sample was not tested in men and women (n=2,380) | * Sample not tested, lost, damaged or insufficient.

4.3.2 Distribution of the population tested for HIV by sociodemographic factors

A subset of 8,406 eligible and tested individuals with complete data on HIV status, sociodemographic and behavioural factors of interest were included in the subsequent analyses. **Table 4.2 and 4.3** show the population distribution by sociodemographic and behavioural risk factors for HIV. In this population, 54.9% were women and 51.4% lived in rural areas (**Table 4.2**). The population size decreased with increasing age group (19.3% aged 15–19 to 6.6% aged 45–49 years). The majority of the population was educated to secondary level (58.4%). Of this population, 24.1% were in the fourth wealth quintile and 16.0% were in the lowest wealth quintile. Almost half the population were unemployed (48.8%) and 32.8% were in professional employment. Similar sociodemographic trends were observed between men and women.

Table 4.2: Population distribution by sociodemographic risk factors for HIV

Sociodemographic factors	Overall No. (%)	Men No. (%)	Women No. (%)	*p*
Sex				
Men	3,793 (45.1)	—	—	
Women	4,613 (54.9)	—	—	
Age group				
15 – 19	1,619 (19.3)	782 (20.6)	837 (18.1)	0.148
20 – 24	1,434 (17.1)	643 (17.0)	791 (17.2)	
25 – 29	1,170 (13.9)	527 (13.9)	643 (13.9)	
30 – 34	975 (11.6)	424 (11.2)	551 (11.9)	
35 – 39	891 (10.6)	388 (10.2)	503 (10.9)	
40 – 44	706 (8.4)	322 (8.5)	384 (8.3)	
45 – 49	558 (6.6)	255 (6.7)	303 (6.6)	
50+	1,053 (12.5)	452 (11.9)	601 (13.0)	
Education level				
No education	779 (9.3)	437 (11.5)	342 (7.4)	<0.001
Primary	2,191 (26.1)	1,037 (27.3)	1,154 (25.0)	
Secondary	4,906 (58.4)	2,070 (54.6)	2,836 (61.5)	
Higher	530 (6.3)	249 (6.6)	281 (6.1)	
Wealth quintile				
Lowest	1,345 (16.0)	593 (15.6)	752 (16.3)	0.003
Second	1,626 (19.3)	768 (20.3)	858 (18.6)	
Middle	1,844 (21.9)	885 (23.3)	959 (20.8)	
Fourth	2,026 (24.1)	877 (23.1)	1,149 (24.9)	
Highest	1,565 (18.6)	670 (17.7)	895 (19.4)	
Occupation				
Professional	2,760 (32.8)	1,048 (27.6)	1,712 (37.1)	<0.001
Agricultural	469 (5.6)	382 (10.1)	87 (1.9)	
Manual	1,078 (12.8)	903 (23.8)	175 (3.8)	
Unemployed	4,099 (48.8)	1,460 (38.5)	2,639 (57.2)	
Residence type				
Urban	4,083 (48.6)	1,796 (47.4)	2,287 (49.6)	0.042
Rural	4,323 (51.4)	1,997 (52.7)	2,326 (50.4)	
Total	8,406 (100.0)	3,793 (100.0)	4,613 (100.0)	

P value corresponds to a chi-squared test

The majority of the population had never been married (56.6%), 20.0% were currently married, 16.2% lived with their partner and 7.2% were formerly married (**Table 4.3**). The majority of the population had more than one sexual partner in their lifetime (66.3%) and 12.6% of the population had never had a sexual partner. Just over half of the population were aged between 15 and 19 years at their first sexual encounter (57.6%), 22.6% were aged over 20, and 7.3% were younger than 15 years of age. Similar trends were observed between men and women.

Table 4.3: Population distribution by behavioural risk factors for HIV

Behavioural factors	**Overall** No. (%)	**Men** No. (%)	**Women** No. (%)	***p***
Marital status				
Never married	4,775 (56.6)	2,267 (59.8)	2,488 (53.9)	<0.001
Currently married	1,680 (20.0)	801 (21.1)	879 (19.1)	
Living with partner	1,362 (16.2)	576 (15.2)	786 (17.0)	
Formerly/ever married	609 (7.2)	149 (3.9)	460 (10.0)	
Lifetime sexual partners				
None	1,056 (12.6)	542 (14.3)	514 (11.1)	<0.001
1	1,517 (18.1)	412 (10.9)	1,105 (24.0)	
>1	5,575 (66.3)	2,634 (69.4)	2,941 (63.8)	
Don't know	258 (3.1)	205 (5.4)	53 (1.2)	
Age at first sex				
Never had sex	1,056 (12.6)	542 (14.3)	514 (11.1)	<0.001
<15 years	610 (7.3)	386 (10.2)	224 (4.9)	
15 – 19 years	4,834 (57.6)	2,125 (56.2)	2,781 (58.9)	
20+ years	1,897 (22.6)	740 (19.5)	1,157 (25.1)	
Total	8,406 (100.0)	3,793 (100.0)	4,613 (100.0)	

P value corresponds to a chi-squared test

4.3.3 Prevalence and distribution of HIV

The prevalence of HIV in this DHS population was 13.9%; 10.6% in men and 16.6% in women (**Table 4.4**). Following adjustment for age and sex, these prevalence estimates were unchanged. Further adjustment for household, EA and regional clustering resulted in a reduction in the prevalence of HIV to 13.0% overall, 10.2% in men and 15.5% in women.

Table 4.4: Crude and adjusted prevalence of HIV

	Overall (n=8,406) % (95% CI)	Men (n=3,793) % (95% CI)	Women (n=4,613) % (95% CI)
Crude	13.9 (13.2 – 14.7)	10.6 (9.7 – 11.7)	16.6 (15.5 – 17.7)
Adjusted for age (and sex)	13.9 (13.1 – 14.7)	10.6 (9.6 – 11.7)	16.6 (15.4 – 17.8)
Adjusted for age, (sex) and clustering*	13.0 (10.4 – 15.7)	10.2 (8.3 – 12.1)	15.5 (12.0 – 19.1)

Adjusted for sex only in overall models
*clustering at the household, enumeration area and regional level
95% CI: 95% confidence interval

4.3.4 Regional prevalence of HIV

Inter-regional variations in the prevalence of HIV were observed (**Figure 4.3**). HIV was most prevalent in the northern regions (Omusati, Oshana, Oshikoto, Ohangwena, Kavango and Zambezi). Zambezi had the highest prevalence at 24.7%, with the lowest prevalence in Hardap (7.7%).

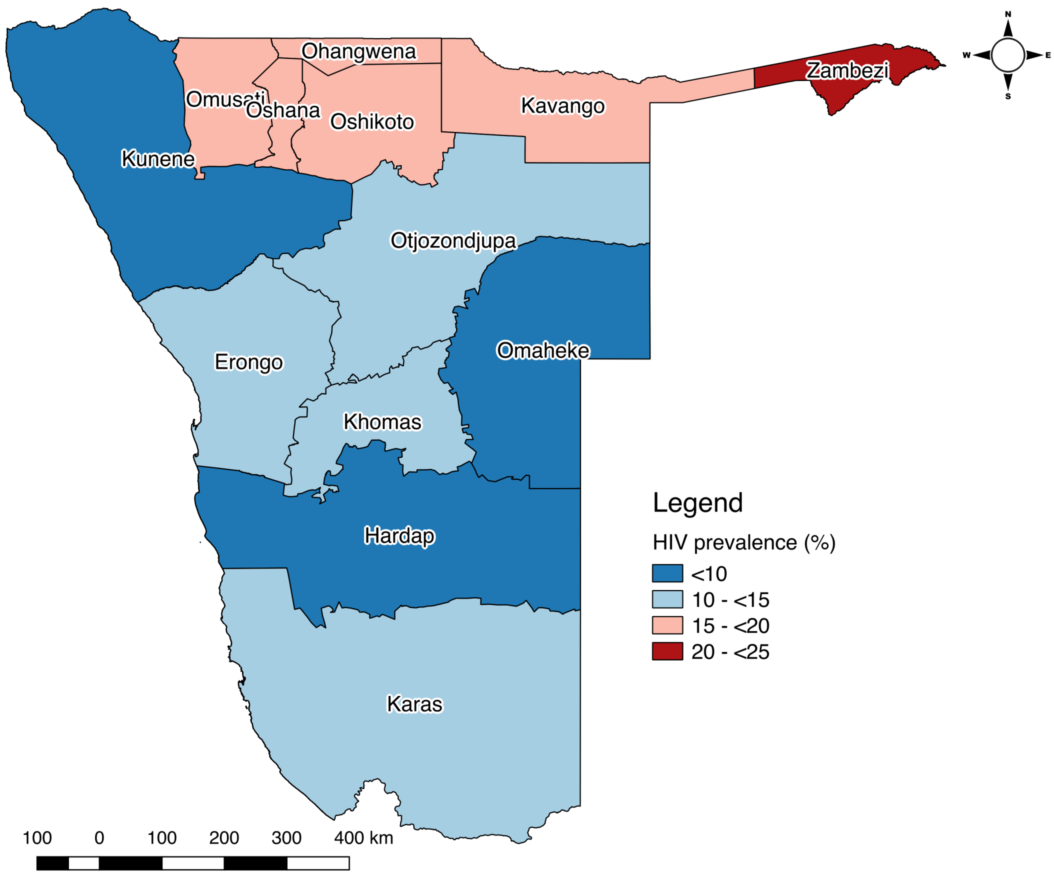


Figure 4.3: Regional prevalence of HIV in the DHS population (n=8,406).

4.3.5 Distribution of HIV by sociodemographic ad behavioural factors

Next, I explored the distribution of HIV by established sociodemographic and behavioural risk factors. HIV was more prevalent amongst women compared with men across age groups, with the highest prevalence observed in the 35–39 age group for both men and women (**Figure 4.4**). The lowest prevalence was in those aged 15–19 (3.4% of women, 2.3% of men) and increased with age up to the 35–39 age group, after which prevalence declined (**Table 4.4**).

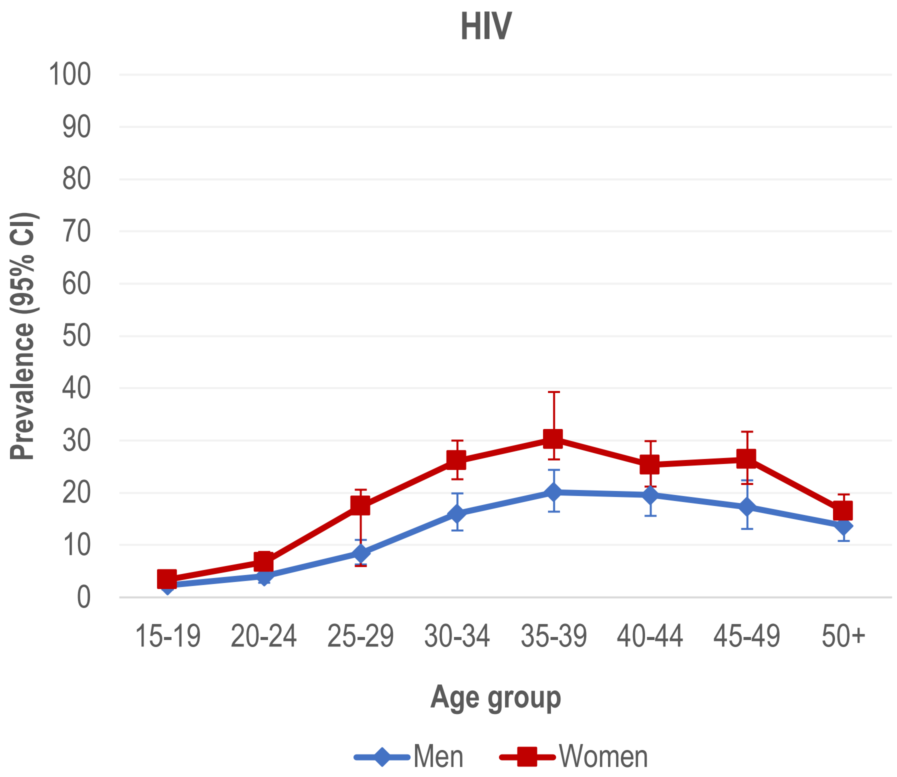


Figure 4.4: HIV prevalence by age and sex presented with 95% confidence intervals (n=8,406).

95% CI: 95% Confidence Interval.

HIV was more prevalent in those with lower levels of education and wealth (**Table 4.5**). Prevalence was highest in those with a professional occupation (16.8%) and lowest among the unemployed (11.7%, $p<0.001$). There was no substantial difference in HIV prevalence by residence type ($p=0.085$). HIV was most prevalent among those who were formerly married (27.6%, $p<0.001$). HIV prevalence increased with the number of lifetime sexual partners, and of those who had more than one sexual partner in their lifetime 17.4% had HIV ($p<0.001$). HIV prevalence increased the older the age at first sex ($p<0.001$). In a subset of 8,403 individuals with data on ethnicity, the prevalence of HIV was highest in the Oshiwambo population (17.6%) and was lowest in the Afrikaans population (5.1%; $p<0.001$) (**Appendix 3; Table 1**).

Table 4.5: Prevalence of HIV by sociodemographic and behavioural characteristics (n=8,406)

Sociodemographic and behavioural characteristics	HIV negative No. (%)	HIV positive No. (%)	*p*
Sex			
Men	3,390 (89.4)	403 (10.6)	<0.001
Women	3,848 (83.4)	765 (16.6)	
Age group			
15 – 19	1,573 (97.2)	46 (2.8)	<0.001
20 – 24	1,355 (94.5)	76 (5.5)	
25 – 29	1,014 (86.7)	156 (13.3)	
30 – 34	763 (78.3)	212 (21.7)	
35 – 39	661 (74.2)	230 (25.8)	
40 – 44	546 (77.3)	160 (22.7)	
45 – 49	434 (77.8)	124 (22.2)	
50+	892 (84.7)	161 (15.3)	
Education level			
No education	643 (82.5)	136 (17.5)	<0.001
Primary	1,797 (82.0)	394 (18.0)	
Secondary	4,301 (87.7)	605 (12.3)	
Higher	497 (93.8)	33 (6.2)	
Wealth quintile			
Lowest	1,102 (81.9)	243 (18.1)	<0.001
Second	1,337 (82.2)	289 (17.8)	
Middle	1,556 (84.4)	288 (15.6)	
Fourth	1,761 (86.9)	265 (13.1)	
Highest	1,482 (94.7)	83 (5.3)	
Occupation			
Professional	2,296 (83.2)	464 (16.8)	<0.001
Agricultural	400 (85.3)	69 (14.7)	
Manual	922 (85.5)	156 (14.5)	
Unemployed	3,620 (88.3)	479 (11.7)	
Residence type			
Urban	3,543 (86.8)	540 (13.2)	0.085
Rural	3,695 (85.5)	628 (14.5)	
Marital status			
Never married	4,247 (88.3)	508 (10.7)	<0.001
Currently married	1,465 (87.2)	215 (12.8)	
Living with partner	1,085 (79.7)	277 (20.3)	
Formerly/ever married	441 (72.4)	168 (27.6)	
Lifetime sexual partners			
None	1,035 (98.0)	21 (2.0)	<0.001
1	1,403 (92.5)	114 (7.5)	
>1	4,604 (82.6)	971 (17.4)	
Don't know	196 (76.0)	62 (24.0)	
Age at first sex			
Never had sex	1,035 (98.0)	21 (2.0)	<0.001
<15 years	545 (89.3)	65 (10.7)	
15 – 19 years	4,087 (84.4)	756 (15.6)	
20+ years	1,571 (82.8)	326 (17.2)	
Total	7,238 (86.1)	1,168 (13.9)	

P value corresponds to a chi-squared test

There was an inverse relation between wealth and HIV, which was consistent among men and women (**Figure 4.5A**). For women, HIV prevalence was highest in the lowest wealth quintile (23.3%), whilst for men HIV was most prevalent in the second quintile (13.7%). Women consistently had a higher prevalence of HIV across wealth quintiles. An inverse relation between education and HIV was observed in both men and women (**Figure 4.5B**). Women consistently had a higher prevalence of HIV across education levels. For men, the highest prevalence was in those without education (14.9%) but for women HIV was most prevalent in those educated to primary level (22.4%).

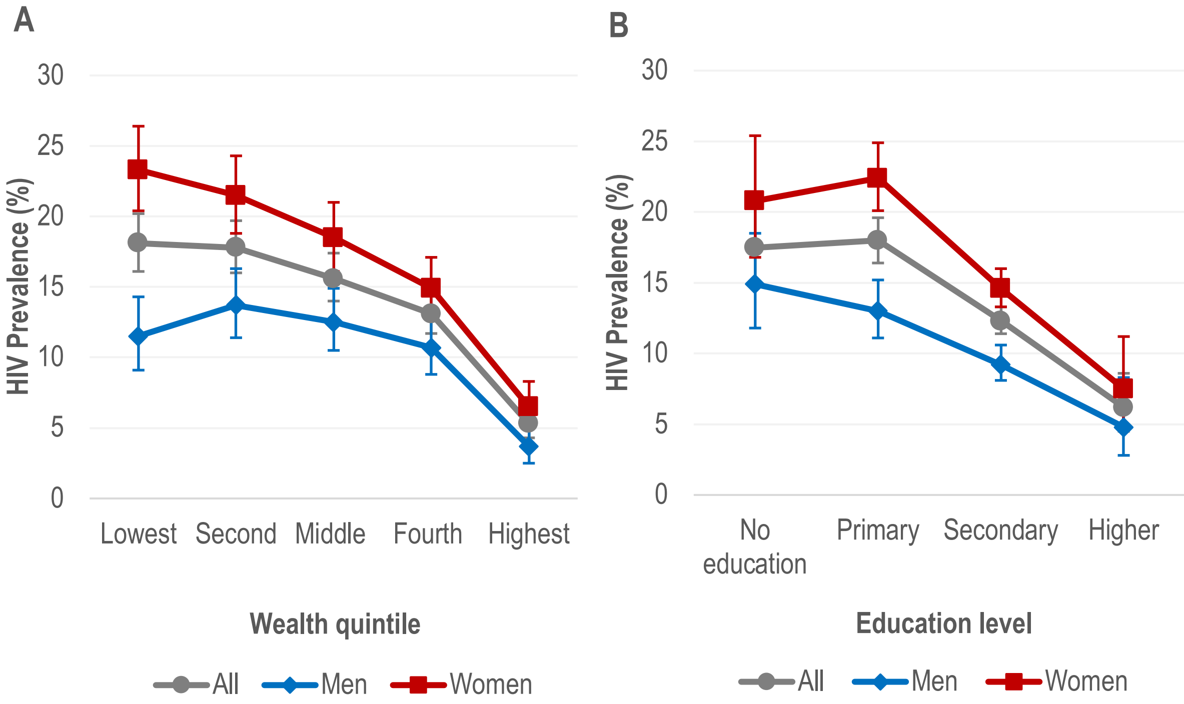


Figure 4.5: Proportion of HIV positive individuals by wealth quintile and education, stratified by sex (n=8,406) | A: The prevalence of HIV and 95% confidence intervals at each level of wealth, stratified by sex | **B:** The prevalence of HIV and 95% confidence intervals at each level of education, stratified by sex.

ICCs were used to assess clustering of HIV status and sociodemographic and behavioural risk factors at the household, EA and regional level (**Table 4.6**). There was evidence for clustering of HIV or risk factors at all three levels. HIV status was clustered at the household level (ICC: 0.22; 95% CI: 0.19 – 0.25). Education was clustered at the EA and household level (household level ICC: 0.38; 95% CI: 0.36 – 0.41), and wealth was highly clustered at the EA level and at the regional level (EA ICC: 0.69; 95% CI: 0.66 – 0.72). Residence type was clustered at the regional level (ICC: 0.34; 95% CI: 0.16 – 0.52). There was some evidence for clustering of marital status at the household level (ICC: 0.24; 95% CI: 0.13 – 0.18).

Table 4.6: Intraclass correlation coefficient (ICC) to assess clustering of HIV status and sociodemographic and behavioural risk factors at the household, EA and regional level (n=8,406)

	Household	EA	Region
	ICC (95% CI)	ICC (95% CI)	ICC (95% CI)
HIV status	0.22 (0.19 - 0.25)	0.04 (0.03 - 0.06)	0.02 (0.00 - 0.03)
Sex	0.00 (0.00 - 0.03)	0.01 (0.00 - 0.02)	0.00 (0.00 - 0.01)
Age	0.00 (0.00 - 0.03)	0.04 (0.03 - 0.05)	0.02 (0.00 - 0.04)
Education	0.38 (0.36 - 0.41)	0.23 (0.20 - 0.25)	0.09 (0.02 - 0.16)
Wealth	N/A	0.69 (0.66 - 0.72)	0.30 (0.13 - 0.47)
Residence type	N/A	N/A	0.34 (0.16 - 0.52)
Occupation	0.15 (0.13 - 0.18)	0.10 (0.08 - 0.11)	0.04 (0.01 - 0.07)
Marital status	0.24 (0.21 - 0.27)	0.08 (0.06 - 0.10)	0.05 (0.01 - 0.09)
Age at first sex	0.00 (0.00 - 0.03)	0.03 (0.01 - 0.04)	0.01 (0.00 - 0.01)
Lifetime sexual partners	0.03 (0.00 - 0.06)	0.06 (0.05 - 0.08)	0.03 (0.01 - 0.06)

N/A where variable is measured at the household or EA level | EA: enumeration area | ICC: intraclass correlation coefficient | 95% CI: 95% confidence intervals

4.3.6 Association between sociodemographic and behavioural factors and HIV

Following descriptive assessments of the prevalence and distribution of HIV and potential determinants of interest, I conducted univariable and multivariable mixed effects Poisson regressions to assess the relation between these determinants and HIV status (**Table 4.7**). Across all three models, women were more likely to be HIV positive than men. In the fully-adjusted model (Model 3), women were almost 60% more likely to have HIV (RR: 1.59; 95% CI: 1.38 – 1.83; p<0.001). There was a positive association between age and HIV up to the 35–39 age group. Those in the 35–39 age group were most likely to have HIV (RR: 4.93; 95% CI: 2.85 – 8.53; p<0.001).

Those with higher education were least likely to be HIV-positive (RR: 0.62; 95% CI: 0.40 – 0.96; p=0.033). Individuals in the fourth and highest wealth quintiles were less likely to be HIV-positive (highest wealth quintile RR: 0.36; 95% CI: 0.26 – 0.50; p<0.001). No association was observed between occupation and HIV status. Individuals who lived in rural areas were less likely to have HIV (RR: 0.73; 95% CI: 0.59 – 0.91; p=0.006).

Individuals who were currently married were less likely to be HIV positive (RR: 0.70; 95% CI: 0.59 – 0.84; p<0.001). Individuals who had one or more than one sexual partner in their lifetime were less likely to be HIV positive than those who had no sexual partners in the fully-adjusted model. However, in Model 2 (univariable mixed effects models) there was a strong positive association between the number of sexual partners and HIV status. Individuals who were aged between 15 and 19 years at their first sexual encounter were most likely to be HIV-positive (RR: 4.32; 95% CI: 2.54 – 7.35; p<0.001).

In a subset of 8,403 individuals with data on ethnicity, the Oshiwambo population had the highest risk of HIV (RR:2.42; 95% CI: 1.76 – 3.31; p<0.001), followed by those in the “other” category (RR: 2.19; 95% CI: 1.51 – 3.19; p<0.001)(**Appendix 3; Table 2**).

Table 4.7: Association between HIV and sociodemographic and behavioural factors (n=8,406)						
Sociodemographic and behavioural characteristics	**Model 1**		**Model 2**		**Model 3**	
	RR (95% CI)	***p***	**RR (95% CI)**	***p***	**RR (95% CI)**	***p***
Sex						
Men	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Women	1.56 (1.38 - 1.76)	<0.001	1.53 (1.35 - 1.74)	<0.001	1.59 (1.38 - 1.83)	<0.001
Age group						
15 – 19	1.00 (reference)		1.00 (reference)		1.00 (reference)	
20 – 24	1.94 (1.35 - 2.79)	<0.001	2.05 (1.45 - 2.88)	<0.001	1.26 (0.83 - 1.91)	0.278
25 – 29	4.69 (3.38 - 6.52)	<0.001	5.03 (3.00 - 8.44)	<0.001	2.66 (1.56 - 4.53)	<0.001
30 – 34	7.65 (5.56 - 10.53)	<0.001	8.27 (4.57 - 14.98)	<0.001	4.26 (2.46 - 7.40)	<0.001
35 – 39	9.09 (6.62 - 12.47)	<0.001	9.84 (5.53 - 17.51)	<0.001	4.93 (2.85 - 8.53)	<0.001
40 – 44	7.98 (5.75 - 11.07)	<0.001	8.87 (4.70 - 16.75)	<0.001	4.82 (2.64 - 8.80)	<0.001
45 – 49	7.82 (5.58 - 10.97)	<0.001	9.02 (5.08 - 16.03)	<0.001	4.82 (2.87 - 8.09)	<0.001
50+	5.38 (3.88 - 7.47)	<0.001	6.10 (3.45 - 10.76)	<0.001	3.26 (1.94 - 5.49)	<0.001
Education level						
No education	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Primary	1.03 (0.85 - 1.25)	0.766	0.90 (0.76 - 1.07)	0.226	1.06 (0.90 - 1.24)	0.496
Secondary	0.71 (0.59 - 0.85)	<0.001	9.60 (0.47 - 0.78)	<0.001	0.88 (0.72 - 1.09)	0.250
Higher	0.56 (0.24 - 0.52)	<0.001	0.31 (0.17 - 0.56)	<0.001	0.62 (0.40 - 0.96)	0.033
Wealth quintile						
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Second	0.98 (0.83 - 1.17)	0.851	1.01 (0.85 - 1.20)	0.912	1.02 (0.91 - 1.14)	0.788
Middle	0.86 (0.73 - 1.03)	0.095	0.89 (0.68 - 1.15)	0.367	0.91 (0.75 - 1.10)	0.343
Fourth	0.72 (0.61 - 0.86)	<0.001	0.75 (0.55 - 1.03)	0.071	0.76 (0.60 - 0.97)	0.029
Highest	0.29 (0.23 - 0.38)	<0.001	0.30 (0.19 - 0.46)	<0.001	0.36 (0.26 - 0.50)	<0.001
Occupation						
Professional	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Agricultural	0.88 (0.68 - 1.13)	0.301	1.05 (0.81 - 1.36)	0.714	1.14 (0.85 - 1.54)	0.374
Manual	0.86 (0.72 - 1.03)	0.105	0.89 (0.73 - 1.08)	0.242	1.00 (0.83 - 1.21)	0.996
Unemployed	0.70 (0.61 - 0.79)	<0.001	0.64 (0.56 - 0.73)	<0.001	0.89 (0.78 - 1.02)	0.097

Table 4.7: Association between HIV and sociodemographic and behavioural factors (n=8,406)

Sociodemographic and behavioural characteristics	Model 1		Model 2		Model 3	
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*
Residence type						
Urban	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Rural	1.10 (0.98 - 1.23)	0.110	0.91 (0.72 - 1.15)	0.446	0.73 (0.59 - 0.91)	0.006
Marital status						
Never married	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Currently married	1.20 (1.02 - 1.41)	0.026	1.27 (1.02 - 1.59)	0.035	0.70 (0.59 - 0.84)	<0.001
Living with partner	1.90 (1.64 - 2.20)	<0.001	2.28 (1.92 - 2.72)	<0.001	1.16 (1.00 - 1.34)	0.052
Formerly/ever married	2.58 2.17 - 3.07)	<0.001	2.66 (2.16 - 3.27)	<0.001	1.18 (0.97 - 1.45)	0.106
Lifetime sexual partners						
None	1.00 (reference)		1.00 (reference)		1.00 (reference)	
1	3.78 (2.37 - 6.02)	<0.001	3.93 (2.46 - 6.29)	<0.001	0.39 (0.28 - 0.54)	<0.001
>1	8.76 (5.68 - 13.50)	<0.001	9.76 (6.23 - 15.30)	<0.001	0.70 (0.55 - 0.89)	0.004
Don't know	12.08 (7.37 - 19.82)	<0.001	13.27 (7.76 - 22.72)	<0.001	—	—
Age at first sex						
Never had sex	1.00 (reference)		1.00 (reference)		1.00 (reference)	
<15 years	5.36 (3.28 - 8.76)	<0.001	5.72 (4.13 - 7.93)	<0.001	3.52 (2.03 - 6.12)	<0.001
15 – 19 years	7.85 (5.09 - 12.11)	<0.001	8.53 (5.45 - 13.33)	<0.001	4.32 (2.54 - 7.35)	<0.001
20+ years	8.64 (5.56 - 13.44)	<0.001	9.16 (5.66 - 14.84)	<0.001	4.04 (2.31 - 7.05)	<0.001

Model 1: univariable Poisson regression for association between exposure and HIV
Model 2: mixed effects Poisson regression between each exposure and HIV adjusted for regional, EA and household clustering
Model 3: multivariable mixed effects Poisson regression, additionally adjusted for all other exposures in the table
RR: Risk Ratio | 95% CI: 95% Confidence Interval

4.3.7 Completeness of hyperglycaemia and hypertension data

A total of 4,747 individuals were invited to have their blood pressure measured (2,163 men and 2,584 women). Of those individuals, 1,117 (23.5%) did not have their blood pressure measured and were excluded on this basis. Of those excluded based on the lack of an average systolic and diastolic blood pressure measurement (n=1,117; 55.9% men and 44.1% women), 0.8% consented but had no measurement, 16.9% refused measurements, 30.1% were not present and 51.2% had missing consent information.

A total of 3,630 individuals had their blood pressure measured and were included in these analyses. Of these individuals, 3,625 provided consent (99.9%) and five individuals had missing information on consent (0.1%) and thus were ultimately not included in this analysis (**Figure 4.6**).

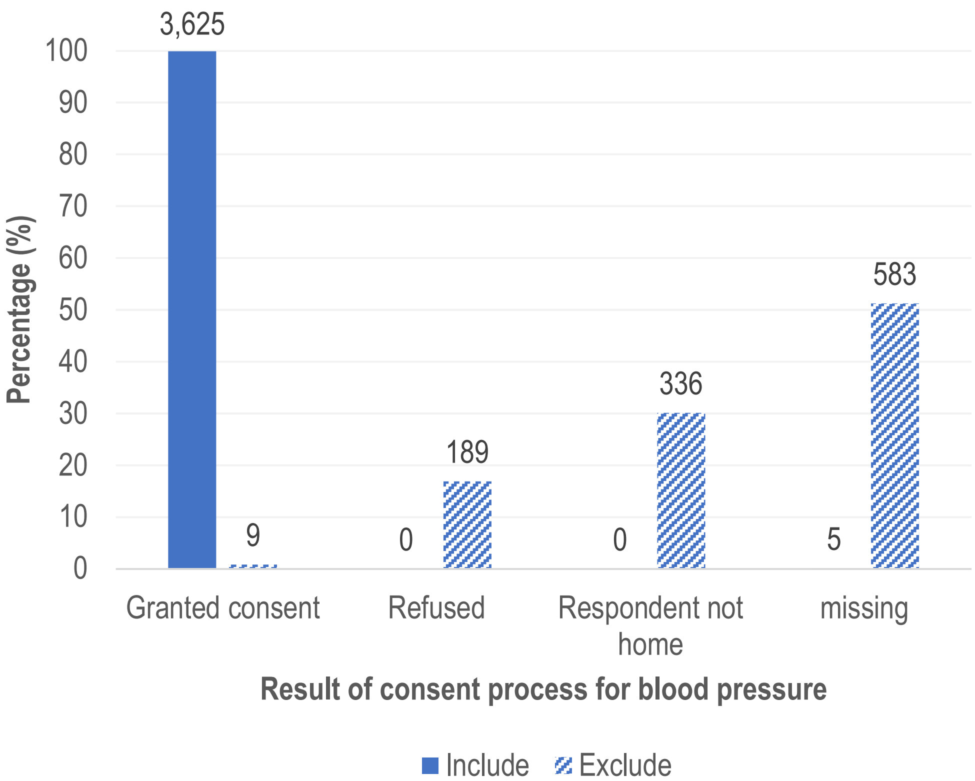


Figure 4.6: Consent for blood pressure measurements in those included and excluded based on the collection of a blood pressure measurement. Data labels refer to the number of individuals in each category.

A total of 3,804 individuals were invited and read the consent form to have their blood glucose measured (1,615 men and 2,189 women). A total of 3,316 (87.2%) individuals consented, leaving 488 individuals who did not consent (12.8%). Of the 488 individuals who did not consent 19 (0.2%) refused, 67 (13.7%) were absent and 402 (82.4%) had missing data on consent (**Figure 4.7**). For an additional 30 individuals (0.8% of eligible participants) who consented to an FPG measurement, no measurement was obtained. As such, a total of 518 eligible individuals (13.6%) did not have an FPG measurement and were excluded from the analysis; 48.5% were men and 51.5% were women. The total number of individuals with a FPG measurement was 3,286 (86.4% of eligible individuals).

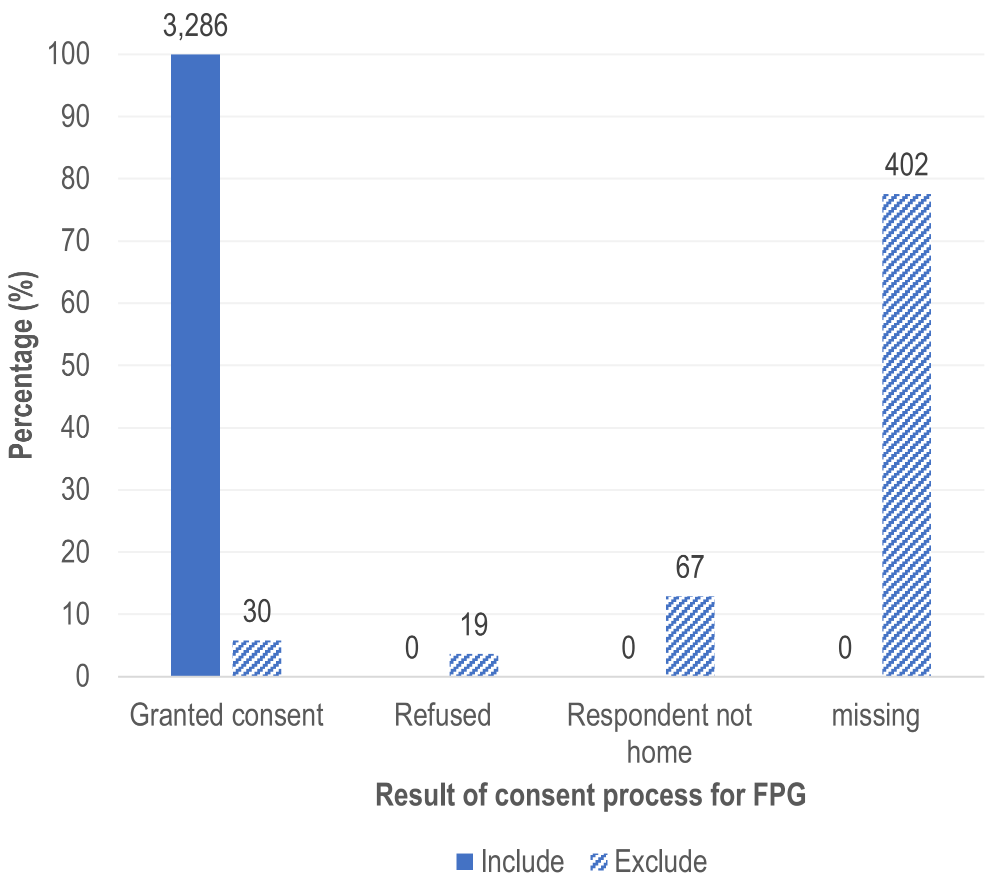


Figure 4.7: Consent for fasting plasma glucose measurement in those included and excluded based on the collection of a fasting plasma glucose measurement. Data labels refer to the number of individuals in each category. FPG: fasting plasma glucose.

4.3.8 Distribution of population tested for hyperglycaemia and hypertension

Of the 3,247 individuals with complete data on hypertension, hyperglycaemia, BMI and sociodemographic factors, 58.5% were women, 24.6% were in the lowest age group (34–39 years) and the proportion of the population decreased with increasing age group (**Table 4.8**). Overall and in both men and women, most were educated to secondary level (42.1% of women and 44.1% of men). The distribution by wealth was similar for men and women with the lowest proportion of the population in the lowest wealth quintile (15.3 – 18.9%) and the highest proportion in the fourth wealth quintile (22.7 – 24.2%, p=0.046). There was a slightly higher proportion of the population in rural areas (52.0 – 54.4%) compared with urban areas (45.6 – 48.0%).

Table 4.8: Demographic characteristics of population explored for cardiometabolic risk factors				
Sociodemographic characteristics	**All** No. (%)	**Men** No. (%)	**Women** No. (%)	***p***
Sex				
Men	1,347 (41.5)	—	—	
Women	1,900 (58.5)	—	—	
Age group				
34 – 39	800 (24.6)	336 (24.9)	464 (24.4)	0.035
40 – 44	680 (20.9)	308 (22.9)	372 (19.6)	
45 – 49	572 (17.6)	232 (17.2)	340 (17.9)	
50 – 54	519 (16.0)	185 (13.7)	334 (17.6)	
55 – 59	346 (10.7)	144 (10.7)	202 (10.6)	
60 – 64	330 (10.2)	142 (10.5)	188 (9.9)	
Education level				
No education	476 (15.3)	233 (18.2)	243 (13.3)	<0.001
Primary	1,073 (34.5)	412 (32.1)	661 (36.1)	
Secondary	1,335 (42.9)	528 (41.2)	807 (44.1)	
Higher	230 (7.4)	109 (8.5)	121 (6.6)	
Wealth quintile				
Lowest	565 (17.4)	206 (15.3)	359 (18.9)	0.046
Second	594 (18.3)	236 (17.5)	358 (18.8)	
Middle	643 (19.8)	278 (20.6)	365 (19.2)	
Fourth	758 (23.3)	3265 (24.2)	432 (22.7)	
Highest	687 (21.2)	301 (22.4)	386 (20.3)	
Residence type				
Urban	1,514 (46.6)	647 (48.0)	867 (45.6)	0.177
Rural	1,733 (53.4)	700 (52.0)	1,033 (54.4)	
Total	3,247 (100.0)	1,347 (100.0)	1,900 (100.0)	

P value corresponds to a chi-squared test

4.3.9 Prevalence of hyperglycaemia and hypertension

The distribution of FPG, systolic and diastolic blood pressure measurements are presented in Figure 4.8. FPG and systolic blood pressure were positively skewed, whilst diastolic blood pressure was normally distributed.

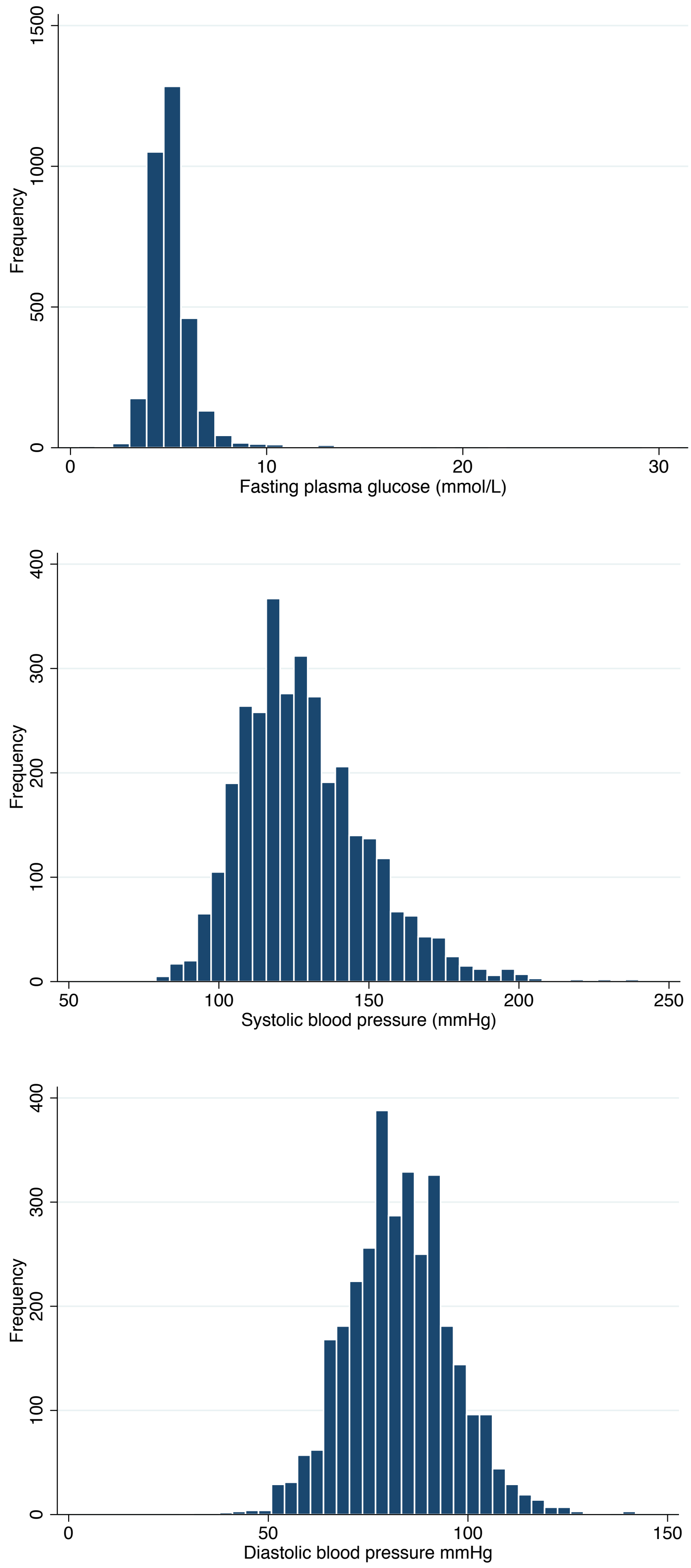


Figure 4.8: Frequency distribution of fasting plasma glucose, average systolic and average diastolic blood pressure measurements (n=3,247).

The median FPG (IQR) in men and women was 4.4 (1.1) mmol/L in men and 5.0 (1.1) mmol/L in women. In men, the maximum FPG measurement was 30.2 mmol/L and in women was 30.9 mmol/L. FPG measurements of 7 mmol/L or above, indicative of hyperglycaemia, are signified by the red line (**Figure 4.9**). Of individuals with FPG measurements greater than 7 mmol/L, 44.4% were men and 55.6% were women.

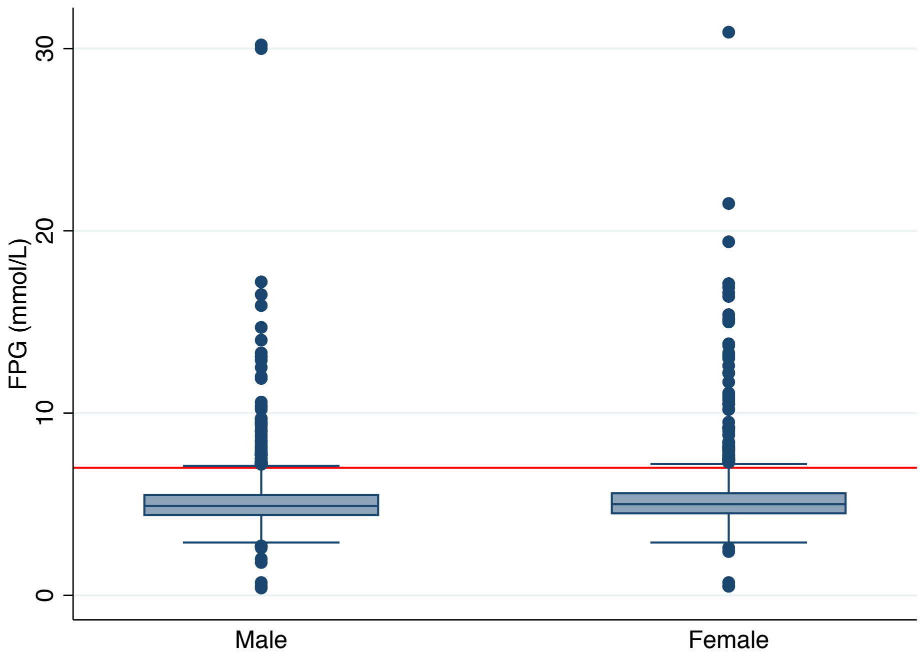


Figure 4.9: Box and whisker plot showing the median and interquartile range for the fasting plasma glucose measurement (mmol/L) in men and women (n=3,247). The red line represents 7 mmol/L, above which individuals are classified as being hyperglycaemic. FPG: Fasting Plasma Glucose.

The median (IQR) FPG measurement was 5.0 (1.1) mmol/L, which differed by sex ($p<0.001$)(**Table 4.9**). The mean systolic blood pressure measurement was 128.6 (± 21.1) mmHg and the mean diastolic blood pressure measurement was 83.0 (± 13.1). Mean systolic blood pressure was higher in men than women, whilst diastolic blood pressure was higher in women.

The prevalence of hyperglycaemia was 5.4% (5.7% in men and 5.2% in women). The prevalence of hypertension was 36.9% (38.2% in men and 36.1% in women). The prevalence of hypertension and hyperglycaemia did not differ by sex ($p>0.05$).

Table 4.9: Prevalence of hyperglycaemia and hypertension (n=3,247)

	Overall	Men	Women	*p*
Continuous variables				
Median (IQR) FPG (mmol/L)	5.0 (1.1)	4.9 (1.1)	5.0 (1.1)	<0.001
Mean (± SD) systolic blood pressure (mmHg)	128.6 (21.1)	130.5 (21.0)	127.3 (21.0)	<0.001
Mean (± SD) diastolic blood pressure (mmHg)	83.0 (13.1)	82.4 (13.4)	83.3 (13.0)	0.044
Categorical variables				
Hyperglycaemia No. (%)				
No	3,071 (94.6)	1,270 (94.3)	1,801 (94.8)	0.530
Yes	176 (5.4)	77 (5.7)	99 (5.2)	
Hypertension No. (%)				
No	2,048 (63.1)	833 (61.8)	1,215 (64.0)	0.220
Yes	1,199 (36.9)	514 (38.2)	685 (36.1)	

P value corresponds to a t test for mean systolic and diastolic blood pressure, a Wilcoxon rank sum test for median FPG and a chi-squared test for categorical variables | FPG: fasting plasma glucose | IQR: interquartile range | SD: standard deviation

Table 4.10 shows crude and adjusted prevalence estimates of cardiometabolic risk factors. Adjusting for age, sex and clustering reduced the overall prevalence estimates for overweight, obesity and hyperglycaemia. Overall hypertension estimates were relatively unchanged between crude and adjusted models. However, when stratified by sex, hypertension prevalence increased to 45.7% (95% CI: 41.4 – 49.9) in men and 46.7% (95% CI: 42.1 – 51.3) in women. Adjusted prevalence estimates for overweight, obesity and hyperglycaemia were lower than crude estimates in men. In women, adjusted prevalence of overweight was relatively unchanged from the crude estimate, whilst the adjusted prevalence estimates for obesity and hyperglycaemia were lower compared with the crude estimates.

Table 4.10: Crude and adjusted prevalence estimates of cardiometabolic risk factors in men and women

	Overall (n=3,247)		Men (n=1,347)		Women (n=1,900)	
	No.	% (95% CI)	No.	% (95% CI)	No.	% (95% CI)
Crude						
BMI Class						
Overweight	724	22.3 (20.9 - 23.8)	245	18.2 (16.2 - 20.3)	479	25.2 (23.3 - 27.2)
Obese	655	20.2 (18.8 - 21.6)	142	10.5 (9.0 - 12.3)	513	27.0 (25.0 - 29.0)
Hypertension	1,199	36.9 (25.3 - 38.6)	514	38.2 (35.6 - 40.8)	685	36.1 (33.9 - 38.2)
Hyperglycaemia	176	5.4 (4.7 - 6.3)	77	5.7 (4.6 - 7.1)	99	5.2 (4.3 - 6.3)
Adjusted						
BMI Class						
Overweight	724	21.5 (18.6 - 24.5)	245	16.8 (13.0 - 20.5)	479	25.0 (22.1 - 27.8)
Obese	655	17.6 (12.4 - 22.7)	142	8.7 (5.7 - 11.7)	513	24.1 (16.9 - 31.2)
Hypertension	1,199	36.8 (34.5 - 39.2)	514	38.1 (34.9 - 41.5)	685	35.9 (32.8 - 39.1)
Hyperglycaemia	176	3.6 (2.4 - 4.8)	77	4.8 (2.8 - 6.8)	99	3.5 (1.9 – 5.1)

Adjusted prevalence estimates are based on Poisson regression models adjusted for sex (overall models only), age and regional, enumeration area and household clustering | 95% CI: 95% Confidence Interval

4.3.10 Regional prevalence of hyperglycaemia and hypertension

Inter-regional differences in the prevalence of hyperglycaemia and hypertension were observed (**Figure 4.10**). Hypertension was most prevalent in Otjozondjupa, Khomas and Hardap (>40%) and was less prevalent in northern regions. The prevalence of hypertension was highest in Khomas at 45.0%. Hyperglycaemia was most prevalent in Hardap at 13.1% and least prevalent in Kavango at 1.8%. The geographical distribution of hyperglycaemia was more varied than that of hypertension.

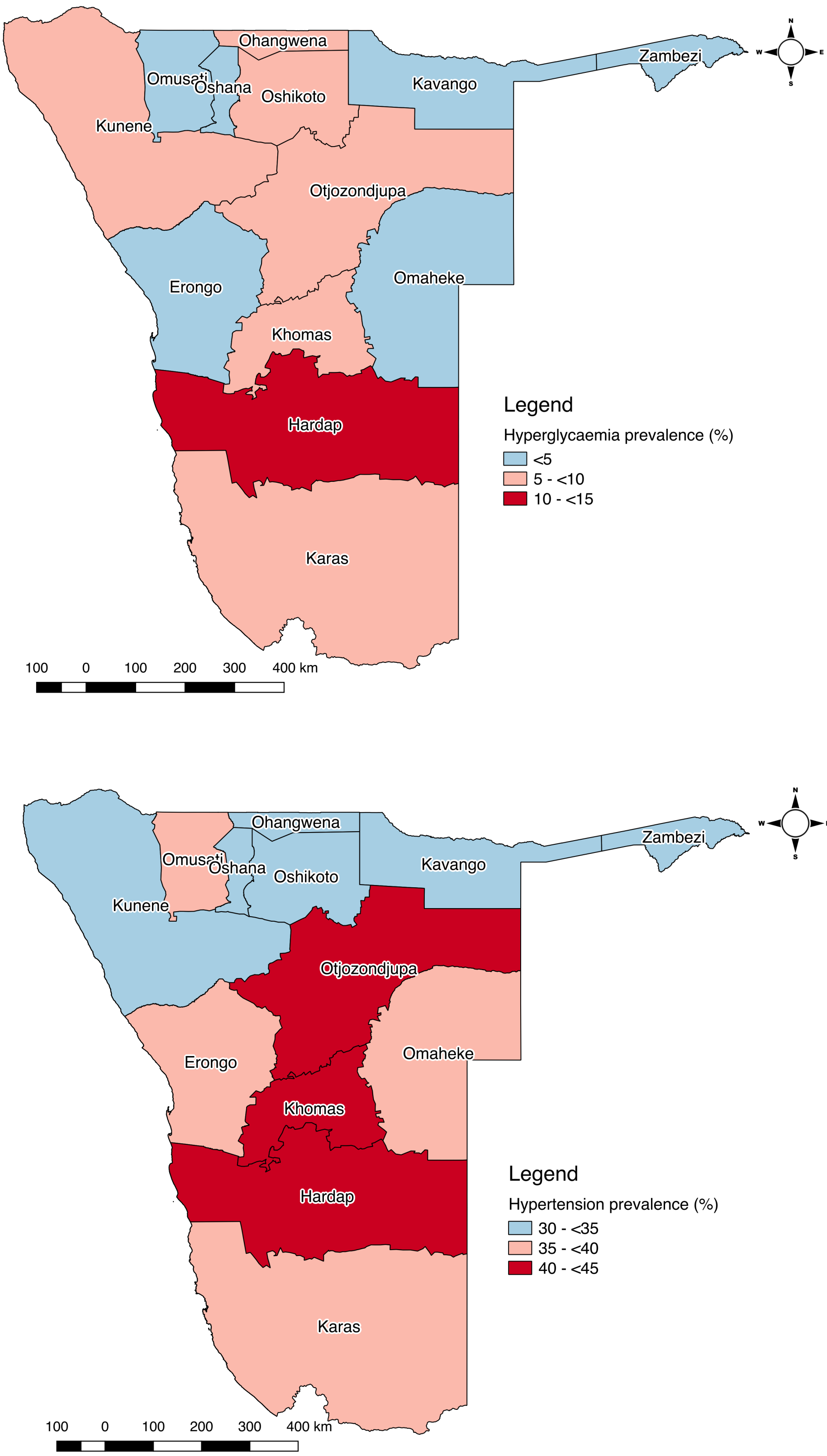


Figure 4.10: Regional prevalence of hyperglycaemia and hypertension in Namibia (n=3,247).

4.3.11 Prevalence and distribution of hyperglycaemia and hypertension by sociodemographic factors

I also explored the distribution of hyperglycaemia and hypertension by sociodemographic factors (**Figure 4.11** and **Table 4.11**). There was no significant difference in the prevalence of hypertension or hyperglycaemia between men and women across age groups but there was an increase in the prevalence of both conditions with age in both men and women (**Figure 4.11 and Table 4.11 and 4.12**).

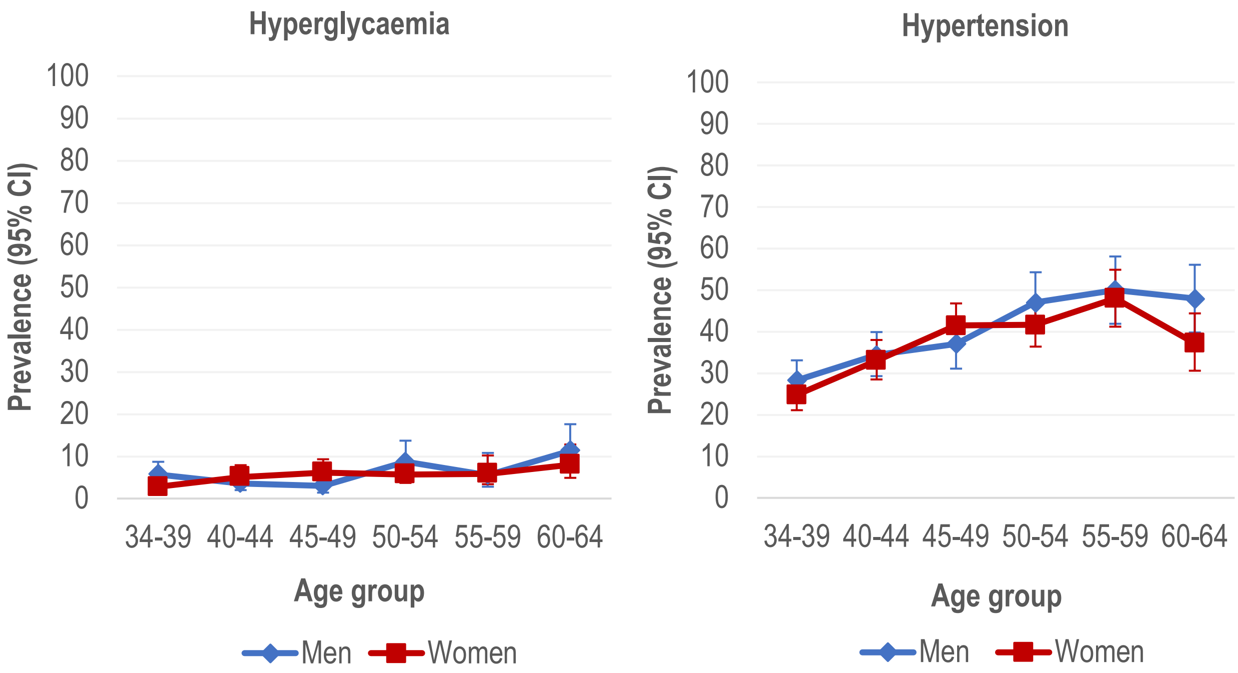


Figure 4.11: Prevalence of hyperglycaemia and hypertension by age and sex presented with 95% confidence intervals (n=3,247). 95% CI: 95% Confidence Interval.

The prevalence of hyperglycaemia increased with age from 4.0% in the 34–39 age group to 9.4% in the 60–64 age group (p=0.005)(**Table 4.11**). The prevalence of hyperglycaemia increased with education level from 3.2% in those with no education to 9.1% in those with higher education (p=0.011). There was also an increase in the prevalence of hyperglycaemia with increasing wealth quintile from 2.8% in the lowest quintile, to 9.0% in the highest (p<0.001). There was a higher prevalence of hyperglycaemia in urban populations (7.0% vs 4.0%; p<0.001).

In a subset of 3,114 individuals with data on ethnicity, the prevalence of hyperglycaemia was highest in the Afrikaans population at 10.7%, followed by the Damara/Nama population at 8.4% (**Appendix 3; Table 1**). Hyperglycaemia prevalence was lowest in the "other" population at 3.0% (p<0.001).

Table 4.11: The prevalence and distribution of hyperglycaemia by sociodemographic risk factors (n=3,247)

Sociodemographic factors	No hyperglycaemia No. (%)	Hyperglycaemia No. (%)	*p*
Sex			
Men	1,270 (94.3)	77 (5.7)	0.530
Women	1,801 (94.8)	99 (5.2)	
Age group			
34 – 39	768 (96.0)	32 (4.0)	0.005
40 – 44	650 (95.6)	30 (4.4)	
45 – 49	544 (95.1)	28 (4.9)	
50 – 54	484 (93.3)	35 (6.7)	
55 – 59	326 (94.2)	20 (5.8)	
60 – 64	299 (90.6)	31 (9.4)	
Education level			
No education	490 (96.7)	17 (3.4)	0.014
Primary	1,044 (94.6)	60 (5.4)	
Secondary	1,317 (94.5)	77 (5.5)	
Higher	220 (90.9)	22 (9.1)	
Wealth quintile			
Lowest	549 (97.2)	16 (2.8)	<0.001
Second	573 (96.5)	21 (3.5)	
Middle	618 (96.1)	25 (3.9)	
Fourth	706 (93.1)	52 (6.9)	
Highest	625 (91.0)	62 (9.0)	
Residence type			
Urban	1,408 (93.0)	106 (7.0)	<0.001
Rural	1,663 (96.0)	70 (4.0)	
Total	3,071 (92.6)	176 (5.4)	

p value corresponds to chi-squared test

The prevalence of hyperglycaemia was 6.8% in those who were overweight and 9.5% in those who were obese, compared with 3.5% in those who were underweight or normal weight (**Table 4.12**). The prevalence of hyperglycaemia was 6.3% amongst current smokers (p=0.253) and it was more prevalent amongst those with adequate fruit and vegetable intake (7.8% vs 5.2%). The prevalence of hyperglycaemia was higher amongst those who also had hypertension (6.8% vs 4.6%, p=0.010).

The prevalence of hyperglycaemia increased the higher the number of risk factors a person had (p<0.001) and ranged from 4.1% in those with just one risk factor to 13.5% in those with four risk factors. However, it is important to note the small number of individuals with four risk factors.

Table 4.12: Distribution of hyperglycaemia by behavioural and biophysical risk factors (n=3,247)

Potential risk factors	**No hyperglycaemia** No. (%)	**Hyperglycaemia** No. (%)	***p***	**Total** No. (%)
Levels of obesity				
Not overweight/obese	1,803 (96.5)	65 (3.5)	<0.001	1,868 (100.0)
Overweight	675 (93.2)	49 (6.8)		724 (100.0)
Obese	593 (90.5)	62 (9.5)		655 (100.0)
Smoking*				
Non-smoking	2,392 (94.9)	130 (5.2)	0.253	2,522 (100.0)
Current smoker	595 (93.7)	40 (6.3)		635 (100.0)
Fruit and vegetable intake				
Adequate intake	271 (92.2)	23 (7.8)	0.056	294 (100.0)
Low intake	2,800 (94.8)	153 (5.2)		2,953 (100.0)
Hypertension				
Non-hypertensive	1,953 (95.4)	95 (4.6)	0.010	2,048 (100.0)
Hypertensive	1,118 (93.2)	81 (6.8)		1,199 (100.0)
Clustering of risk factors*				
0	102 (93.6)	7 (6.4)	<0.001	109 (100.0)
1	1,257 (96.0)	53 (4.1)		1,310 (100.0)
2	1,192 (95.2)	60 (4.8)		1,252 (100.0)
3	404 (90.0)	45 (10.0)		449 (100.0)
4	32 (86.5)	5 (13.5)		37 (100.0)

*N=3,157 with complete data on fasting plasma glucose, body mass index, diet and smoking | p value corresponds to chi-squared test

The prevalence of hypertension was 36.9% overall and was not significantly different between men and women (*p*=0.220)(**Table 4.13**). The prevalence of hypertension increased with age group and was highest amongst those aged 55–59 years at 48.8% (*p*<0.001). Hypertension prevalence was highest amongst those with no education (41.4%) and lowest in those with secondary education (34.9%, *p*=0.077)(**Table 4.12**). The prevalence of hypertension increased with increasing wealth quintile and was highest in the fourth quintile at 40.9% (*p*<0.001). Hypertension was most prevalent in urban areas (41.1% vs 33.3%; *p*<0.001).

In a subset of 3,114 individuals with data on ethnicity, the Damara/Nama and Afrikaans populations had the highest prevalence of hypertension at 40.4% and 41.1%, respectively. Those in the "other" category had the lowest prevalence of hypertension (**Appendix 3; Table 1**). However, there was no significant difference in hypertension prevalence by ethnicity (*p*=0.095).

Table 4.13: The prevalence and distribution of hypertension by sociodemographic risk factors (n=3,247)

Sociodemographic characteristics	No hypertension No. (%)	Hypertension No. (%)	*p*
Sex			
Men	833 (61.8)	514 (38.2)	0.220
Women	1,215 (64.0)	685 (36.1)	
Age group			
34 – 39	590 (73.8)	210 (26.3)	<0.001
40 – 44	451 (66.3)	229 (33.7)	
45 – 49	345 (60.3)	227 (39.7)	
50 – 54	293 (56.5)	226 (43.6)	
55 – 59	177 (51.2)	169 (48.8)	
60 – 64	192 (58.2)	138 (41.8)	
Education level			
No education	297 (58.6)	210 (41.4)	0.077
Primary	692 (62.7)	412 (37.3)	
Secondary	907 (65.1)	487 (34.9)	
Higher	152 (62.8)	90 (37.2)	
Wealth quintile			
Lowest	401 (71.0)	164 (29.0)	<0.001
Second	379 (63.8)	215 (36.2)	
Middle	399 (62.1)	244 (38.0)	
Fourth	448 (59.1)	310 (40.9)	
Highest	421 (61.3)	266 (38.7)	
Residence type			
Urban	892 (58.9)	622 (41.1)	<0.001
Rural	1,156 (66.7)	577 (33.3)	
Total	2,048 (63.1)	1,199 (36.9)	

p value corresponds to chi-squared test

The prevalence of hypertension increased with levels of obesity (*p*<0.001)(**Table 4.14**). The prevalence of hypertension was 31.8% in those underweight or normal weight, 39.9% in those who were overweight and 48.3% in those who were obese (**Table 4.14**). There was no significant difference in the prevalence of hypertension between smokers and non-smokers (*p*=0.492) nor between those who had adequate and low fruit and vegetable intake (*p*=0.663).

There was an increase in the prevalence of hypertension by the number of hypertension risk factors a person had (*p*<0.001), ranging from 32.9% in those with no risk factors to 55.2% in those with three. Hypertension prevalence was 36.9% in individuals with four risk factors. However, again, it is important to note the small number of individuals with four risk factors.

Table 4.14: Prevalence of hypertension by behavioural and biophysical risk factors (n=3,247)

Potential risk factors	**Non-hypertensive** No. (%)	**Hypertensive** No. (%)	***p***	**Total** No. (%)
Levels of obesity				
Not overweight/obese	1,274 (68.2)	594 (31.8)	<0.001	1,868 (100.0)
Overweight	435 (60.1)	289 (39.9)		724 (100.0)
Obese	339 (51.8)	316 (48.2)		655 (100.0)
Smoking*				
Non-smoking	1,598 (63.4)	924 (36.6)	0.492	2,522 (100.0)
Current smoker	393 (61.9)	242 (38.1)		635 (100.0)
Fruit and vegetable intake				
Adequate intake	182 (61.9)	112 (38.1)	0.663	294 (100.0)
Low intake	1,866 (63.2)	1,087 (36.8)		2,953 (100.0)
Clustering of risk factors*				
0	102 (67.1)	50 (32.9)	<0.001	152 (100.0)
1	1,214 (65.8)	632 (34.2)		1,846 (100.0)
2	613 (60.2)	405 (39.8)		1,018 (100.0)
3	59 (44.4)	74 (55.6)		133 (100.0)
4	3 (37.5)	5 (36.9)		8 (100.0)

*n=3,157 with complete data on fasting plasma glucose, body mass index, diet and smoking | *p* value corresponds to chi-squared test

ICCs were generated to assess the clustering of cardiometabolic risk factors at the household, EA and regional level. ICCs indicated that cardiometabolic risk factors were not strongly clustered within households, EAs or regions (**Table 4.15**). Within households, diastolic blood pressure clustered most strongly (ICC: 0.19; 95% CI: 0.11 – 0.28), followed by BMI (ICC: 0.16; 95% CI: 0.08 – 0.25). Within EAs, BMI (ICC: 0.15; 95% CI: 0.12 – 0.19) and FPG (ICC: 0.15; 95% CI: 0.11 – 0.18) were clustered most strongly. There was little or no evidence of clustering at the regional level. There was limited evidence for clustering of categorical measures of overweight, obesity, hypertension and hyperglycaemia at the household, EA and regional level. A number of sociodemographic factors were clustered at the household, EA or regional level. Age was highly clustered at the household level (ICC: 0.49; 95% CI: 0.43 – 0.54), education was clustered at the household and EA level, wealth was strongly clustered at the EA and regional level and residence type was clustered at the regional level (ICC: 0.32; 95% CI: 0.14 – 0.50).

Table 4.15: Clustering of cardiometabolic risk factors within households, EAs and regions (n=3,247)

Cardiometabolic risk factors	Household	EA	Region
	ICC (95% CI)	ICC (95% CI)	ICC (95% CI)
Continuous variables			
BMI (Kg/m^2)	0.16 (0.08 - 0.25)	0.15 (0.12 - 0.19)	0.07 (0.01 - 0.13)
Blood pressure			
Systolic blood pressure (mmHg)	0.07 (0.00 - 0.17)	0.03 (0.01 - 0.06)	0.00 (0.00 - 0.01)
Diastolic blood pressure (mmHg)	0.19 (0.11 - 0.28)	0.08 (0.06 - 0.11)	0.03 (0.00 - 0.06)
Fasting plasma glucose (mmol/L)	0.07 (0.00 - 0.16)	0.15 (0.11 - 0.18)	0.00 (0.00 - 0.01)
Categorical variables			
Overweight	0.00 (0.00 - 0.10)	0.02 (0.00 - 0.04)	0.01 (0.00 - 0.02)
Obese	0.03 (0.00 - 0.12)	0.08 (0.05 - 0.11)	0.04 (0.01 - 0.07)
Hypertension	0.09 (0.00 - 0.18)	0.02 (0.00 - 0.04)	0.01 (0.00 - 0.01)
Hyperglycaemia	0.03 (0.00 - 0.12)	0.09 (0.06 - 0.12)	0.01 (0.00 - 0.03)
Sociodemographic factors			
Sex	0.00 (0.00 – 0.10)	0.00 (0.00 – 0.02)	0.02 (0.00 – 0.04)
Age	0.49 (0.43 – 0.54)	0.09 (0.06 – 0.12)	0.01 (0.00 – 0.01)
Education	0.51 (0.45 – 0.56)	0.25 (0.21 – 0.29)	0.10 (0.02 – 0.17)
Wealth	N/A	0.68 (0.65 – 0.71)	0.33 (0.15 – 0.52)
Residence type	N/A	N/A	0.32 (0.14 – 0.50)

EA: enumeration area | ICC: intraclass correlation coefficient | 95% CI: 95% confidence interval | BMI: body mass index | N/A where sociodemographic factor is measured at the respective level

4.3.12 Association between sociodemographic and behavioural risk factors and hyperglycaemia and hypertension

In multivariable mixed effects analyses (Model 3), there was no significant association between hyperglycaemia and sex, age, education, wealth, residence type, hypertension, low fruit and vegetable intake and smoking (**Table 4.16**). However, individuals aged 60–64 were most likely to have hyperglycaemia (RR: 2.14; 95% CI: 1.54 – 2.97; p<0.001). Furthermore, individuals who were overweight and obese were more likely to have hyperglycaemia, with obese individuals being most likely to have hyperglycaemia (obese RR: 2.19; 95% CI: 1.41 – 3.41; p=0.001). No association was observed between ethnicity and hyperglycaemia in fully-adjusted models (**Appendix 3; Table 3**).

Table 4.16: Association between hyperglycaemia and sociodemographic, biophysical and behavioural risk factors

Potential risk factors	Model 1 (n=3,247)		Model 2 (n=3,247)		Model 3 (n=3,157)	
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*
Sex						
Men	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Women	0.91 (0.68 - 1.23)	0.542	0.93 (0.68 - 1.27)	0.638	0.81 (0.59 - 1.12)	0.196
Age group						
34 – 39	1.00 (reference)		1.00 (reference)		1.00 (reference)	
40 – 44	1.10 (0.67 - 1.82)	0.700	1.09 (0.70 - 1.69)	0.698	0.95 (0.61 - 1.48)	0.831
45 – 49	1.22 (0.74 - 2.03)	0.435	1.15 (0.63 - 2.07)	0.652	0.98 (0.55 - 1.73)	0.937
50 – 54	1.69 (1.04 - 2.72)	0.033	1.66 (1.08 - 2.54)	0.020	1.42 (0.88 - 2.28)	0.150
55 – 59	1.45 (0.83 - 2.53)	0.196	1.41 (0.83 - 2.40)	0.209	1.26 (0.75 - 2.11)	0.385
60 – 64	2.35 (1.43 - 3.85)	0.001	2.34 (1.65 - 3.30)	<0.001	2.14 (1.54 - 2.97)	<0.001
Education level						
No education	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Primary	1.62 (0.95 - 2.78)	0.079	1.45 (0.81 - 2.59)	0.212	1.56 (0.84 - 2.89)	0.162
Secondary	1.65 (0.97 - 2.79)	0.062	1.49 (0.89 - 2.47)	0.128	1.33 (0.77 - 2.28)	0.306
Higher	2.71 (1.44 - 5.11)	0.002	2.55 (1.23 - 5.27)	0.012	1.67 (0.83 - 3.38)	0.152
Wealth quintile						
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Second	1.25 (0.65 - 2.39)	0.504	1.18 (0.73 - 1.90)	0.501	1.10 (0.64 - 1.89)	0.741
Middle	1.37 (0.73 - 2.57)	0.322	1.32 (0.72 - 2.42)	0.376	1.01 (0.47 - 2.18)	0.979
Fourth	2.42 (1.38 - 4.24)	0.002	2.33 (1.45 - 3.73)	<0.001	1.44 (0.85 - 2.44)	0.173
Highest	3.19 (1.84 - 5.52)	<0.001	3.12 (1.82 - 5.35)	<0.001	1.70 (0.75 - 3.84)	0.201
Residence type						
Urban	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Rural	0.58 (0.43 - 0.78)	<0.001	0.58 (0.40 - 0.83)	0.003	0.79 (0.58 - 1.09)	0.156
Obesity level						
Normal or underweight	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Overweight	1.95 (1.34 - 2.82)	<0.001	1.84 (1.40 - 2.41)	<0.001	1.67 (1.25 - 2.22)	<0.001
Obese	2.72 (1.92 - 3.85)	<0.001	2.49 (1.54 - 4.04)	<0.001	2.19 (1.41 - 3.41)	0.001
Hypertension						
Not hypertensive	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Hypertensive	1.46 (1.08 - 1.96)	0.013	1.41 (0.95 - 2.09)	0.091	1.21 (0.82 - 1.80)	0.334
Low fruit and vegetable intake						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	0.66 (0.43 - 1.03)	0.065	0.68 (0.49 - 0.94)	0.021	0.89 (0.66 - 1.20)	0.437
Current smoker*						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	1.22 (0.27 - 1.74)	0.267	0.97 (0.76 - 1.24)	0.817	1.15 (0.91 - 1.45)	0.235

*n=3,157 due to 90 with missing data on smoking | Model 1: univariable Poisson regression | Model 2: Univariable mixed effects analyses adjusted for regional, EA and household clustering | Model 3: fully-adjusted multivariable mixed effects analysis, adjusted for clustering and all other exposures in the table | RR: Risk Ratio | 95% CI: 95% Confidence Interval

In multivariable mixed effects analyses examining the potential determinants of hypertension, women were less likely to have hypertension than men in the fully-adjusted model (RR: 0.86; 95% CI: 0.78 – 0.95; *p*=0.002)(**Table 4.17**). There was a positive association between age and hypertension, with those in the 55–59 age group most likely to be hypertensive (RR: 1.82; 95% CI: 1.56 – 2.09; *p*<0.001). Education level was inversely associated with hypertension (higher education level RR: 0.77; 95% CI: 0.60 – 0.99; *p*=0.041). Individuals in the second and middle wealth quintiles were more likely to have hypertension, while those living in rural areas were less likely to be hypertensive (RR: 0.80; 95% CI: 0.73 – 0.87; *p*<0.001).

Obesity level was positively associated with hypertension, with those who were obese being most at risk of hypertension (RR: 1.54; 95% CI: 1.40 – 1.70; *p*<0.001). There was no association between hypertension and hyperglycaemia, low fruit and vegetable consumption and smoking. No association was observed between ethnicity and hypertension in fully-adjusted models (**Appendix 3; Table 4**).

Table 4.17: Association between hypertension and sociodemographic, biophysical and behavioural risk factors

Potential risk factors	Model 1 (n=3,247)		Model 2 (n=3,247)		Model 3 (n=3,157)	
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*
Sex						
Men	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Women	0.95 (0.84 - 1.06)	0.331	0.95 (0.85 - 1.06)	0.334	0.86 (0.78 - 0.95)	0.002
Age group						
34 – 39	1.00 (reference)		1.00 (reference)		1.00 (reference)	
40 – 44	1.28 (1.06 - 1.55)	0.009	1.28 (1.14 - 1.44)	<0.001	1.23 (1.10 - 1.37)	<0.001
45 – 49	1.51 (1.25 - 1.82)	<0.001	1.51 (1.29 - 1.76	<0.001	1.47 (1.24 - 1.73)	<0.001
50 – 54	1.66 (1.38 - 2.00)	<0.001	1.66 (1.37 - 2.01)	<0.001	1.58 (1.34 - 1.88)	<0.001
55 – 59	1.86 (1.52 - 2.28)	<0.001	1.86 (1.60 - 2.17)	<0.001	1.82 (1.56 - 2.09)	<0.001
60 – 64	1.59 (1.29 - 1.97)	<0.001	1.60 (1.35 - 1.89)	<0.001	1.52 (1.24 - 1.86)	<0.001
Education level						
No education	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Primary	0.90 (0.76 - 1.06)	0.219	0.89 (0.82 - 0.97)	0.007	0.86 (0.80 - 0.93)	<0.001
Secondary	0.84 (0.72 - 0.99)	0.039	0.83 (0.74 - 0.93)	0.001	0.82 (0.71 - 0.95)	0.008
Higher	0.90 (0.70 - 1.15)	0.393	0.88 (0.71 - 1.09)	0.250	0.77 (0.60 - 0.99)	0.041
Wealth quintile						
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Second	1.25 (1.02 - 1.53)	0.033	1.25 (1.06 - 1.47)	0.007	1.16 (1.01 - 1.34)	0.031
Middle	1.31 (1.07 - 1.59)	0.008	1.31 (1.19 - 1.43)	<0.001	1.18 (1.07 - 1.29)	<0.001
Fourth	1.41 (1.17 - 1.70)	<0.001	1.41 (1.25 - 1.59)	<0.001	1.09 (0.95 - 1.25)	0.201
Highest	1.33 (1.10 - 1.62)	0.004	1.33 (1.18 - 1.51)	<0.001	0.96 (0.86 - 1.06)	0.415
Residence type						
Urban	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Rural	0.81 (0.72 - 0.91)	<0.001	0.81 (0.73 - 0.90)	<0.001	0.80 (0.73 - 0.87)	<0.001
Obesity level						
Normal or underweight	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Overweight	1.26 (1.09 - 1.45)	0.002	1.26 (1.17 - 1.35)	<0.001	1.26 (1.15 - 1.39)	<0.001
Obese	1.52 (1.32 - 1.74)	<0.001	1.52 (1.38 - 1.67)	<0.001	1.54 (1.40 - 1.70)	<0.001
Hyperglycaemia						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	1.26 (1.01 - 1.58)	0.042	1.26 (0.99 - 1.60)	0.056	1.12 (0.89 - 1.42)	0.328
Low fruit and vegetable intake						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	0.97 (0.80 - 1.17)	0.729	0.97 (0.84 - 1.12)	0.655	1.05 (0.90 - 1.22)	0.530
Current smoker*						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	1.04 (0.90 - 1.20)	0.585	1.04 (0.92 - 1.18)	0.552	1.01 (0.87 - 1.17)	0.881

*n=3,157 due to 90 with missing data on smoking | Model 1: univariable Poisson regression | Model 2: Univariable mixed effects analyses adjusted for regional, EA and household clustering | Model 3: fully-adjusted multivariable mixed effects analysis, adjusted for clustering and all other exposures in the table | RR: Risk Ratio | 95% CI: 95% Confidence Interval

4.3.13 Co-morbidity and multimorbidity of HIV, hyperglycaemia and hypertension

The co- and multi-morbidity of HIV, hypertension and hyperglycaemia was assessed. In a subset of 3,172 individuals, 2.5% had both hyperglycaemia and hypertension, 6.1% had HIV and hypertension and 0.9% had hyperglycaemia and HIV (**Table 4.18**). Just 0.2% of this population had HIV, hypertension and hyperglycaemia. Collectively, these results suggest that there is a low prevalence of co-morbidity of HIV, hyperglycaemia and hypertension in this population.

Table 4.18: Co-morbidity and multimorbidity of HIV, hypertension and hyperglycaemia (n=3,172)

Co- and multi-morbidity scenarios	**Neither condition** No. (%)	**One condition** No. (%)	**Two conditions** No. (%)	**Three conditions** No. (%)
Co-morbidity of hyperglycaemia and hypertension	1,904 (60.0)	1,190 (37.5)	78 (2.5)	—
Co-morbidity of HIV and hypertension	1,561 (49.2)	1,419 (44.7)	192 (6.1)	—
Co-morbidity of HIV and hyperglycaemia	2,401 (75.7)	743 (23.4)	28 (0.9)	—
Multi-morbidity of HIV, hypertension and hyperglycaemia	1,490 (47.0)	1,396 (44.0)	280 (8.8)	6 (0.2)

HIV: human immunodeficiency virus | prevalence estimates refer to those aged 35–64 years with complete information on sex, education, fasting plasma glucose measurement, blood pressure measurement and a HIV test result

When stratified by sex, 46.7% of men and 47.2% of women had none of these conditions, 11.4% of men and 14.2% of women had HIV only, and 2.8% of men and 1.8% of women had hyperglycaemia only (**Figure 4.12**). Hypertension was most prevalent, which was slightly higher in men (30.8% vs 27.3%, *p*=0.012). The prevalence of co-morbidities was low in both men and women with less than 10% of men and women having any co-morbidity and less than 7% having each comorbidity. Only six individuals (0.2%) had HIV, hypertension and hyperglycaemia, all of whom were women.

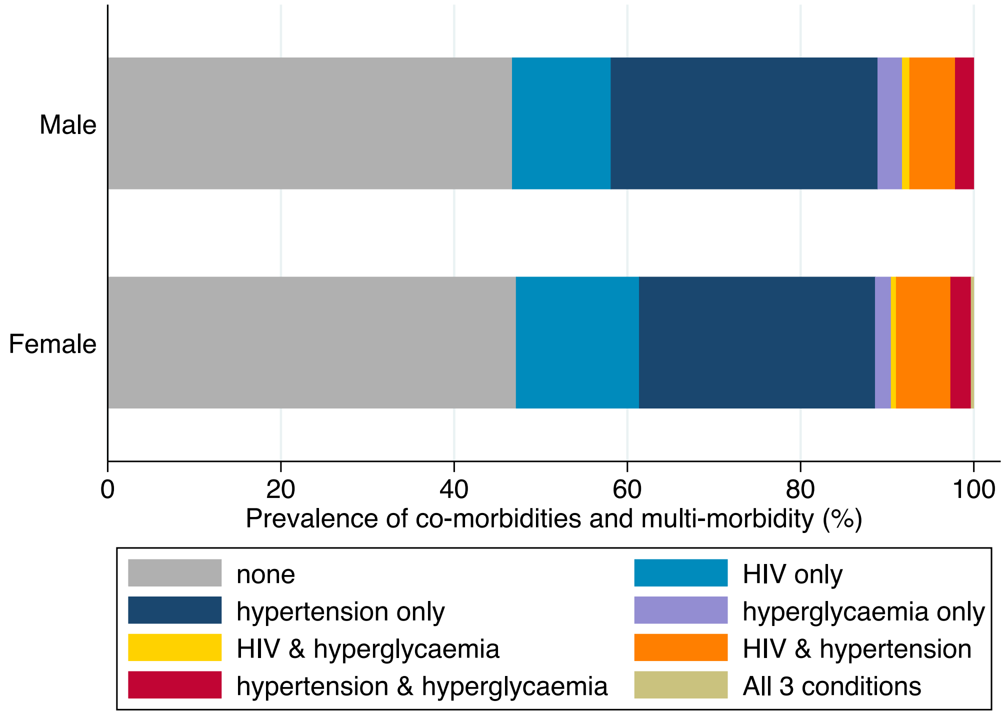


Figure 4.12: The prevalence of co- and multi-morbidity of HIV, hypertension and hyperglycaemia by sex (n=3,172).

In a subset of 3,144 individuals with data on sociodemographic factors, BMI, hyperglycaemia, hypertension and HIV, I explored the association between sociodemographic and behavioural factors and having more than one chronic condition (**Table 4.19**). In the fully-adjusted model (Model 3)(n=3,061), only residence type and smoking were significantly associated with having more than one chronic disease condition. Individuals living in rural areas were significantly less likely to have multiple chronic diseases (RR: 0.62; 95% CI: 0.43 – 0.90; p=0.012). Individuals who were current smokers were also less likely to have multiple chronic disease conditions (RR: 0.50; 95% CI: 0.28 – 0.89; p=0.019).

Table 4.19: Association between sociodemographic and behavioural factors and having more than one chronic disease condition

Potential risk factors	Model 1 (n=3,144)		Model 2 (n=3,144)		Model 3 (n=3,061)	
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*
Sex						
Men	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Women	1.16 (0.91 - 1.48)	0.220	1.15 (1.00 - 1.33)	0.057	1.08 (0.92 - 1.28)	0.344
Age group						
34 – 39	1.00 (reference)		1.00 (reference)		1.00 (reference)	
40 – 44	1.17 (0.82 - 1.66)	0.388	1.17 (0.77 - 1.76)	0.457	1.14 (0.74 - 1.77)	0.557
45 – 49	1.21 (0.84 - 1.75)	0.298	1.22 (0.84 - 1.76)	0.297	1.23 (0.85 - 1.77)	0.281
50 – 54	1.18 (0.81 - 1.72)	0.395	1.18 (0.86 - 1.62)	0.297	1.19 (0.84 - 1.69)	0.319
55 – 59	1.23 (0.81 - 1.88)	0.329	1.24 (0.88 - 1.74)	0.220	1.37 (0.93 - 2.02)	0.110
60 – 64	1.12 (0.72 - 1.76)	0.608	1.13 (0.74 - 1.70)	0.577	1.22 (0.75 - 1.97)	0.426
Education level						
No education	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Primary	1.07 (0.75 - 1.52)	0.710	1.04 (0.84 - 1.29)	0.714	0.97 (0.78 - 1.21)	0.768
Secondary	1.01 (0.72 - 1.43)	0.949	0.98 (0.69 - 1.39)	0.888	0.85 (0.59 - 1.22)	0.373
Higher	0.79 (0.45 - 1.40)	0.423	0.76 (0.29 - 1.97)	0.575	0.69 (0.28 - 1.71)	0.425
Wealth quintile						
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Second	1.16 (0.76 - 1.77)	0.495	1.17 (0.66 - 2.07)	0.592	1.07 (0.62 - 1.87)	0.808
Middle	1.42 (0.95 - 2.12)	0.088	1.42 (0.81 - 2.51)	0.225	1.21 (0.74 - 1.96)	0.445
Fourth	1.64 (1.12 - 2.40)	0.011	1.66 (0.91 - 3.00)	0.096	1.24 (0.78 - 1.98)	0.356
Highest	1.18 (0.78 - 1.78)	0.432	1.20 (0.59 - 2.44)	0.620	0.90 (0.52 - 1.55)	0.703
Residence type						
Urban	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Rural	0.69 (0.54 - 0.86)	0.001	0.65 (0.42 - 1.02)	0.060	0.62 (0.43 - 0.90)	0.012
Obesity level						
Normal or underweight	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Overweight	1.18 (0.89 - 1.57)	0.243	1.18 (0.90 - 1.54)	0.233	1.07 (0.78 - 1.46)	0.683
Obese	1.12 (0.83 - 1.51)	0.447	1.13 (0.72 - 1.76)	0.595	1.00 (0.71 - 1.42)	0.992
Low fruit and vegetable intake						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	0.84 (0.58 - 1.23)	0.380	0.84 (0.59 - 1.20)	0.344	0.85 (0.65 - 1.11)	0.224
Current smoker*						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	0.50 (0.35 - 0.73)	<0.001	0.50 (0.29 - 0.87)	0.015	0.50 (0.28 - 0.89)	0.019

*n=3,061 due to missing data on smoking | Model 1: univariable Poisson regression | Model 2: Univariable mixed effects analyses adjusted for regional, EA and household clustering | Model 3: fully-adjusted multivariable mixed effects analysis, adjusted for clustering and all other exposures in the table | RR: Risk Ratio | 95% CI: 95% Confidence Interval

4.4 Discussion

In the 2013 Namibia DHS population, there was a notable burden of HIV and cardiometabolic risk factors. HIV prevalence was 13.9% in those aged 15–64 years, with the prevalence of hyperglycaemia at 5.4% and hypertension prevalence at 36.9% in those aged 35–64. However, co-morbidity and multi-morbidity of these conditions was low and the prevalence and risk of these infectious and non-infectious chronic conditions differed by sociodemographic and behavioural factors. There is a need for more large-scale data to better understand the interrelation between infectious and NCDs in the country.

4.4.1 Prevalence and distribution of HIV and HIV risk factors

The prevalence of HIV in this population was high at 13.9%. HIV was more prevalent amongst women than men (16.6% vs 10.6%) and women were more likely to be HIV-positive, irrespective of other sociodemographic and behavioural factors. Women are at an increased risk of HIV due to biological factors that make women more susceptible to HIV infection and pathogenesis [149]. However, social factors can also play an important role in the increased risk of HIV in women in SSA [150]. Gender inequalities have been identified as drivers of HIV infection, particularly in lower socioeconomic groups [179-181]. Additionally, traditional and cultural gender norms are thought to put women at increased risk of HIV, with less empowerment to negotiate safer sexual practices or to choose their sexual partners, as well as the occurrence of polygamy and wife inheritance as described in other LMICs [182-185]. It was not possible to explore these factors within the remit of the data nor the scope of this thesis.

In this DHS population, HIV prevalence was highest among the less wealthy and less educated. In fully-adjusted analyses, individuals with higher education and those in the fourth and highest wealth quintiles were less likely to be HIV-positive. Interestingly, although the prevalence of HIV was higher in those less educated and less wealthy, it was higher among those with professional occupations. Whilst this could be in part due to the classification of individuals based on occupation, this could also suggest that the association between HIV and SES is complex in Namibia and more data are needed to better understand this relationship. There is inconsistent literature surrounding the direction of association between poverty or wealth and HIV [145, 186-190]. However, some have suggested that the relationship between lower relative wealth and HIV is due to poverty-related stressors that are themselves linked to HIV risk [148, 188, 191, 192]. It has also been suggested that the relationship between lower wealth and HIV could be due to potential downstream effects of HIV on wealth, whereby HIV-infected individuals and their households lose wealth due to medical expenses or loss of income as a result of the illness [145-

148]. There has also been a growing strength of evidence suggesting that wealth inequality within-country is more important than wealth itself in the context of HIV [186, 192-194]. In terms of income distribution, Namibia is one of the most unequal countries globally [18] and this may influence the socioeconomic distribution of HIV in this population.

Women's education level has been associated with a lower risk of HIV in other populations [181, 195, 196]. However, there is also evidence to the contrary that more educated populations in other LMICs are at a higher risk of HIV [197]. On the one hand, education may lead to a greater knowledge and empowerment to negotiate safer sexual practices. On the other hand, more educated individuals, particularly those from rural areas, often receive higher education in urban areas, where the risk of HIV may be greater due to riskier sexual behaviours [198]. However, it has also been suggested that the socioeconomic patterns of newly acquired HIV infections may be changing, with education being less important for HIV infection in younger individuals [198]. It is evident that the relationship between HIV and education is complex and varies by country [186, 199]. In the context of Namibia, the estimates reported here present a recent picture of sociodemographic patterns of HIV risk that may be used to appropriately tailor preventative and management strategies in the country.

There was also a lower risk of HIV in rural populations compared with urban populations. The increased risk of HIV in urban populations has been attributed to possible riskier sexual behaviours, for example having multiple sexual partners and starting sexual activity earlier in life [148, 200-203]. As urban populations were more likely to be HIV-positive irrespective of the behavioural factors accounted for in this analysis, it is possible that there is confounding by other factors associated with urban residence type and HIV for which no data were collected. Others have suggested that better health care in urban areas results in improved survival among HIV-infected individuals, which could result in higher reported prevalence [186].

HIV was more prevalent in the Northern regions of the country, with the highest prevalence observed in Zambezi at 24.7%. By contrast, central and southern regions had a lower prevalence of HIV (<15%). It is possible that this geographical distribution of HIV is, at least in part, driven by regional differences in SES, such as education and wealth. Zambezi, Kavango and Ohangwena are the poorest regions in Namibia and HIV prevalence was also higher in less wealthy individuals in this population. A report by the Namibian Government suggested that the reason for the higher prevalence of HIV in Zambezi is due to numerous factors including the fact that this region is at an international border, with roads used by people travelling from South Africa, migrant workers and merchants [204]. Additionally, this region has the highest levels of commercial sex, low levels of condom use, earlier sexual debut, polygamy and multiple sexual partners, lower prevalence of male circumcision and a lack of HIV/AIDS knowledge [204]. By contrast Hardap, with a prevalence of less than 10% in this analysis, is characterised by a lower number of sexual partners [204]. Kunene and Omaheke also had some of the lowest HIV prevalence estimates in this analysis and the government report suggested this could be in part due to higher male circumcision in these regions [204].

Other modifiable behavioural risk factors for HIV have also been widely studied in men and women. These factors include marital status, having multiple sexual partners and starting sexual activity earlier in life [151-155]. In this DHS population, HIV prevalence differed by marital status, with HIV most prevalent in formerly married individuals (27.6%). Another study also found formerly married women to be at a higher risk of HIV but there is a dearth of research into the HIV risks in the divorced and widowed [154]. These individuals may have been infected by their former spouse or they may have contracted the infection post-marriage. As may be expected, HIV prevalence in this DHS population was higher in individuals with more than one sexual partner (17.4%). However, associations observed in univariable analyses were not robust to adjustment for multiple other factors, suggesting that this association may be explained by other sociodemographic or behavioural factors. Contrary to findings in the wider literature [205-207], HIV prevalence increased with age at first sex to 17.2% in those who had sex at over 20 years of age. However, in fully-adjusted analyses, there was no association between age at first sex and HIV. Further research is needed to better understand this relationship in Namibian populations.

Collectively, these findings suggest that women, poorer and less educated populations may be at an increased risk of HIV in Namibia and that sexual behaviours and relationships may influence HIV risk. As expected, the number of lifetime sexual partners may be an important risk factor for HIV, indicating the need to advocate for safer sexual practices in the country. These findings are relevant to the control and prevention of HIV in Namibia and could be used to inform the targeting of healthcare resources to prevent and manage HIV infection in the country.

4.4.2 Prevalence and distribution of cardiometabolic risk factors

The prevalence of hyperglycaemia in this DHS population was 5.4%, which is similar to diabetes prevalence elsewhere in southern Africa; for example, the prevalence of diabetes in South Africa was 5.4% in 2017 [208]. Hyperglycaemia did not differ by sex, but increased with age. However, in fully-adjusted analyses, only overweight and obesity were associated with hyperglycaemia.

Hypertension was identified in over a third of this DHS population. Hypertension is one of the leading risk factors for the global disease burden [209]. There is considerable variation in the reported prevalence of hypertension across SSA [210]. However, a study in South Africa found the prevalence of hypertension to be similar to that of this DHS population [211] and another study including participants from Windhoek identified a similarly high burden to that observed in this DHS population [159]. Whilst some of the variation that has been observed across SSA may be explained by differences in study design, it highlights the importance of country-specific estimates to inform appropriate prevention and control strategies.

In this DHS population, women were less likely to have hypertension than men. This is consistent with findings in other LMICs including Uganda and Cameroon [212-214]. By contrast, other studies elsewhere in SSA have found the prevalence of hypertension to be higher in women [211, 215-217] and women have been found to have a higher risk of hypertension across a number of other LMICs [218]. These conflicting findings highlight the importance of context specific research into the determinants of hypertension. As such, the current findings provide valuable context for the sociodemographic factors associated with hypertension specifically in Namibia, but more research, preferably involving longitudinal data, is needed to better assess the association with sex.

Similar to the findings of previous studies [211, 217, 219-222], the risk of hypertension in this DHS population increased with age. Age has been associated with hypertension in other sub-Saharan African countries. The association with age is likely to be largely due to biological factors, whereby aging promotes arterial stiffness through a number of biological pathways, which ultimately leads to hypertension [223]. More research is needed to understand the burden of hypertension in those aged over 64 years.

Consistent with the wider literature [219, 224-226], the prevalence of hypertension increased with wealth in this DHS population. It is thought that the association between wealth and hypertension observed in LMICs is due to rapid urbanisation and rural-to-urban migration, which results in an increase in lifestyle risk factors for cardiometabolic diseases, including sedentary lifestyles, increased caloric fat, alcohol and salt intake [226, 227]. Indeed, urban populations were more likely to be hypertensive. However, in fully-adjusted analyses, no clear association with wealth was observed. Additionally, hypertension prevalence was previously found to be higher in individuals with lower SES in Windhoek in Namibia [159]. In fully-adjusted analyses, education was inversely associated with hypertension. The prevalence of hypertension has also been found to be higher in those with lower levels of education in other LMICs [221, 228]. By contrast, a study in Malawi found hypertension to be more prevalent in more educated populations [224]. In low income countries, such as Malawi, we might expect hypertension to be more prevalent in wealthier and more educated populations as these populations are likely to be more able to afford unhealthy lifestyles, which increase the risk of hypertension [229]. However, as countries develop and living standards improve, the risk of these conditions spreads to poorer populations [229]. As the epidemic declines, wealthier populations adopt healthier behaviours and the risk of these conditions is reduced in these populations [229]. This is otherwise known as the diffusion theory of coronary heart disease [229]. In the current analysis in Namibia, prevalence of hypertension increased with wealth but this was not consistent in fully-adjusted analyses. More large-scale data are needed to better understand the association between SES and cardiometabolic risk factors in Namibia.

Similarly to individuals with hyperglycaemia, individuals who were overweight or obese were more likely to be hypertensive. Approximately 20% of the DHS population measured was obese. Obesity has also been associated with hypertension in other middle-income countries [230]. This underscores the need for nutritional or behavioural interventions in Namibia to reduce the prevalence of overweight and obesity.

The clustering of risk factors is thought to increase the risk of cardiovascular disease and diabetes [156, 157]. In the current analyses, the prevalence of hypertension and hyperglycaemia increased with the number of risk factors exhibited. This suggests the need to identify and target those with multiple risk factors but further research is needed to more comprehensively understand the relationship between multiple risk factors and hypertension or hyperglycaemia in Namibian populations. Strategies to reduce the burden of multiple risk factors could include the integration of a number of behavioural change campaigns such as those to reduce smoking and alcohol consumption, increase fruit and vegetable intake and promote physical activity in Namibian populations.

Further research is also needed to understand the health outcomes associated with hypertension in Namibia; for example, whether hypertension increases the risk of stroke or myocardial infarction in Namibian populations. This is especially important given that ischemic heart disease and stroke are amongst the four leading causes of death in Namibia (2017) [34].

4.4.3 Co- and multi-morbidity of HIV, hypertension and hyperglycaemia

As SSA is undergoing an epidemiological transition, I investigated the co- and multi-morbidity of HIV, hyperglycaemia and hypertension in Namibia. An assessment of co-morbidity and multi-morbidity of HIV, hypertension and hyperglycaemia revealed a low prevalence of co-morbidity of HIV, hypertension and hyperglycaemia, with the co-morbidity of HIV and hypertension being highest at 6.1%. In fully-adjusted analyses, urban populations were more likely to have more than one chronic condition. Surprisingly, current smokers were less likely to have multiple conditions but the reason for this association is unclear.

Geographical heterogeneity in the distribution of HIV, hypertension and hyperglycaemia were observed. HIV was most prevalent in the northern regions, by contrast to the geographical distribution of hyperglycaemia and hypertension. Zambezi had the highest prevalence of HIV (24.7%) but had one of the lowest prevalence estimates for hypertension and hyperglycaemia. hyperglycaemia and hypertension were more prevalent in the central and southern regions, which conversely had the lowest prevalence of HIV (<15%). For example, Hardap had the lowest prevalence of HIV but the highest prevalence of hyperglycaemia. This suggests that HIV, hyperglycaemia and hypertension may differentially affect geographically distinct populations in Namibia. These findings point to a need for region-specific health service planning to prevent and manage the burden of these chronic conditions.

Urban populations were at a higher risk of HIV and hypertension in fully-adjusted analyses. Additionally, an inverse association between education and both HIV and hypertension was observed. By contrast, women were less likely to be hypertensive but more likely to be HIV-positive and, looking at prevalence estimates alone, HIV was more prevalent in poorer households whilst hypertension was more prevalent in wealthier households. In additional analyses, I explored the prevalence of HIV, hypertension and hyperglycaemia by ethnicity. Interestingly, the prevalence of HIV was highest in the Oshiwambo but lowest in the Afrikaans population. By contrast, hypertension and hyperglycaemia prevalence was highest in the Afrikaans population and lowest in the Oshiwambo and “other” populations. This again suggests that these chronic disease conditions do not converge in the same populations. The pattern of chronic disease prevalence by ethnicity may be explained by differences in SES between ethnic groups. This underscores the complexity of the double burden of disease in Namibia and how these chronic conditions differentially affect Namibian population subgroups. Thus, more data are needed to better understand the interrelation between infectious and NCD conditions in Namibian populations in order to inform health service planning and provision.

In addition, it is important to note that the high burden of cardiometabolic risk factors in this population may contribute to an increase in the burden of chronic NCDs in the long-term. The number of NCD-related deaths in Africa is expected to rise and exceed the deaths attributable to communicable, maternal, perinatal and nutritional diseases combined by 2030 [231]. Therefore it will be important to carefully monitor the burdens of these conditions in Namibia. More large-scale research is needed to specifically explore the co-morbidity of infectious and NCDs in Namibia, which may help to identify high risk populations and inform health policy and planning of integrated care for these chronic conditions.

4.4.4 Strengths and limitations

The 2013 Namibia DHS is a useful resource for exploring the prevalence and distribution HIV, hyperglycaemia, hypertension and sociodemographic and behavioural risk factors. However, the broad scope of the DHS can also be a limitation in that no one disease area is covered in extensive detail. This limited the analyses of certain cardiometabolic risk factors as, for example, it was not possible to quantifiably assess alcohol consumption or physical activity in line with WHO guidelines [232, 233]. It was also not possible to assess other biophysical risk factors, such as abnormal lipids. The cross-sectional nature of the DHS data is a further limitation as the temporality of associations and disease incidence cannot be assessed. Longitudinal data would enable assessment of disease incidence and would be useful for better understanding the association between cardiometabolic risk factors and other disease outcomes, such as stroke.

A further limitation was the age range in which FPG and blood pressure measurements were taken and HIV was tested. By only testing individuals aged up to age 64, this prevents an understanding of these chronic conditions in older individuals, who might be more likely to have these diseases. As I observed an increase in the risk of hypertension with age, it would be interesting to understand the patterns of hypertension in those aged over 64 years. Additionally, it is not possible to generalise prevalence estimates to the wider population due to the restriction of FPG and blood pressure measurements to those aged 35–64 years.

Some individuals reported having been previously told they have high blood pressure or blood glucose levels. Including these individuals increased the prevalence estimates for hyperglycaemia and hypertension. These individuals may not have been classified as having hyperglycaemia or hypertension based on blood glucose and blood pressure measurements if they were taking medication to control these conditions. However, as data on treatment was limited, it was decided that these individuals would not be included in the prevalence estimates. As such, only those with measurements indicating hypertension or hyperglycaemia were included. Therefore, the prevalence of these conditions could be underestimated in these analyses. In additional analyses, those who had previously been told they had high blood sugar or diabetes were included in the definition of hyperglycaemia. This reclassification resulted in only a minor increase in the prevalence of hyperglycaemia from 5.4% to 5.8% and no material difference in prevalence by sociodemographic factors or effect estimates (Appendix 4). A further limitation is that as blood pressure and FPG measurements used to derive prevalence estimates were collected in the field they were not clinically validated. Therefore, if individuals were systematically misclassified as hypertensive or hyperglycaemic this could bias prevalence estimates and would likely result in an overestimation of cases.

Current smokers were classified as those who had smoked tobacco in the last 24 hours. The data were limited in relation to smoking status and thus this measure was used; however, this definition is likely to underestimate the prevalence of smoking. More comprehensive measures of smoking status are needed to better assess chronic disease prevalence and risk in relation to smoking as a risk factor.

A further limitation is that pregnant women were not excluded from this analysis. Gestational hypertension or gestational diabetes could result in an over-estimation of prevalence estimates. However, just 1.1% of the included population were pregnant, with only one case of hyperglycaemia and three cases of hypertension. Therefore, any misclassification due to inclusion of pregnant women is unlikely to bias prevalence or effect estimates. There is, however, potential for information bias to be introduced if individual responses to questions relating to sexual behaviours were differentially reported based on HIV status.

When assessing co-morbidities of HIV, hypertension and hyperglycaemia, analyses included 3,172 individuals. A larger sample size may improve the statistical resolution of these analyses. Again, this analysis was also limited by the age range in which hypertension and hyperglycaemia were measured, preventing exploration of the prevalence and distribution of co-morbidity in younger and older age groups. Furthermore, this analysis was limited to the conditions measured in the DHS and therefore the co-morbidity of other infectious and non-infectious diseases in Namibia could not be explored. Assessment of additional co-morbidities may not reflect the low co-morbidity identified in this analysis; however, more data are needed to explore the co-morbidity of other disease conditions in Namibian populations.

Another consideration of these findings is that wealth and residence type are measured at the household level so it is not possible assess the distribution of disease and risk factors by individual-level wealth. As the DHS data are cross-sectional, it is not possible to assess the temporality of associations between sociodemographic and behavioural risk factors and disease outcomes.

4.4.5 Implications

A greater body of research is needed to better quantify and understand the role of chronic diseases and their risk factors in Namibia. There is an acute need for more comprehensive, large-scale data to investigate the co-morbidity of chronic infectious and NCDs and associated risk factors in the country.

There has been limited research into the double burden of disease in Namibia, despite the country having one of the world's highest HIV and TB burdens and a growing burden of NCDs and associated risk factors. Given the wealth of evidence for the interrelation and convergence of infectious and NCDs in populations across SSA and elsewhere [167-174], research into common disease risk factors, convergence in populations and co-infection in individuals will be crucial to informing healthcare planning in Namibia.

Generally, many disease conditions that affect Namibian populations are comparatively under-researched compared with other sub-Saharan African countries; consequently, there is a need for more comprehensive, disease-specific data to study these conditions. However, as these and other findings have shown, the sociodemographic determinants of these conditions are highly variable and are context-specific. As such, longitudinal research that focuses on the prevalence and determinants of NCDs and their risk factors, as well as the prevalence and determinants of infectious-NCD co-infection on a large, nationally-representative scale will be important to appropriately inform healthcare planning and provision to manage and prevent infectious and non-communicable chronic diseases in Namibia.

4.4.6 Conclusions

In this Namibian DHS population, there was a notable prevalence of chronic diseases and associated sociodemographic and behavioural risk factors; however, co-morbidity and multi-morbidity of these conditions was low. The prevalence and risk of HIV, hyperglycaemia and hypertension differed by age, sex, education, wealth, region and urban-rural residence type. Further large-scale research is needed to more comprehensively understand the double burden of disease in Namibia and to define the populations most at risk in order to inform health service provision and targeting of preventative interventions.

5. Coverage of malaria control interventions in Namibia

Summary

Background: Achieving vector control targets is a key step towards malaria elimination. Access to essential services and medicines is an important component of Universal Health Coverage. Such services can encompass public health interventions such as malaria control interventions. Because of variations in reporting of progress towards vector control targets in 2013, this chapter assessed the coverage of these vector control interventions in Namibia.

Methods: Data on 9,846 households from the 2013 Namibia DHS were used to explore the coverage of two vector control methods: indoor residual spraying (IRS) and insecticide-treated nets (ITNs). Regional data on *Plasmodium falciparum* parasite rate in those aged two to ten years (*Pf*$PR_{2\text{-}10}$), obtained from the Malaria Atlas Project, were used to provide information on malaria transmission intensity. Poisson regression analyses were carried out, exploring the relationship between household interventions and *Pf*$PR_{2\text{-}10}$, with fully-adjusted models adjusting for wealth and residence type and accounting for regional and enumeration area clustering. Coverage of interventions was also explored as a function of government intervention zones and different models of transmission intensity were compared using likelihood ratio tests.

Results: Intervention coverage was greatest in the highest transmission areas (*Pf*$PR_{2\text{-}10}$ ≥5%) but was still below target levels of 95% coverage in these regions, with 27.6% of households covered by IRS, 32.3% with an ITN and 49.0% with at least one intervention (ITN and/or IRS). In fully-adjusted models, *Pf*$PR_{2\text{-}10}$ ≥5% was strongly associated with IRS (RR: 14.54; 95% CI: 5.56-38.02; $p<0.001$), ITN ownership (RR: 5.70; 95% CI: 2.84–11.45; $p<0.001$) and ITN and/or IRS coverage (RR: 5.32; 95% CI: 3.09 - 9.16; $p<0.001$).

Conclusions: The prevalence of IRS and ITN interventions in 2013 did not reflect the Namibian government intervention targets. As such, there is a need to include quantitative monitoring of such interventions to reliably inform intervention strategies for malaria elimination in Namibia.

5.1 Introduction

Malaria is a global public health concern, that caused approximately 438,000 deaths, worldwide, in 2015 [234]. The WHO Africa region experiences a disproportionately high burden of malaria, with 88% of global cases in 2015 occurring in the region [234]. Namibia is one of eight sub-Saharan African countries aiming to eliminate malaria, and intends to eliminate by 2020.

5.1.1 Malaria elimination

Malaria elimination is defined by the WHO as "the interruption of local transmission (i.e. reducing the rate of malaria cases to zero) of a specified malaria parasite in a defined geographic area" [235]. Malaria elimination is complicated by changing epidemiology and transmission dynamics, underlying infectious reservoirs, potential for cross-border transmission, financial constraints, weakening of malaria programmes and technical barriers, such as insecticide and drug resistance. These factors can lead to resurgence or reintroduction of malaria during and post-elimination [236].

To achieve elimination status, a country must interrupt indigenous transmission of malaria and prevent reintroduction and onward local transmission for at least three years [237]. Interruption of the intrinsic potential for malaria transmission in a given area can be achieved through universal coverage of effective malaria control interventions, such as mass screen and treat campaigns and integrated vector management initiatives.

5.1.2 Vector control interventions

Interventions for malaria control and elimination include IRS, ITNs and long-lasting insecticide-treated nets (LLINs). These are effective tools for reducing the adult mosquito population density and longevity, and are therefore fundamental for interrupting transmission [238].

IRS involves spraying the inside walls of a dwelling with insecticide, targeting endophilic vectors, which rest on the inside walls of the dwelling post-feeding. The malaria-infected mosquitoes come into contact with the insecticide on the interior walls of sprayed household and are killed, preventing onward transmission of the parasite. The insecticide DDT (dichlorodiphenyltrichloroethane) remains effective against mosquitoes for 6–12 months, whereas other insecticides, such as pyrethroids, do not last as long [239].

ITNs are mosquito nets, treated with the insecticide permethrin, that are used for sleeping under to protect from mosquito biting and thereby transmission of the malaria parasite from the mosquito to the human and from the human host to the mosquito. ITNs can be a mosquito net that is treated at home or may be pre-treated. These nets require re-treatment every 6 to 12 months. The term ITN may also encompass LLINs—factory-treated nets that do not require any further treatment and need only replacing every three years.

IRS and ITNs target the adult stages of the mosquito and, when used in conjunction, form the basis of many malaria vector control initiatives. These control methods can be combined with larviciding, which targets vector breeding sites. This involves the treatment of larva-infested water sources with insecticide to kill the larval stages of the mosquito, preventing maturation to the adult vector stage [240].

ITNs and LLINs have successfully reduced the risk of infection in a number of settings [241-243], with up to 90% reductions in malaria transmission recorded following ITN implementation in some high-transmission settings [244]. High coverage of ITNs and IRS can both result in community-level protection [239, 245], highlighting the importance of high coverage and uptake of these interventions. There is also evidence to suggest that using IRS and ITNs in combination is more effective at reducing the vector population and interrupting transmission than ITNs alone [246, 247].

5.1.3 Malaria in Namibia

Malaria transmission in Namibia is heterogeneous. In 2013, it was estimated that 67% of Namibia's population were living in the highest transmission areas [248]. Prevalence of malaria is highest in the northern regions that border Angola [249]. Although Namibia aims to eliminate malaria by 2020, the country has experienced fluctuations in malaria incidence with reported cases rising from 4,911 in 2013 [248] to 15,915 in 2014 [234], with two outbreaks occurring in 2016 and 2017 [42-45]. Importantly, between 2000 and 2015, Namibia's overall malaria incidence and mortality rates increased by over 20% [46], highlighting the need for an effective elimination programme. Namibia is one of five countries in Africa with an elimination programme (also including Eritrea, Swaziland, Botswana, South Africa and Comoros) [45]. The 2017 World Malaria Report (WMR17) identified Namibia and Swaziland as the only two countries to have an increase in malaria incidence from 2010 to 2016, with the incidence in Namibia increasing by approximately 100% [45]. The WMR17 also reported an increase in indigenous malaria cases in Namibia from 556 in 2010 to 25,198 in 2016 [45].

5.1.4 Access to malaria control interventions in Namibia

Achieving a high coverage of malaria control interventions is central to reducing the vector population and thus preventing malaria transmission. As such, access to ITNs it is one of the essential services that makes up the "Tracking Universal Health Coverage Global Monitoring Report UHC index" [4].

Namibia's 2010-2016 Malaria Strategic Plan (MSP) aimed to achieve at least 95% coverage with a combination of vector control interventions in all malaria endemic areas and identified transmission foci by 2013 [249]. This high level of coverage is reflected in the WMR17 [45], which makes the rise in cases surprising. A governmental report also indicated high coverage, reporting that IRS was successfully completed in the eight malaria regions, with 93% coverage of targeted households achieved by the end of January 2013 [250]. By contrast, the 2013 Namibia DHS reported that only 24% of households had at least one ITN, and just 16% of households had received IRS during the previous 12 months [120]. To understand these discordant findings, a detailed analysis of ITN and IRS coverage was conducted as a function of DHS data, malaria transmission patterns and government intervention zones across Namibia in 2013. It is important to understand the level of vector control coverage as under- or over-estimations of vector control coverage could misinform future vector control planning and implementation.

The specific aims of this chapter are as follows:

i. Assess the coverage of malaria interventions in the context of measures of transmission intensity;
ii. Explore the factors associated with coverage of malaria control interventions.

5.2 Methods

5.2.1 Data sources

The Demographic and Health Survey

The DHS programme conducts standardised, nationally-representative surveys in over 90 countries worldwide, collecting data pertaining to the broad themes of fertility, family planning, maternal and child health, HIV, malaria, and nutrition [251]. The methods of the 2013 Namibia DHS are detailed elsewhere and in **Chapter 2** [120].

Available data on vector control indicators, collected as part of the DHS Household survey, included data pertaining to ITNs and IRS. A household member was asked to show all the mosquito nets to the interviewer and identify which household members slept under each net the night before the survey. IRS coverage was determined by asking a household member if the dwelling had been sprayed against mosquitoes in the last 12 months. DHS definitions of IRS and ITN were as follows:

- **Indoor residual spraying (IRS):** Spraying of the interior walls of the dwelling with an insecticide against mosquitoes.

- **Insecticide-treated net (ITN):** A factory-treated net that does not require any further treatment (LLIN), or a pre-treated net obtained in the past 12 months, or a net that has been soaked with insecticide within the past 12 months.

Households were classified as not having an ITN if the household did not have any mosquito net or only had untreated nets. Households with at least one ITN per two people were classified as having a sufficient number of ITNs.

EA coordinates were obtained from the DHS Program. EA coordinates represent a group of up to 20 households and are randomly displaced. Rural EAs are randomly displaced by up to 5 Km and urban EAs are displaced by up to 2 Km.

Indicators of malaria transmission

The indicator *Plasmodium falciparum* Parasite Rate (*Pf*PR) is a commonly used indicator of malaria transmission intensity. $Pf\mathrm{PR}_{2\text{-}10}$ is the proportion of the population aged two to ten years carrying asexual blood parasites [252]. We obtained regional $Pf\mathrm{PR}_{2\text{-}10}$ estimates and $Pf\mathrm{PR}_{2\text{-}10}$ raster data from MAP [253].

Malaria zones were assigned in line with MSP district strata outlined in the MSP documentation [249]. As part of Namibia's 2010-2016 MSP, the objective for integrated vector control was to achieve at least 95% coverage with a combination of vector control interventions in all malaria endemic areas and identified transmission foci by 2013 [249]. The country was divided into three Zones, with Zone 1 representing the highest transmission areas (moderate transmission risk), Zone 2 representing low transmission risk and Zone 3 for "risk free" areas. Vector control targets were set for each zone. In Zone 1 the aim was to achieve 95% coverage of a combination of IRS and ITNs in addition to winter larviciding. In Zone 2 IRS, ITNs and larviciding were to be targeted to selected foci.

Spatial data

For spatial representations of data, shapefiles for Namibia were downloaded from DIVA_GIS [139], originally sourced from the Database of Global Administrative Areas (GADM) [254]. All maps presented in this chapter are displayed in CRS WGS84 therefore scale bars are approximate.

5.2.2 Data analysis and statistical methods

Quantum GIS (QGIS) 2.14.1 was used for all maps and spatial analyses. All statistical analyses were carried out using STATA 14.0 software package (StataCorp: College Station, TX, USA). All households captured in the survey period (May to September 2013) were included in the subsequent analyses, giving a total of 9,846 households.

Three models of transmission intensity were constructed. The first classified households according to weighted regional *Pf*$PR_{2\text{-}10}$ values obtained from MAP for the year 2013. Regions were classified into three categories based on their *Pf*$PR_{2\text{-}10}$ values. The <1% category constitutes very low transmission risk or malaria-free areas, the 1-<5% category represents low transmission risk and the ≥5% category signifies moderate risk of transmission. Regions with *Pf*$PR_{2\text{-}10}$ estimates of zero (malaria-free) were classified into the <1% category.

The second model used raster data for *Pf*$PR_{2\text{-}10}$ obtained from MAP for the year 2013. *Pf*$PR_{2\text{-}10}$ values for each EA were assigned using the “Point Sampling Tool” in QGIS 2.14.1 [255]. Raster values were converted to percentages and were similarly classified into three *Pf*$PR_{2\text{-}10}$ categories: <1%; 1-<5% and ≥5%. Where no raster values were available for EAs because they were located in areas where no transmission was predicted to occur, the EAs were assigned the value of zero. To account for random displacement in DHS data, Euclidean buffers were drawn around EA points of 2 Km for urban EAs and 5 Km for rural EAs. The MAP *Pf*$PR_{2\text{-}10}$ raster surface was overlaid with buffered EA locations and the mean *Pf*$PR_{2\text{-}10}$ value was extracted. A high correlation between extracted mean *Pf*$PR_{2\text{-}10}$ values and extracted point *Pf*$PR_{2\text{-}10}$ values was observed. EAs were re-categorized into *Pf*$PR_{2\text{-}10}$ categories (<1%, 1-<5%, ≥5%) according to the mean *Pf*$PR_{2\text{-}10}$ values.

In additional sensitivity analyses, EAs outside of the boundary of the *Pf*$PR_{2\text{-}10}$ raster were assigned the value of the nearest raster cell up to 5 Km away, relative to the maximum EA displacement distance. This was repeated to assign EAs up to 10 Km and 20 Km outside of the raster boundary the value of the nearest cell. EAs were re-categorised into *Pf*$PR_{2\text{-}10}$ categories (<1%, 1-<5%, ≥5%) and the coverage of IRS, having an ITN and having either intervention for the three models respectively was explored (assigning raster cell values to EAs up to 5 Km, 10 Km and 20 Km away).

The third model classified households according to MSP zones. Zones were assigned using Quantum GIS (QGIS) 2.14.1. Administrative districts were assigned Zone 1, 2 or 3, as defined by the MSP, and EAs were mapped. To assign zones to EAs, polygon attributes were assigned to the EA points using the QGIS 2.14.1 "Join Attributes by Location" tool.

Categorical data are presented as a frequency and percentage. *P* values were calculated using a chi-squared test. Primary analyses were unweighted but additional weighted analyses were carried out to make the data representative of the whole population (**Appendix 2**). Weighted analyses used the DHS weight variable as per DHS Programme guidance [256].

First, a univariable Poisson model was used to test for the association between IRS and regional *Pf*$PR_{2\text{-}10}$. In the second model, EA and region were added as mixed effects. In the third model, wealth and residence type covariates were additionally adjusted for. These analyses were carried out for the other outcomes of interest: whether a household owned at least one ITN, and whether a household had at least one intervention (ITN and/or IRS). Risk ratios (RRs) are presented with 95% confidence intervals (95% CIs) and the *p* value. In additional analyses, cluster robust standard errors were used to generate 95% CIs (**Appendix 5**).

Likelihood ratio tests were carried out to compare regional *Pf*$PR_{2\text{-}10}$, EA *Pf*$PR_{2\text{-}10}$ and MSP zones. The first model tested the association between regional *Pf*$PR_{2\text{-}10}$ and IRS, adjusted for covariates (wealth and residence type) and accounted for regional and EA clustering. The second model additionally adjusted for EA *Pf*$PR_{2\text{-}10}$. The third model adjusted for MSP zones in addition to model 1. Likelihood ratio tests were carried out with model 1 nested in model 2 and model 3, respectively.

Likelihood ratio tests were repeated for the additional models of EA *Pf*$PR_{2\text{-}10}$. The mean EA *Pf*$PR_{2\text{-}10}$ model was compared to the regional *Pf*$PR_{2\text{-}10}$ model for each intervention using likelihood ratio tests. First, the association between regional *Pf*$PR_{2\text{-}10}$ and IRS was tested, adjusting for regional and EA clustering, wealth and residence type. The second model additionally adjusted for the mean EA *Pf*$PR_{2\text{-}10}$ and a likelihood ratio test was conducted with the first model nested in the second. This was repeated for the association with having an ITN and either intervention.

Further, EA *Pf*$PR_{2\text{-}10}$ models, where EAs were assigned raster cell values at up to 5 Km, 10 Km and 20 Km away, were compared to the regional *Pf*$PR_{2\text{-}10}$ model, respectively, for each intervention (IRS, ITN and either intervention). First, the association between regional *Pf*$PR_{2\text{-}10}$ and having IRS was tested, adjusting for regional and EA clustering, wealth and residence type. The second model additionally adjusted for EA *Pf*PR_{2-10} and a likelihood ratio test was carried out with the first model nested in the second. This was repeated for each model of EA *Pf*PR_{2-10} and for each intervention.

5.3 Results

5.3.1 Study characteristics

These analyses included 9,846 households distributed across 550 EAs. There were a total of 4,763 urban and 5,083 rural households, and 50.2% of households were in the highest transmission areas (*Pf*PR_{2-10} ≥5%)(**Table 5.1**).

Table 5.1: Background characteristics of households surveyed

Background characteristics	Distribution of households No. (%)
Residence type	
Urban	4,763 (48.4)
Rural	5,083 (51.6)
Wealth quintile	
Lowest	1,696 (17.2)
Second	1,945 (19.8)
Middle	2,012 (20.4)
Fourth	2,178 (22.1)
Highest	2,015 (20.5)
Regional *Pf*PR$_{2-10}$	
<1%	3,467 (35.2)
1-<5%	1,432 (14.5)
≥5%	4,947 (50.2)
EA *Pf*PR$_{2-10}$	
<1%	4,184 (42.5)
1-<5%	1,082 (11.0)
≥5%	4,580 (46.5)
MSP zone	
3	3,588 (36.4)
2	2,033 (20.7)
1	4,225 (42.9)
IRS coverage*	
No IRS	7,921 (80.5)
IRS	1,676 (17.0)
Don't know	245 (2.5)
ITN coverage	
No net	6,533 (66.4)
untreated net	940 (9.6)
ITN	2,373 (24.1)
Number of ITNs in household	
0	7,473 (75.9)
1	1,142 (11.6)
>1	1,231 (12.5)
ITN per two people	
<1 ITN per two people	8,724 (88.6)
≥1 ITN per two people	1,122 (11.4)
Total	9,846 (100.0)

*Pf*PR$_{2-10}$: *Plasmodium falciparum* Parasite Rate in ages 2 to 10 years | EA: enumeration area | MSP: Malaria Strategic Plan | IRS: Indoor Residual Spraying | ITN: Insecticide-treated net| *n=9,842

Malaria transmission intensity was highest among the northern and north-eastern regions of Namibia in 2013 across all three models (**Figure 5.1A-C**). The highest transmission regions (*Pf*PR$_{2-10}$ ≥5%) were Kunene, Omusati, Oshana, Oshikoto, Ohangwena, Otjozondjupa and Kavango (**Figure 5.1A**). Low transmission occurred in Zambezi and Omaheke (*Pf*PR$_{2-10}$ 1-<5%).

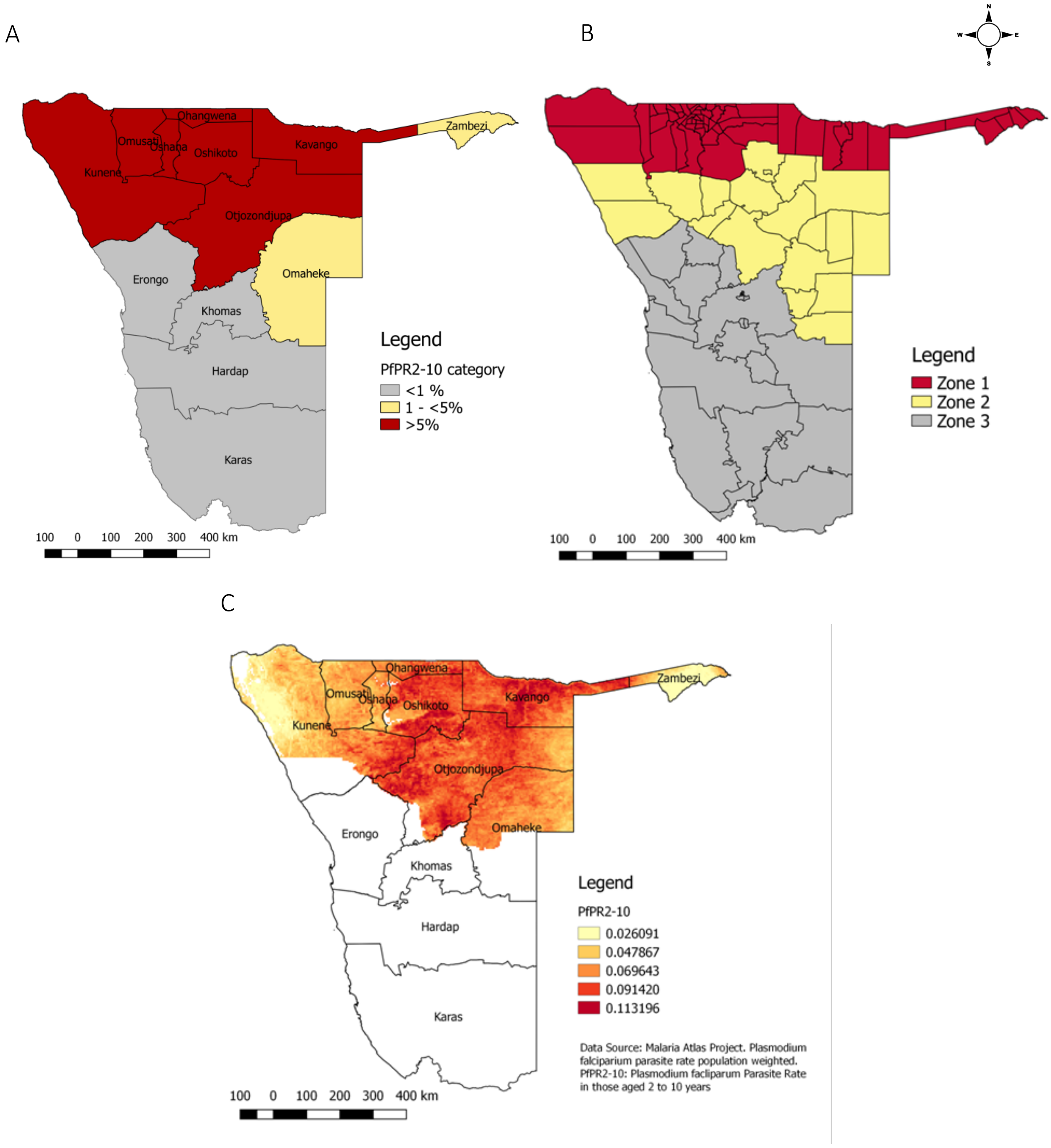


Figure 5.1: Three models of transmission intensity in Namibia. A: Regional *Pf*PR$_{2-10}$ used to classify regions into three categories; **B:** Namibia classified according to Malaria Strategic Plan (MSP) defined zones; **C:** *Pf*PR$_{2-10}$ values used to classify enumeration areas (EAs) into three categories. All *Pf*PR$_{2-10}$ data sourced from the Malaria Atlas Project [257]. *Pf*PR$_{2-10}$: *Plasmodium falciparum* Parasite Rate in those aged two to ten years. Data source: Malaria Atlas Project.

Here unweighted household-level ITN and IRS coverage is described. In secondary weighted analyses, no material difference in prevalence estimates for intervention coverage were observed (**Appendix 2**). ITN and IRS coverage are primarily explored as a function of regional *Pf*$PR_{2\text{-}10}$.

7.3.2 Coverage of malaria control interventions

Table 5.2 outlines the coverage of malaria control interventions by residence type, wealth and the various measures of transmission intensity.

Table 5.2: IRS and ITN coverage by household background characteristics

Household factors	IRS in previous 12 months				At least one ITN			ITN and/or IRS			ITN and IRS		
	No	Yes	DN	*p*	No	Yes	*p*	None	Yes	*p*	No	Yes	*p*
	No. (%)	No. (%)	No. (%)		No. (%)	No. (%)		No. (%)	No. (%)		No. (%)	No. (%)	
Residence type													
Urban	4,433 (93.1)	214 (4.5)	113 (2.4)	<0.001	4,017 (84.3)	748 (15.7)	<0.001	3,782 (81.4)	865 (18.6)	<0.001	4,566 (98.3)	81 (1.7)	<0.001
Rural	3,488 (68.6)	1,462 (28.8)	132 (2.6)		3,456 (68.0)	1,625 (32.0)		2,588 (52.3)	2,362 (47.7)		4,257 (86.0)	693 (14.0)	
Wealth quintile													
Lowest	1,107 (65.3)	561 (33.1)	28 (1.7)	<0.001	1,145 (67.5)	551 (32.5)	<0.001	808 (48.4)	860 (51.6)	<0.001	1,426 (85.5)	242 (14.5)	<0.001
Second	1,440 (74.1)	452 (23.3)	52 (2.7)		1,388 (71.4)	557 (28.6)		1,114 (58.9)	778 (41.1)		1,668 (88.2)	224 (11.8)	
Middle	1,634 (81.2)	327 (16.3)	51 (2.5)		1,470 (73.1)	542 (26.9)		1,265 (64.5)	696 (35.5)		1,797 (91.6)	164 (8.4)	
Fourth	1,873 (86.1)	227 (10.4)	76 (3.5)		1,727 (79.3)	451 (20.7)		1,544 (73.5)	556 (26.5)		1,993 (94.9)	107 (5.1)	
Highest	1,867 (92.7)	109 (5.4)	38 (1.9)		1,743 (86.5)	272 (13.5)		1,639 (83.0)	337 (17.1)		1,939 (98.1)	37 (1.9)	
Regional *Pf*PR$_{2-10}$													
<1%	3,341 (96.4)	41 (1.2)	82 (2.4)	<0.001	3,254 (93.9)	213 (6.1)	<0.001	3,141 (92.9)	241 (7.1)	<0.001	3,374 (99.8)	8 (0.2)	<0.001
1-<5%	1,137 (79.4)	270 (18.9)	25 (1.8)		870 (60.8)	562 (39.3)		778 (55.3)	629 (44.7)		1,213 (86.2)	194 (13.8)	
≥5%	3,443 (69.6)	1,365 (27.6)	138 (2.8)		3,349 (67.7)	1,598 (32.3)		2,451 (51.0)	2,357 (49.0)		4,236 (88.1)	572 (11.9)	
EA *Pf*PR$_{2-10}$													
<1%	3,959 (94.7)	122 (2.9)	100 (2.4)	<0.001	3,811 (91.1)	373 (8.9)	<0.001	3,639 (89.2)	442 (10.8)	<0.001	4,039 (99.0)	42 (1.0)	<0.001
1-<5%	721 (66.6)	327 (30.2)	34 (3.1)		560 (51.8)	522 (48.2)		422 (40.3)	626 (59.7)		837 (79.9)	211 (20.1)	
≥5%	3,241 (70.8)	1,227 (26.8)	111 (2.4)		3,102 (67.7)	1,478 (32.3)		2,309 (51.7)	2,159 (48.3)		3,947 (88.3)	521 (11.7	
MSP zones													
3	3,459 (96.5)	43 (1.2)	83 (2.3)	<0.001	3,363 (93.7)	225 (6.3)	<0.001	3,249 (92.8)	253 (7.2)	<0.001	3,493 (99.7)	9 (0.3)	<0.001
2	1,703 (83.8)	282 (13.9)	48 (2.4)		1,629 (80.1)	404 (19.9)		1,392 (70.1)	593 (29.9)		1,869 (95.5)	89 (4.5)	
1	2,759 (65.3)	1,351 (32.0)	114 (2.7)		2,481 (58.7)	1,744 (41.3)		1,729 (42.1)	2,381 (57.9)		3,434 (83.6)	676 (16.5)	
Total	7,921 (80.5)	1,676 (17.0)	245 (2.5)		7,473 (75.9)	2,373 (24.1)		6,370 (66.4)	3,227 (33.6)		8,823 (91.9)	774 (8.1)	

IRS: Indoor Residual Spraying | ITN: Insecticide-treated net | *Pf*PR$_{2-10}$: Plasmodium falciparum Parasite Rate in ages 2 to 10 years | EA: enumeration area | MSP: Malaria Strategic Plan | *p* value corresponds to chi-squared test

Household IRS coverage

Only 17.0% of households were sprayed in Namibia in 2013 (**Table 5.1**). Of these households, 91.0% reported that the dwelling was sprayed by the government. A higher proportion of rural households received IRS compared with urban households (28.8% vs 4.5%)(**Table 5.2**). The highest proportion of households sprayed were in the Kavango region (**Figure 5.2A**) and overall IRS coverage was highest in the Northern regions, in line with the geographical distribution of malaria transmission intensity (**Figure 5.1A**). Similarly, IRS coverage was highest in the ≥5% *Pf*PR$_{2\text{-}10}$ category at 27.6% and was 18.9% in the 1-<5% category, again suggesting that IRS was targeted to higher transmission areas.

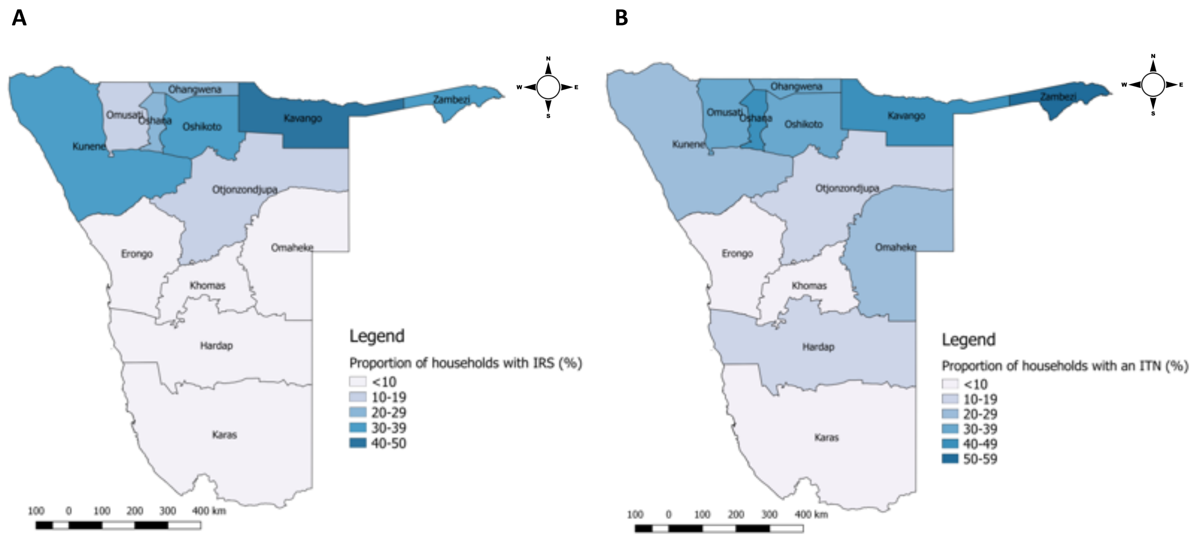


Figure 5.2: Regional household coverage of ITNs and IRS. A: proportion of households in each region that reported receiving IRS in the previous 12 months; **B:** proportion of households in each region with at least one ITN. ITN: insecticide-treated net | IRS: indoor residual spraying.

Household ITN coverage

Overall, 66.4% of households did not own a net of any kind, 9.6% owned only an untreated net and 24.1% owned at least one ITN (**Table 5.1**). Only 11.4% of all households had sufficient ITNs for at least one ITN per two people (**Table 5.1**). ITN ownership was highest in the *Pf*PR$_{2\text{-}10}$ 1-<5% category, with 39.3% of households owning an ITN, followed by 32.3% in the *Pf*PR$_{2\text{-}10}$ ≥5% category (**Table 5.2**). A higher proportion of rural households owned an ITN compared with urban households (32.0% vs 15.7%)(**Table 5.2**). As expected, there was geographical heterogeneity in ITN ownership. A higher proportion of households in the northern and north-eastern regions owned an ITN, with Zambezi having the highest proportion of households owning at least one ITN (>50%)(**Figure 5.2B**).

A total of 1,122 households had sufficient ITNs for one per two people in the household (11.4% of households)(**Table 5.3**). The prevalence of sufficient ITN coverage decreased with increasing wealth quintile. A higher proportion of households in rural areas had at least one ITN per two people (14.8% vs 7.7%). In Zone 1, 20.2% of households had sufficient ITNs. However, regional *Pf*PR$_{2-10}$ and EA *Pf*PR$_{2-10}$ 1-<5% categories had the highest prevalence of households with at least one ITN per two people (20.7% and 21.4% respectively).

Table 5.3: Background characteristics of households with and without at least one ITN per two people

Background characteristics	**At least one ITN per two people**	
	<1 ITN per two people No. (%)	**≥1 ITN per two people** No. (%)
Wealth quintile		
Lowest	1,451 (85.6)	245 (14.5)
Second	1,685 (86.6)	260 (13.4)
Middle	1,757 (87.3)	255 (12.7)
Fourth	1,957 (89.9)	221 (10.2)
Higher	1,874 (93.0)	141 (7.0)
Residence type		
Urban	4,395 (92.3)	368 (7.7)
Rural	4,329 (85.2)	754 (14.8)
Malaria zones		
Zone 3	3,485 (97.1)	103 (2.9)
Zone 2	1,867 (91.8)	166 (8.2)
Zone 1	3,372 (79.8)	853 (20.2)
Regional *Pf*PR$_{2-10}$		
<1%	3,370 (97.2)	97 (2.8)
1-<5%	1,136 (79.3)	296 (20.7)
≥5%	4,218 (85.3)	729 (14.7)
EA *Pf*PR$_{2-10}$		
<1%	3,382 (97.0)	105 (3.0)
1-<5%	1,204 (78.6)	327 (21.4)
≥5%	4,138 (85.7)	690 (14.3)
Total	8,724 (88.6)	1,122 (11.4)

ITN: insecticide-treated net | *Pf*PR$_{2-10}$: *Plasmodium falciparum* parasite rate in those aged two to ten years | EA: enumeration area | estimates based on total number of household members

ITN and/or IRS coverage

Across the country, 33.6% of households had at least one intervention (ITN and/or IRS) (**Table 5.2**). In the highest transmission areas, 49.0% of households had at least one intervention (**Table 5.2**). In the highest transmission areas (*Pf*PR$_{2\text{-}10}$ ≥5%), 51% of households had neither an ITN or IRS, 16.5% had IRS only, 20.6% had only an ITN and 11.9% had both an ITN and IRS (**Figure 5.3**). Households in rural areas were more likely to have at least one intervention (47.7% vs 18.6%) and a higher proportion of rural households had both interventions (14.0% vs 1.7%)(**Table 5.2**).

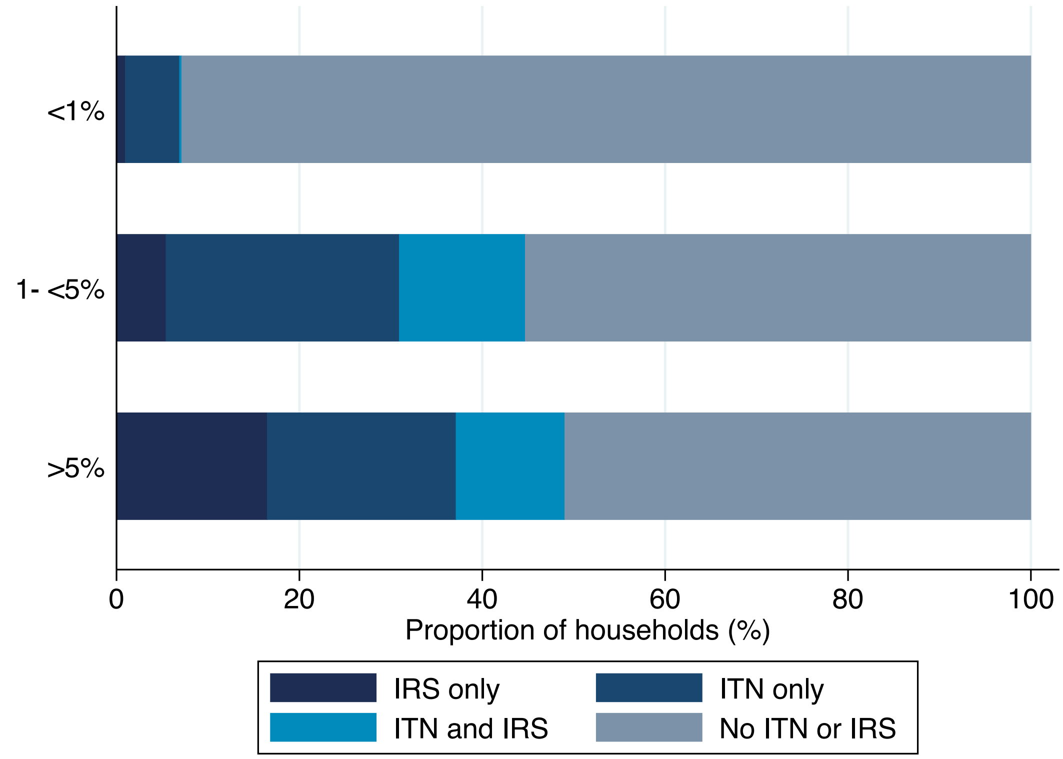


Figure 5.3: ITN and IRS coverage by *Pf*PR$_{2\text{-}10}$ category in Namibia 2013. The proportion of households in each *Pf*PR$_{2\text{-}10}$ category that had only IRS, only an ITN, an ITN and IRS and neither an ITN or IRS. ITN: insecticide-treated net | IRS: indoor residual spraying | *Pf*PR$_{2\text{-}10}$: *Plasmodium falciparum* Parasite Rate in those aged two to ten years.

5.3.3 Determinants of IRS coverage

In multivariable mixed effects analyses, regional *Pf*$PR_{2\text{-}10}$ was significantly positively associated with IRS, with households in the ≥5% category most likely to have been sprayed (RR: 14.54; 95% CI: 5.56 – 38.02; p<0.001)(**Table 5.4**). Rural residence type was also strongly significantly associated with IRS coverage (RR: 5.02; 95% CI: 3.83 – 6.58; p<0.001). Some evidence was found for a modest and positive association between wealth and IRS coverage (**Table 5.4**). However, sensitivity analyses indicated that this relationship was inconsistent across urban and rural areas (**Table 5.5**). Additional analyses showing the association between wealth, residence type and *Pf*$PR_{2\text{-}10}$ and IRS coverage with 95% CIs generated using robust standard errors are presented in **Appendix 5: Tables 1 and 2.** These results indicate no material difference from those presented in **Tables 5.4 and 5.5.**

Table 5.4: Association between IRS and exposures of interest (n=9,597)

Exposures of interest	Model 1		Model 2		Model 3	
	RR (95%CI)	*p*	RR (95%CI)	*p*	RR (95%CI)	*p*
Residence type						
Urban	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Rural	6.41 (5.56 - 7.40)	<0.001	4.53 (3.5 - 5.9)	<0.001	5.02 (3.83 - 6.58)	<0.001
Wealth quintile						
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Second	0.71 (0.63 - 0.80)	<0.001	1.12 (0.98 - 1.28)	0.097	1.16 (1.02 - 1.33)	0.029
Middle	0.50 (0.43 - 0.57)	<0.001	1.11 (0.95 - 1.30)	0.189	1.20 (1.03 - 1.40)	0.023
Fourth	0.32 (0.28 - 0.37)	<0.001	1.02 (0.84 - 1.25)	0.813	1.25 (1.03 - 1.51)	0.021
Highest	0.16 (0.13 - 0.20)	<0.001	1.11 (0.84 - 1.47)	0.449	1.63 (1.25 - 2.13)	<0.001
Regional *Pf*PR$_{2\text{-}10}$						
<1%	1.00 (reference)		1.00 (reference)		1.00 (reference)	
1-<5%	15.83 (11.40 - 22.0)	<0.001	11.00 (3.18 - 38.07)	<0.001	5.82 (1.60 - 21.22)	0.008
≥5%	23.42 (17.16 - 31.95)	<0.001	27.12 (10.76 - 68.35)	<0.001	14.54 (5.56 - 38.02)	<0.001

Model 1: univariable association between exposures of interest and IRS coverage | Model 2: Adjusted for regional and enumeration area clustering | Model 3: Additionally adjusted for all other exposures of interest in the table | RR: risk ratio | 95% CI: 95% confidence interval | EA: enumeration area | *Pf*PR$_{2\text{-}10}$: *Plasmodium falciparum* parasite rate in those aged 2 to 10 years | IRS: Indoor residual spraying

Table 5.5: Association of *Pf*PR$_{2-10}$ and wealth quintile with IRS, stratified by residence type

Exposures of interest	Urban				Rural			
	Model 1		Model 2		Model 1		Model 2	
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*
Wealth quintile								
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)	
Second	0.79 (0.27 - 2.28)	0.660	1.23 (0.41 - 3.65)	0.713	0.92 (0.81 - 1.04)	0.169	1.18 (1.03 - 1.34)	0.018
Middle	1.21 (0.44 - 3.36)	0.709	1.91 (0.68 - 5.42)	0.222	0.70 (0.61 - 0.81)	<0.001	1.16 (0.99 - 1.37)	0.071
Fourth	0.91 (0.33 - 2.51)	0.860	1.76 (0.61 - 5.06)	0.297	0.68 (0.57 - 0.81)	<0.001	1.25 (1.02 - 1.53)	0.032
Highest	0.79 (0.29 - 2.17)	0.652	2.44 (0.83 - 7.18)	0.105	0.48 (0.35 - 0.66)	<0.001	1.47 (1.03 - 2.09)	0.035
***Pf*PR$_{2-10}$**								
<1%	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)	
1-<5%	1.23 (0.51 - 2.97)	0.649	1.57 (0.26 - 9.44)	0.623	14.36 (8.39 - 24.58)	<0.001	9.86 (2.48 - 39.22)	0.001
≥5%	12.12 (8.09 - 18.16)	<0.001	11.69 (3.47 - 39.36)	<0.001	17.85 (10.54 - 30.23)	<0.001	22.14 (7.43 - 65.96)	<0.001

Model 1: Univariable | Model 2: Adjusted for enumeration area and regional clustering and adjusted for other exposures of interest in the table | RR: risk ratio | 95% CI: 95% confidence interval | IRS: Indoor residual spraying | *Pf*PR$_{2-10}$: Plasmodium falciparum parasite rate in those aged 2 to 10 years

5.3.4 Determinants of ITN ownership

In multivariable mixed effects analyses, households in the *Pf*PR_{2-10} 1-<5% category were most likely to own an ITN (RR: 5.92; 95% CI: 2.83 – 12.38; p<0.001)(**Table 5.6**). In these analyses, rural households were significantly more likely to own an ITN than urban households (RR: 1.32; 95% CI: 1.15 - 1.51; p<0.001). Again, there was some evidence to suggest a modest and positive association between wealth and ITN ownership (**Table 5.6**). However, this was not consistent across urban and rural residence types (**Table 5.7**). Results of analyses using cluster robust standard errors (**Appendix 5: Tables 3 and 4**) indicated no material difference from those presented in **Tables 5.6 and 5.7**.

Table 5.6: Association between ITN ownership and exposures of interest (n=9,846)

Exposures of Interest	Model 1		Model 2		Model 3	
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*
Residence						
Urban	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Rural	2.04 (1.87-2.23)	<0.001	1.17 (1.03 - 1.32)	0.017	1.32 (1.15 - 1.51)	<0.001
Wealth quintile						
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Second	0.88 (0.78-0.99)	0.036	1.17 (1.03 - 1.32)	0.014	1.20 (1.06 - 1.36)	0.004
Middle	0.83 (0.74-0.93)	0.002	1.32 (1.16 - 1.51)	<0.001	1.39 (1.21 - 1.58)	<0.001
Fourth	0.64 (0.56-0.72)	<0.001	1.36 (1.17 - 1.57)	<0.001	1.48 (1.27 - 1.72)	<0.001
Highest	0.42 (0.36-0.48)	<0.001	1.29 (1.08 - 1.54)	0.005	1.49 (1.23 - 1.80)	<0.001
Regional *Pf*PR$_{2\text{-}10}$						
<1%	1.00 (reference)		1.00 (reference)		1.00 (reference)	
1-<5%	6.39 (5.46-7.48)	<0.001	5.96 (2.94 - 12.12)	<0.001	5.92 (2.83 - 12.38)	<0.001
≥5%	5.26 (4.56-6.07)	<0.001	5.36 (3.19 - 9.02)	<0.001	5.32 (3.09 - 9.16)	<0.001

Model 1: univariable association between exposures of interest and ITN coverage | Model 2: Adjusted for regional and enumeration area clustering | Model 3: Additionally adjusted for all other exposures of interest in the table | RR: risk ratio | 95% CI: 95% confidence interval | EA: enumeration area | *Pf*PR2-10: *Plasmodium falciparum* parasite rate in those aged 2 to 10 years | ITN: Insecticide-treated net

Table 5.7: Association of *Pf*PR$_{2-10}$ and wealth quintile with ITN ownership, stratified by residence type (n=9,846)

Exposures of interest	Urban Model 1 RR (95% CI)	*p*	Urban Model 2 RR (95% CI)	*p*	Rural Model 1 RR (95% CI)	*p*	Rural Model 2 RR (95% CI)	*p*
Wealth quintile								
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)	
Second	1.35 (0.73 - 2.52)	0.342	1.60 (0.85 - 3.00)	0.141	0.98 (0.87 - 1.12)	0.807	1.18 (1.04 - 1.35)	0.012
Middle	1.51 (0.82 - 2.77)	0.186	1.86 (1.01 - 3.46)	0.048	0.95 (0.83 - 1.09)	0.457	1.35 (1.17 - 1.57)	<0.001
Fourth	1.13 (0.62 - 2.07)	0.686	1.78 (0.96 - 3.30)	0.068	0.95 (0.81 - 1.11)	0.510	1.56 (1.31 - 1.86)	<0.001
Highest	0.94 (0.51 - 1.72)	0.843	1.95 (1.05 - 3.64)	0.035	0.57 (0.42 - 0.77)	<0.001	1.29 (0.93 - 1.79)	0.127
***Pf*PR$_{2-10}$**								
<1%	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)	
1-<5%	5.22 (4.15 - 6.57)	<0.001	5.63 (2.50 - 12.68)	<0.001	5.13 (3.93 - 6.68)	<0.001	5.67 (2.62 - 12.26)	<0.001
≥5%	5.48 (4.55 - 6.59)	<0.001	6.19 (3.40 - 11.27)	<0.001	3.81 (2.96 - 4.92)	<0.001	4.62 (2.53 - 8.44)	<0.001

Model 1: Univariable | Model 2: Adjusted for enumeration area and regional clustering and adjusted for other exposures of interest in the table | RR: risk ratio | 95% CI: 95% confidence interval | ITN: Insecticide treated net | *Pf*PR2-10: Plasmodium falciparum parasite rate in those aged 2 to 10 years

5.3.5 Determinants of ITN and/or IRS coverage

Transmission intensity was strongly associated with intervention coverage, with households in the *Pf*PR_{2-10} ≥5% category the most likely to have at least one intervention (RR: 6.10; 95% CI: 3.74 – 9.97; $p<0.001$)(**Table 5.8**). This suggests a targeting of these interventions to the higher transmission areas. Rural residence type was also associated with a significantly higher coverage with at least one intervention (RR: 1.62; 95% CI: 1.45 – 1.81; $p<0.001$). A significant positive association between wealth and coverage with at least one intervention was observed (**Table 5.8**). Results of analyses using cluster robust standard errors (**Appendix 5: Table 5**) showed no material difference from those presented in **Table 5.8**.

Table 5.8: Association of exposures of interest with coverage of IRS and/or an ITN in Namibia in 2013 (n=9,597)

Exposure of interest	Model 1		Model 2		Model 3	
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*
Residence type						
Urban	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Rural	2.56 (2.37 – 2.77)	<0.001	1.47 (1.33 – 1.63)	<0.001	1.62 (1.45 – 1.81)	<0.001
Wealth quintile						
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Second	0.80 (0.72 – 0.88)	<0.001	1.07 (0.96 – 1.18)	0.218	1.12 (1.01 – 1.24)	0.032
Middle	0.69 (0.62 – 0.76)	<0.001	1.12 (1.01 – 1.26)	0.039	1.22 (1.10 – 1.37)	<0.001
Fourth	0.51 (0.46 – 0.57)	<0.001	1.10 (0.97 – 1.25)	0.140	1.29 (1.14 – 1.46)	<0.001
Highest	0.33 (0.29 – 0.38)	<0.001	1.07 (0.91 – 1.25)	0.416	1.36 (1.16 – 1.60)	<0.001
Regional *Pf*PR$_{2\text{-}10}$						
<1%	1.00 (reference)		1.00 (reference)		1.00 (reference)	
1-<5%	6.27 (5.41 – 7.28)	<0.001	5.72 (2.94 – 11.11)	<0.001	5.05 (2.59 – 9.85)	<0.001
≥5%	6.88 (6.03 – 7.85)	<0.001	6.96 (4.28 – 11.31)	<0.001	6.10 (3.74 – 9.97)	<0.001

Model 1: univariable association between exposures of interest and IRS and/or ITN coverage | Model 2: Adjusted for regional and enumeration area clustering | Model 3: Additionally adjusted for all other exposures of interest in the table | RR: risk ratio | 95% CI: 95% confidence interval | *Pf*PR$_{2\text{-}10}$: *Plasmodium falciparum* parasite rate in those aged 2 to 10 years | ITN: Insecticide-treated net | IRS: Indoor residual spraying

5.3.6 Patterns of transmission intensities and ITN and IRS coverage

Across the three models of transmission intensity (regional *Pf*PR$_{2-10}$, EA *Pf*PR$_{2-10}$ and MSP zones), intervention coverage did not exceed 60% (**Table 5.2**). Additionally, only 2.6% of all enumeration areas had ≥95% coverage with at least one intervention in MSP Zone 1 (**Figure 5.4**). These analyses suggest that regional transmission intensity was strongly associated with the likelihood of owning an ITN or having household IRS. MSP Zones 1 and 2 were also associated with having an ITN and IRS or either intervention in fully adjusted models (**Table 5.9**). Results using robust standard errors (**Appendix 5: Table 6**) were not materially different from those presented in **Table 5.9**.

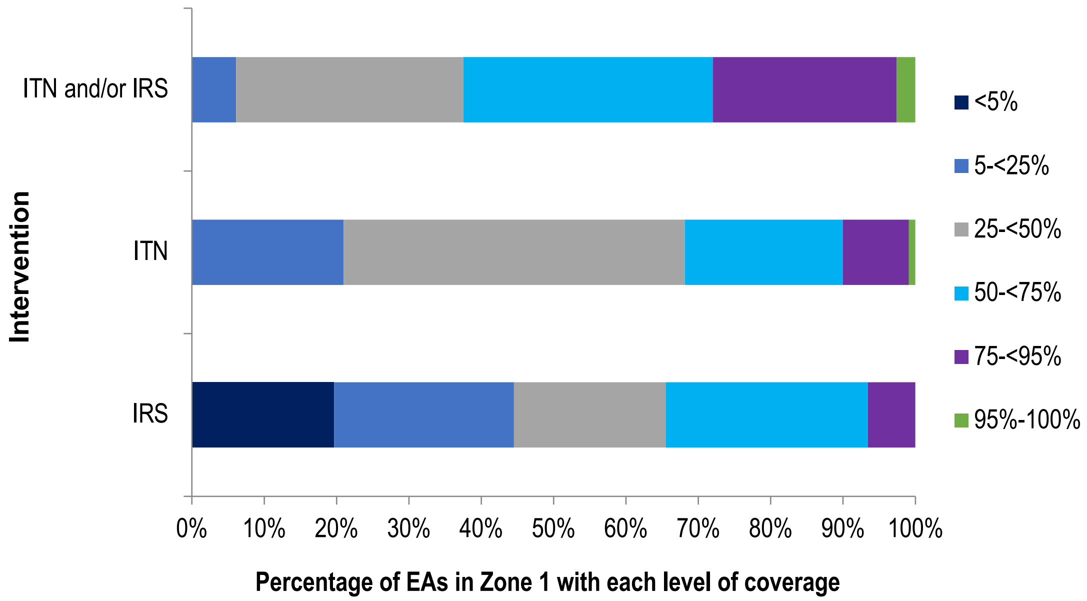


Figure 5.4: The percentage of enumeration areas in MSP Zone 1 that achieved each level of coverage for each intervention. EA: enumeration area | MSP: Malaria Strategic Plan | IRS: indoor residual spraying | ITN: insecticide-treated net.

Table 5.9: Multivariable association between vector control intervention and exposures of interest, adjusted for regional and EA clustering and other covariates, in Namibia 2013 (n=9,597)

Exposures of interest	IRS		ITN*		IRS and/or ITN	
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*
MSP Zone						
3	1.00 (reference)		1.00 (reference)		1.00 (reference)	
2	6.99 (2.93 - 16.70)	<0.001	3.11 (2.10 - 4.61)	<0.001	3.89 (2.69 - 5.62)	<0.001
1	11.62 (4.89 - 27.60)	<0.001	5.36 (3.55 - 8.09)	<0.001	5.62 (3.82 - 8.25)	<0.001
Wealth quintile						
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Second	1.16 (1.02 - 1.33)	0.026	1.21 (1.07 - 1.37)	0.003	1.12 (1.01 - 1.24)	0.026
Middle	1.21 (1.03 - 1.41)	0.019	1.40 (1.23 - 1.60)	<0.001	1.23 (1.10 - 1.38)	<0.001
Fourth	1.27 (1.05 - 1.53)	0.015	1.51 (1.30 - 1.75)	<0.001	1.31 (1.15 - 1.49)	<0.001
Highest	1.66 (1.27 - 2.17)	<0.001	1.52 (1.26 - 1.84)	<0.001	1.39 (1.18 - 1.63)	<0.001
Residence type						
Urban	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Rural	4.71 (3.59 - 6.17)	<0.001	1.27 (1.11 - 1.46)	<0.001	1.57 (1.40 - 1.75)	<0.001

*n=9,846 households

RR: risk ratio | 95% CI: 95% confidence interval | MSP: Malaria Strategic Plan | IRS: Indoor residual spraying | ITN: Insecticide-treated net | EA: enumeration area

Given government strategies for targeted distribution of ITNs and IRS, and intra-regional variations in transmission intensity, EA level transmission intensities and MSP zones were assessed to understand whether these explained the distribution of ITNs and IRS in the DHS data better than the regional *Pf*$PR_{2\text{-}10}$ model.

We first fitted a multivariable statistical model with regional *Pf*$PR_{2\text{-}10}$. Using likelihood ratio tests, we assessed whether EA *Pf*$PR_{2\text{-}10}$ improved the fit of this model, to examine whether EA *Pf*$PR_{2\text{-}10}$ better explained the variation in IRS and ITN distribution. All likelihood ratio tests found that EA *Pf*$PR_{2\text{-}10}$ did not explain the variation in ITN and IRS coverage compared with regional *Pf*$PR_{2\text{-}10}$ (p values ranged from 0.70—0.93; **Table 5.10**). This finding highlights that regional malaria transmission indices explain the distribution of ITNs and IRS in these data better than those derived at the EA level, which is consistent with the government MSP intervention strategy.

Next models were fitted using MSP zones for IRS and ITN coverage and compared them with regional *Pf*$PR_{2\text{-}10}$. All likelihood ratio tests showed that adding MSP zones statistically significantly improved the fit of the model (p values ranged from <0.001—0.009; **Table 5.10**). These analyses indicate that the Namibian Government's intervention strategy explains additional variation in the coverage of IRS and ITNs in the 2013 Namibia DHS data.

Table 5.10: Comparison of regional *Pf*PR$_{2-10}$, EA *Pf*PR$_{2-10}$ and MSP Zones for predicting the likelihood of having IRS, an ITN or either intervention (n=9,597)

Models		IRS			ITN*			IRS and/or ITN		
		RR (95% CI)	*p*	LR test *p*	RR (95% CI)	*p*	LR test *p*	RR (95% CI)	*p*	LR test *p*
Model 1:	Regional *Pf*PR$_{2-10}$	3.71 (2.29 - 6.02)	<0.001		2.20 (1.57 - 3.10)	<0.001		2.38 (1.78 - 3.19)	<0.001	
Model 2:	Regional *Pf*PR$_{2-10}$	3.86 (2.29 - 6.53)	<0.001	0.7000	2.19 (1.54 - 3.13)	<0.001	0.9347	2.42 (1.79 - 3.27)	<0.001	0.7480
	EA *Pf*PR$_{2-10}$	0.96 (0.76 - 1.20)	0.700		1.01 (0.89 - 1.13)	0.935		0.98 (0.89 - 1.08)	0.748	
Model 3:	Regional *Pf*PR$_{2-10}$	2.40 (1.41 - 4.10)	0.001	0.0091	1.43 (1.04 - 1.97)	0.029	0.0001	1.71 (1.31 - 2.34)	<0.001	<0.0001
	MSP Zone	1.69 (1.15 - 2.50)	0.008		1.69 (1.31 - 2.18)	<0.001		1.50 (1.24 - 1.81)	<0.001	

*n=9,846

RR: risk ratio | 95% CI: 95% confidence interval | *Pf*PR$_{2-10}$: *Plasmodium falciparum* parasite rate in those aged 2 to 10 years | ITN: Insecticide-treated net | IRS: Indoor residual spraying | LR test: Likelihood ratio test | LR test *p* value corresponds to a likelihood ratio test where Model 1 is nested in Model 2 and Model 3, respectively.

Model 1: Association between regional *Pf*PR$_{2-10}$ and interventions, adjusted for wealth and residence type, with region and enumeration area added as mixed effects

Model 2: Same as Model 1 but additionally adjusted for EA *Pf*PR$_{2-10}$

Model 3: Same as Model 1 but additionally adjusted for MSP Zones

5.3.7 EA model comparison

Given the varying approaches used to assign *Pf*PR_{2-10} values to EAs located I areas where no transmission was thought to occur, further sensitivity analyses were conducted to assess the impact of this on the results. Re-parameterising EA *Pf*PR_{2-10} metrics did not materially affect the estimates for the coverage of interventions (IRS, ITN, IRS and/or ITN) by EA *Pf*PR_{2-10} category (<1%, 1-<5% and ≥5%)(**Appendix 5: Table 7**).

Further, these additional EA *Pf*PR_{2-10} models did not improve upon the regional *Pf*PR_{2-10} model for predicting intervention coverage (**Appendix 5: Tables 8-10**). Assigning EAs *Pf*PR_{2-10} values of the nearest cell up to 5 Km away did not improve on the regional *Pf*PR_{2-10} model for IRS coverage (p=0.1858), ITN coverage (p=0.4534) or having either intervention (p=0.2751)(**Appendix 5: Table 8**). Additionally, accounting for EA displacement did not improve upon the regional *Pf*PR_{2-10} model for IRS coverage (p=0.5002), ITN coverage (p=0.5441) or having either intervention (p=0.6507) (**Appendix 5: Tables 11 and 12**).

5.4 Discussion

The findings presented in this chapter indicate that the prevalence of IRS and ITN interventions for malaria in 2013 did not reflect governmental malaria intervention targets in Namibia. The prevalence of at least one intervention (ITN or IRS) was around 34% across Namibia, and 49% in the highest transmission regions in 2013. These analyses highlight the need to include quantitative monitoring of such interventions, to provide a framework to reliably evaluate intervention strategies for malaria.

Operational constraints for IRS delivery have been reported previously in Namibia [258]. These constraints included a lack of community acceptability, shortage of human resources, late payments of spray men and challenges in access due to rains and flooding [258]. High levels of community acceptability of ITNs have also historically been difficult to achieve [258]. The need for the government to address operational constraints, particularly human resource capacity, to implement these interventions, has been identified [258] and may partly explain the low coverage observed in the DHS.

Low coverage of malaria control interventions is not unique to Namibia; this has also been observed in DHS reports for other southern African countries. The Zambia 2013-14 DHS found ITN coverage to be 68% and IRS coverage to be 28% [259]. In Zimbabwe, 48% of households in 2015 had an ITN and 21% had IRS [260]. Angola had a lower coverage of interventions than reported by the Namibia DHS, with 7% of households with IRS and 35% that owned an ITN in 2011 [261]. ITN coverage was higher than IRS coverage in all of these countries, consistent with the findings in Namibia.

By contrast to the 2013 Namibia DHS Report and these findings, the Namibia Ministry of Health and Social Services Annual Report 2012/13 stated that at least 93% of households received these interventions [250]. It was reported that across eight malaria regions, 669,578 households out of a targeted 719,412 structures received IRS by the end of January 2013 [250]. The report also stated that 87,900 ITNs were procured but only 7,000 ITNs were distributed at the time of the Annual Report [250]. The DHS identified around 4,300 ITNs owned by the survey households collectively, 49% of which were obtained in the previous 12 months but 37% of which were obtained more than three years prior to the survey (**Appendix 5: Table 13**).

The DHS was carried out at least four months following the end of the spray season and at the end of the malaria transmission season. As such, the survey was well timed to provide a nationally-representative estimate of the coverage of these interventions by the end of the transmission season.

One of the limitations of this analysis is that it uses data collected as part of a survey investigating a range of health and disease indices, not only malaria. Data were not collected on larviciding practices so it was not possible to include larviciding in the intervention coverage estimates. Further, differences in intervention coverage reported by the DHS and the Annual Report could be due to a lack of overlap between households surveyed in the DHS and the households reported to be sprayed in the Annual Report or targeted by the IRS program. However, the DHS surveyed approximately 2% of all households recorded in the 2011 Population and Housing Census and was designed to be nationally representative. In this context, the DHS appropriately represents the Namibian population based on national census data. Additionally, weighted analyses showed no material difference in coverage estimates.

The nature of data collection on vector control methods as part of the DHS may be a further limitation. Information on whether a household received IRS was obtained by asking a household member whether the household had been sprayed against mosquitoes in the last 12 months. It is possible that the household member who answered the question may not have remembered this event or may not have been present at the time of spraying, for example, which would result in under-reporting of IRS. It was also not possible to ascertain which specific households were targeted for spraying by the IRS program; thus these estimates may not reflect program efforts in targeted areas. However, it was observed that, as well as regional transmission intensity, MSP target zones additionally explained the variation in ITN and IRS in the DHS data.

Information on ITN ownership and use was gathered from survey questions, in addition to an inventory conducted by the interviewer. The number of ITNs could have been underestimated if not all the ITNs originally distributed were shown to the interviewer, for example, or if the nets were discarded, sold, or used for other purposes, as has been reported elsewhere [262-265]. The number of ITNs may also have been overestimated, as not all ITNs reported as part of the DHS were actually observed by the interviewer. The source of the ITNs is also unknown. Whilst these factors together may result in some uncertainty around the estimates of IRS and ITN coverage, they are unlikely to fully account for the difference between estimates provided by the DHS data and governmental reports.

Study inferences may also be limited by the classification of regions and EAs based on MAP data. MAP *Pf*$PR_{2\text{-}10}$ values are predicted values and do not necessarily reflect actual levels of transmission intensity in 2013. Using MAP data, Zambezi is classified as being in the 1-<5% regional *Pf*$PR_{2\text{-}10}$ category; however, other studies and reports have identified this as one of the higher risk regions in Namibia [249, 258, 266]. Re-categorising Zambezi resulted in only a minor increase in ITN and IRS coverage of no more than 4% for any intervention in the highest transmission regions (**Appendix 5: Table 14**). *Pf*$PR_{2\text{-}10}$ data were also analysed at both EA and regional levels, with regional level analyses found to better explain variation in ITN and IRS distribution in the DHS data—suggesting that finer-scale geographical data on transmission intensity data does not explain these patterns of ITN and IRS distribution.

The two conflicting reports and data suggest a need for improved monitoring and evaluation of vector control programmes in Namibia. There are limitations to both data sources, which suggests a lack of appropriate data to analyses the coverage of interventions for malaria. The Ministry of Health and Social Services Annual Report 2012/13 lacked information on how these data were collected. We therefore do not know how representative these findings are or how they relate the MSP target zones. On the other hand, the DHS, although it is a nationally representative survey, it was not designed for the purpose of evaluating control programmes in Namibia and, as aforementioned, there may therefore be lack of overlap with households targeted for the malaria control programme and there may be under reporting of ITNs and IRS, amongst other possible explanations. As such, more appropriate data are needed to better evaluate malaria control programmes in Namibia.

In conclusion, these findings indicate that the prevalence of IRS and ITN interventions for malaria in 2013 did not reflect governmental malaria intervention targets in Namibia. The WHO recommends that "Malaria control and elimination programmes should prioritise delivering either LLINs or IRS at high coverage and to a high standard rather than introducing the second intervention as a means of compensating for deficiencies in the implementation of the first"[267]. Given the relatively low malaria transmission in Namibia and the operational challenges of delivering vector control interventions, it will be relevant to identify the barriers to implement interventions or prioritise the implementation of a single intervention. As countries such as Namibia work towards malaria elimination, high coverage of vector control interventions will be critical, not only to reduce the incidence of malaria but also to prevent resurgence. Such efforts will require quantitative monitoring to assess implementation and provide a framework to reliably evaluate the effectiveness of these interventions and inform future strategies for malaria elimination.

6. Barriers to healthcare for women in Namibia: the user perspective

Summary

Background: As Namibia's small population is distributed across its vast landscape, some populations may have to travel long distances to reach health facilities. Geographical inaccessibility of health facilities presents a barrier to healthcare in SSA. Geographical inaccessibility can be assessed in a number of ways but here, the perceptions of inaccessibility are investigated. Perceptions of distance as a barrier to healthcare are not well understood in Namibian populations. Therefore, this chapter aims to explore the geographical barriers to healthcare from the perspective of women.

Methods: Data on 9,981 women from the 2013 Namibia DHS were used to explore the prevalence of four perceived barriers to healthcare. Multivariable mixed effects Poisson regression analyses were conducted to explore the association between age, education, wealth, residence type, marital status, occupation and health insurance, and reporting distance as a barrier to healthcare. In fully-adjusted models, region, enumeration area and household were included as mixed effects and all covariates were adjusted for.

Results: Overall, 45.6% of women experienced at least one barrier to healthcare with 32.9% reporting distance as a barrier. Reporting of distance as a barrier was positively associated with rural residence type (RR: 1.69; 95% CI: 1.49 – 1.92; p<0.001) and age (45–49 age group RR: 1.30 95% CI: 1.10 – 1.53; p=0.002) and was inversely associated with education (higher education RR: 0.74 95% CI: 0.58 – 0.96; p=0.023) and wealth (highest wealth quintile RR: 0.35; 95% CI: 0.28 – 0.42; p<0.001). Insured women were less likely to report distance as a barrier to healthcare (RR: 0.74; 95% CI: 0.59 – 0.93; p=0.010). There was evidence to suggest that wealth modified the association between residence type and reporting distance as a barrier to healthcare, with a greater magnitude of association between rural residence type and distance barriers with increasing wealth (p for interaction <0.001). There was also evidence for a statistical interaction between education and wealth in the association with reporting distance as a barrier (p for interaction =0.019)

Conclusions: Almost half of women experienced at least one barrier to healthcare and distance to health facilities was a problem for a third of women in this DHS population. Rural residence type, low education levels, lower relative wealth and being uninsured were independently associated with reporting distance as a barrier to healthcare. Further research is needed to explore physical inaccessibility using objective measures such as distance and travel time.

6.1 Introduction

One of the most commonly reported barriers to healthcare access in LMICs is the distance to health facilities and transport costs [61, 69-76, 78]. Individuals living in rural or remote areas are often particularly disadvantaged in accessing healthcare [73, 75, 94, 99-101]. Geographical inaccessibility of health facilities has been linked to delays in diagnosis and treatment initiation and lower utilisation of health services [81-85]. Therefore, ensuring that health services are physically accessible to populations is an important factor in achieving equity in healthcare.

Namibia's small population is dispersed over a large geographical area [120], with clustering of the population in certain areas [9]. A large proportion of the Namibian population is located in inaccessible areas with some estimated to have to travel more than eight hours to the nearest settlement comprising more than 50,000 people [9]. Geographical barriers are likely to be exacerbated by the lack of transport options in the country [143]. Some communities lack access to permanent health infrastructure [3]. Outreach services are used to reach more remote communities; however, the coverage of these services is variable across regions and may be limited to certain types of healthcare provision [3]. It is therefore important to explore the physical accessibility of health facilities in Namibia as a key component of healthcare access.

In LMICs, women are often particularly disadvantaged when seeking healthcare because of social issues; for example, needing permission or not wanting to attend a health facility alone [69]. Women also need to be able to access formal health facilities in a timely manner during pregnancy, but long distances and travel times to health facilities prevent women accessing maternal health services and having skilled attendance at birth [70, 71, 268]. Geographical barriers also present challenges for healthcare access for children, with implications for child survival [78]. In Namibia, health service utilisation for fever symptoms in children under five decreased with travel times of more than three hours to health facilities [114]. In Namibia, women living with HIV/AIDS have been found to be burdened by transport costs, which add to the expense of treatment for HIV/AIDS, the leading cause of death in the country, which also disproportionately affects women [143]. Therefore, long travel times and distances to health facilities can have implications for woman and child health.

Existing studies of healthcare barriers in Namibia have largely focused on health-seeking for specific disease outcomes or health services [92, 114, 116, 117]. Health seeking behaviour may be influenced by the severity of the disease outcome, thus there is a need to understand healthcare barriers more broadly, irrespective of the reason for seeking care. The DHS asks questions to women regarding the factors that they perceive to be a problem for them when seeking healthcare. Therefore, this chapter aimed to explore barriers to healthcare access more broadly, not relative to a specific health service need. Furthermore, in addition to assessing the prevalence of healthcare barriers, investigating the sociodemographic patterns of reporting these healthcare barriers helps to understand equity in healthcare access. This may help to inform the targeting of resources and the design of strategies to close gaps in healthcare access at the population level.

Using data from the 2013 Namibia DHS, this chapter specifically aimed to:

i. Explore the prevalence of reporting various barriers to healthcare amongst women;
ii. Assess the sociodemographic factors associated with geographical barriers among women.

6.2 Methods

6.2.1 Data sources

Data from the 2013 Namibia DHS were obtained from the DHS Program. Methodology of the 2013 Namibia DHS is detailed elsewhere [120], and in **Chapter 2**. The DHS collected data via three surveys: the Household Questionnaire, Man's Questionnaire and the Woman's Questionnaire. Women aged 15–49 residing in all pre-selected households and women aged 50–64 in half of selected households were eligible for the Woman's survey giving a total of 10,018 respondents; data from which was used in these analyses [120].

As part of the Woman's Questionnaire, women were asked whether certain factors were a big problem or not a problem when seeking healthcare for themselves. These factors included distance to the health facility (geographical barrier), getting money for treatment (financial barrier), needing permission to go to a health facility and not wanting to go alone (social barriers). Questions pertaining to healthcare barriers were not asked to men.

Shapefiles for administrative boundaries were obtained from DIVA-GIS [269], originally sourced from the Database of Global Administrative Areas (GADM) [254]. All maps presented in this chapter are displayed in CRS WGS84 therefore scale bars are approximate.

6.2.2 Defining perceived barriers to healthcare

This analysis explored the perceived barriers to healthcare. The perception of barriers is the opinion of the individual in question as to whether they consider distance, getting money for treatment, needing permission or not wanting to go to a health facility alone a “big problem” when seeking medical help for themselves. Perceived barriers to do not necessarily reflect actual differences in abilities to access healthcare between individuals.

6.2.3 Statistical analyses

All analyses were carried out using Stata 14 software package (StataCorp: College Station, TX, USA). The Household, Woman’s and Man’s datasets were merged and data were cleaned. Only women were included in these analyses as questions pertaining to perceived barriers to healthcare access were only asked as part of the Woman’s Questionnaire.

A total of 9,981 women who answered questions pertaining to problems in seeking healthcare and who also had information on age, education, wealth, residence type, marital status, occupation and health insurance were included in these analyses. Data on age, education, marital status, occupation and health insurance obtained in the individual Woman’s Questionnaire were used. Data on wealth and residence type were obtained as part of the Household Questionnaire dataset. Age was recoded into five year groups, with those aged 50–64 years categorised into one age group to reduce the number of parameters in the age variable. Marital status was recoded so that those who were widowed, divorced or no longer living together were categorised as “formerly married”. The occupation variable was recoded into four categories: Professional (including clerical, sales and services), agricultural (including self-employed and employee), manual (including skilled and unskilled) and unemployed.

To explore outpatient health seeking behaviour, a variable for whether individuals did or did not seek outpatient care in the four weeks preceding the survey was generated. This was done based on the line number of the individual who sought care. Individuals whose line number matched that of the variable for the line number of the person seeking outpatient care were coded as “1” and those whose line numbers did not match were coded as “0” (not having sought outpatient care). This was repeated for inpatient care in a separate analysis.

The prevalence and determinants of reporting of geographical barriers to healthcare access in this DHS population were explored. Categorical data were presented as a frequency and percentage. *P* values were calculated using a chi-squared test for categorical variables. Adjusted prevalence of healthcare barriers were estimated using marginal standardisation. Intraclass correlation coefficients (ICCs) were calculated to assess the clustering of categorical risk factors and outcomes of interest at the household, EA and regional level.

The association between reporting of each barrier to healthcare and inpatient and outpatient care was assessed in Poisson regression analyses. Fully-adjusted models are presented, which adjusted for age, education, wealth, residence type, marital status, and health insurance, and accounted for household, EA and regional clustering.

As the primary focus was geographical barriers to healthcare, Poisson regression analyses were conducted to explore the sociodemographic factors associated with reporting distance as a barrier to healthcare. Model 1 constituted a univariable analysis exploring the association between each covariate (age, education, wealth, residence type, marital status, occupation and health insurance) and reporting distance as a problem. Model 2 involved a mixed effects Poisson regression analysis to explore the association between each covariate and distance as a barrier to healthcare with region, EA and household included as mixed effects. In Model 3, I adjusted for all other covariates in addition to accounting for household, EA and regional clustering as in Model 2. For mixed effects models, 95% confidence intervals (95% CIs) were generated using cluster-robust standard errors.

Additionally, fully-adjusted analyses were stratified by levels of wealth, education, urban and rural residence type and health insurance status, to assess effect modification. I also assessed whether there was statistical evidence of interaction between education and residence type, wealth and residence type, education and wealth and health insurance and wealth, in regards to their association with reporting distance as a healthcare barrier, using likelihood ratio tests to compare models with and without an interaction term.

In additional analyses (**Appendix 3**), I used language as proxy for ethnicity by recoding the variable for the main language spoken in the home into five groups: Afrikaans, Damara/Nama, Herero, Oshiwambo and “other”, which included small populations of English, San, Kwagali and Lozi. In these additional analyses I explored the prevalence of reporting distance as a barrier by ethnicity and the association between ethnicity and accessibility barriers to healthcare.

6.3 Results

6.3.1 Completeness of data

A total of 9,981 women with complete information on barriers to healthcare and sociodemographic factors of interest were included in this analysis (**Table 6.1**). A total of 37 (0.4%) women who did not have information on healthcare barriers, occupation or health insurance were excluded on this basis. The proportion of individuals excluded was similar between those who did and did not report each barrier to healthcare. The proportion of those excluded was slightly more variable by age group.

Table 6.1: Completeness of data from individual questionnaires used in this chapter

Outcomes and sociodemographic characteristics	Overall No. (%)	Included No. (%)	Excluded No. (%)	*p*
Overall	10,018 (100.0)	9,981 (99.6)	37 (0.4)	
Distance barrier				
No	6,715 (100.0)	6,695 (99.7)	20 (0.3)	<0.001
Yes	3,299 (100.0)	3,286 (99.6)	13 (0.4)	
Missing	4 (100.0)	0 (0.0)	4 (100.0)	
Getting money for treatment				
No	7,043 (100.0)	7,021 (99.7)	22 (0.3)	<0.001
Yes	2,970 (100.0)	2,960 (99.7)	10 (0.3)	
Missing	5 (100.0)	0 (0.0)	5 (100.0)	
Needing permission				
No	9,373 (100.0)	9,341 (99.7)	1 (0.2)	<0.001
Yes	641 (100.0)	640 (99.8)	32 (0.3)	
Missing	4 (100.0)	0 (0.0)	4 (100.0)	
Not wanting to go alone				
No	8,550 (100.0)	8,527 (99.7)	23 (0.3)	<0.001
Yes	1,461 (100.0)	1,454 (99.5)	7 (0.5)	
Missing	7 (100.0)	0 (0.0)	7 (100.0)	
Age group				
15 – 19	1,857 (100.0)	1,854 (99.8)	3 (0.2)	0.114
20 – 24	1,720 (100.0)	1,716 (99.8)	4 (0.2)	
25 – 29	1,495 (100.0)	1,489 (99.6)	6 (0.4)	
30 – 34	1,262 (100.0)	1,256 (99.5)	6 (0.5)	
35 – 39	1,146 (100.0)	1,138 (99.3)	8 (0.7)	
40 – 44	942 (100.0)	940 (99.8)	2 (0.2)	
45 – 49	754 (100.0)	748 (99.2)	6 (0.8)	
50 – 64	842 (100.0)	840 (99.8)	2 (0.2)	

P value corresponds to a chi-squared test

6.3.2 Study population

Of the 9,981 women included in these analyses the proportion of women in each age group decreased with increasing age group (**Table 6.2**). The majority of women were educated to secondary level (62.3%), followed by primary level (23.0%). The proportion of women in each wealth quintile ranged from 16.4% in the lowest quintile to 23.5% in the fourth quintile. There was a fairly even distribution by residence type with 51.5% of the population in urban areas. Most women were never married (53.3%), 16.7% lived with a partner and 21.2% were currently married. Over half of women were unemployed (56.0%) and 83.8% were uninsured.

Table 6.2: Background characteristics of women

Sociodemographic characteristics	No. (%)
Age group	
15 – 19	1,845 (18.6)
20 – 24	1,716 (17.2)
25 – 29	1,489 (14.9)
30 – 34	1,256 (12.6)
35 – 39	1,138 (11.4)
40 – 44	940 (9.4)
45 – 49	748 (7.5)
50 – 64	840 (8.4)
Education level	
No education	722 (7.2)
Primary	2,296 (23.0)
Secondary	6,221 (62.3)
Higher	742 (7.4)
Wealth quintile	
Lowest	1,632 (16.4)
Second	1,815 (18.2)
Middle	2,045 (20.5)
Fourth	2,345 (23.5)
Highest	2,144 (21.5)
Residence type	
Urban	5,140 (51.5)
Rural	4,841 (48.5)
Marital status	
Never married	5,317 (53.3)
Currently married	2,119 (21.2)
Living with partner	1,667 (16.7)
Formerly/ ever married	878 (8.8)
Occupation	
Professional	3,823 (38.3)
Agricultural	202 (2.0)
Manual	372 (3.7)
Unemployed	5,584 (56.0)
Health insurance	
No	8,362 (83.8)
Yes	1,619 (16.2)
Total	9,981 (100.0)

6.3.3 Perceived barriers to healthcare

The leading reported barrier to healthcare access was the distance to the health facility (geographical barrier)(32.9%), followed by getting money for treatment (financial barrier)(29.7%) (**Table 6.3**). Social access barriers included not wanting to go to a health facility alone (14.6%) and the need for permission to go to the facility (6.4%).

Table 6.3: Barriers to healthcare access reported by women

Barrier to healthcare access	**Not considered a big problem** No. (%)	**Considered a big problem** No. (%)	**Total** No. (%)
Geographical barrier			
Distance to health facility	6,695 (67.1)	3,286 (32.9)	9,981 (100.0)
Financial barrier			
Getting money for treatment	7,021 (70.3)	2,960 (29.7)	9,981 (100.0)
Social barriers			
Needing permission	9,341 (93.6)	640 (6.4)	9,981 (100.0)
Not wanting to go alone	8,527 (85.4)	1,454 (14.6)	9,981 (100.0)

When adjusted for age as well as regional, EA and household clustering, the prevalence of reporting distance as a healthcare barrier was reduced to 27.1% (21.1 – 33.1%)(**Table 6.4**). The prevalence of reporting cost as a barrier was 25.9% (20.1 – 31.7%), needing permission was 4.7% (3.5 – 5.9%) and not wanting to go alone to a health facility was 10.8% (8.1 – 13.4%). However, the prevalence of reporting distance as a barrier was still the highest amongst women, followed by getting money for treatment.

Table 6.4: Crude and adjusted prevalence of barriers to healthcare

Barriers to healthcare access	**Crude** % (95% CI)	**Adjusted** % (95% CI)
Geographical barrier		
Distance to health facility	32.9 (32.0 - 33.9)	27.1 (21.1 - 33.1)
Financial barrier		
Getting money for treatment	29.7 (28.8 - 30.6)	25.9 (20.1 - 31.7)
Social barriers		
Needing permission	6.4 (6.0 - 6.9)	4.7 (3.5 - 5.9)
Not wanting to go alone	14.6 (13.9 - 15.3)	10.8 (8.1 - 13.4)

Adjusted prevalence estimates are adjusted for age and regional, EA and household clustering

6.3.4 Co-occurrence of barriers

As women were asked consecutively whether each potential barrier was a problem for them, I assessed the co-occurrence of these barriers amongst the women to understand to what extent women reported more than one barrier to healthcare. Almost half of women reported at least one barrier to healthcare (45.6%); 19.2% reported one problem, 16.9% reported two, 7.4% reported three and just 2.1% reported all four barriers (**Figure 6.1**).

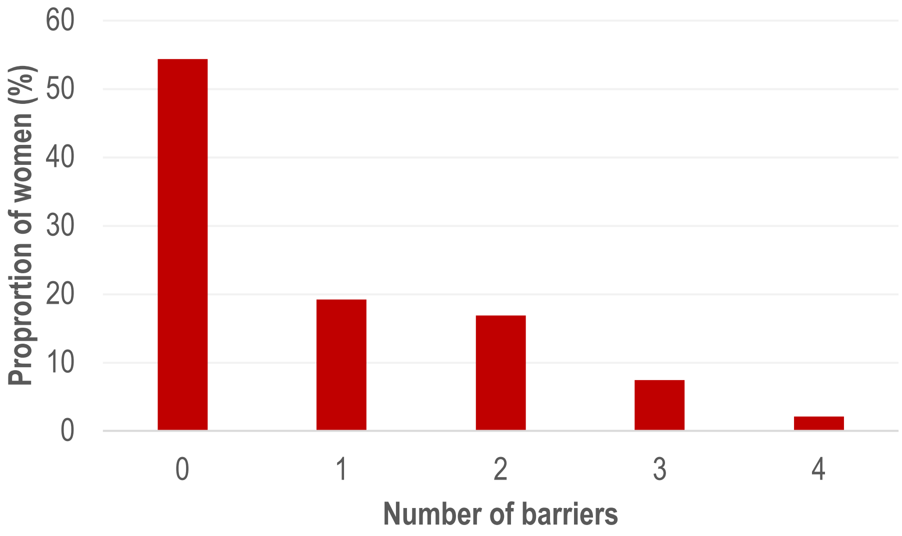


Figure 6.1: The number of barriers reported by 9,981 women from the 2013 Namibia DHS.

Of the women who reported barriers to healthcare, 11% reported both distance and getting money for treatment to be a problem (**Figure 6.2**). Around 3% reported distance and not wanting to go alone as problems. Notably, 6% of women reported that distance, getting money for treatment and not wanting to go to a facility alone were problems for them.

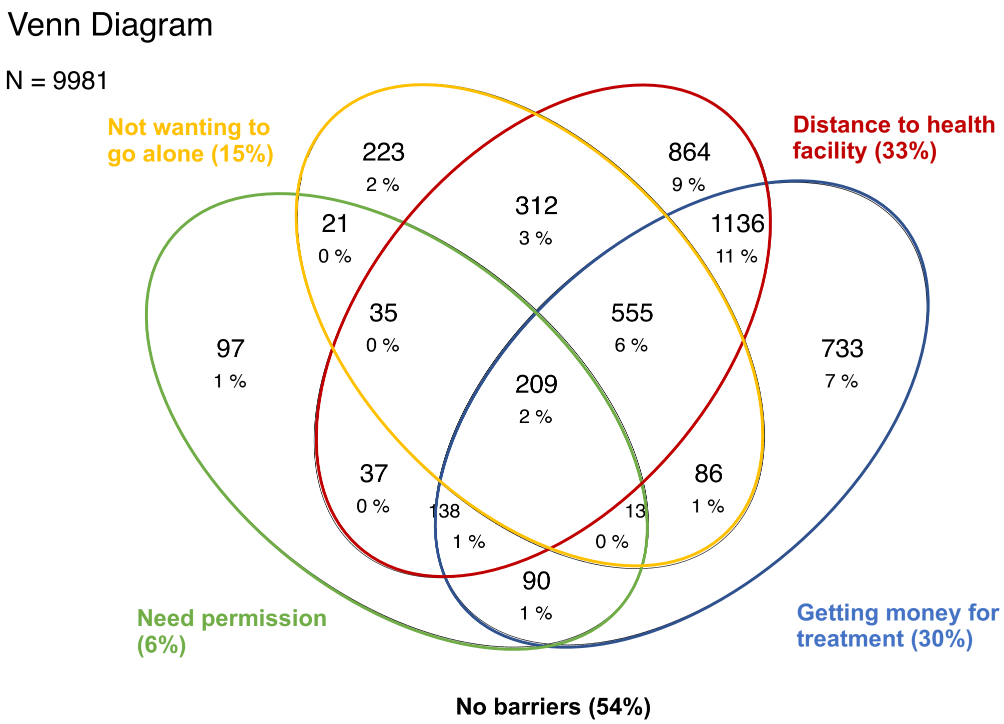


Figure 6.2: Venn diagram showing the co-occurrence of barriers reported by women.

The proportion of women who reported at least one barrier to healthcare declined with increasing education level and increasing wealth quintile (p<0.001)(**Figure 6.3**). The proportion of women who reported at least one healthcare barrier declined from 73.7% in those with no education to 20.6% of women with higher education and declined from 75.0% of women in the lowest quintile to 20.3% in the highest quintile.

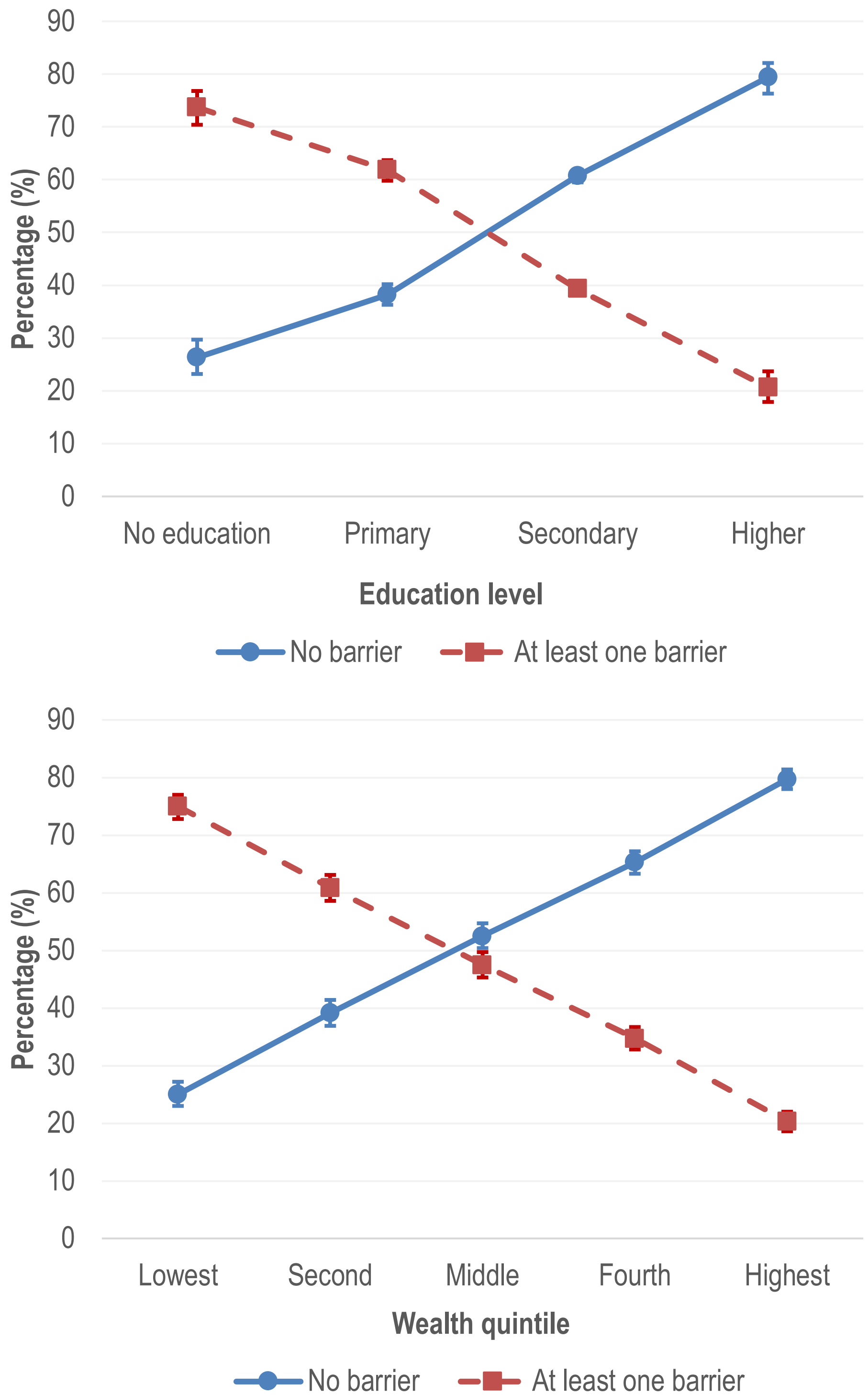


Figure 6.3: The proportion of women at each level of education and wealth that reported no barriers or at least one barrier to healthcare (n=9,981).

6.3.5 Clustering of healthcare barriers and sociodemographic factors

The clustering of healthcare barriers and sociodemographic factors by household, EA and region were assessed using ICCs (**Table 6.5**). There was evidence for clustering of healthcare barriers at the household and EA level and weak evidence of clustering at the regional level. All barriers were most strongly clustered at the household level, with distance and getting money for treatment being the most clustered (distance ICC: 0.38; 95% CI: 0.35 – 0.41; cost ICC: 0.28; 95% CI: 0.24 – 0.31).

Age was not clustered at any level, education was clustered at all levels but most strongly at the household level (ICC: 0.37; 95% CI: 0.34 – 0.40). Wealth was highly clustered at the EA level (ICC: 0.70; 95% CI: 0.67 – 0.73) and the regional level. There was also modest evidence for clustering of marital status, occupation and health insurance across all levels.

Table 6.5: Clustering of healthcare barriers and sociodemographic factors by region, EA and household (n=9,981)

	Household ICC (95% CI)	EA ICC (95% CI)	Region ICC (95% CI)
Healthcare barriers			
Distance	0.38 (0.35 – 0.41)	0.26 (0.23 – 0.29)	0.07 (0.02 – 0.13)
Getting money for treatment	0.28 (0.24 – 0.31)	0.19 (0.17 – 0.21)	0.10 (0.03 – 0.17)
Need permission	0.18 (0.15 – 0.22)	0.06 (0.05 – 0.07)	0.02 (0.00 – 0.03)
Not wanting to go alone	0.19 (0.15 – 0.22)	0.14 (0.12 – 0.16)	0.04 (0.01 – 0.07)
Sociodemographic factors			
Age group	0.00 (0.00 – 0.04)	0.02 (0.01 – 0.02)	0.01 (0.00 – 0.01)
Education level	0.37 (0.34 – 0.40)	0.23 (0.21 – 0.26)	0.11 (0.03 – 0.20)
Wealth quintile	N/A	0.70 (0.67 – 0.73)	0.32 (0.15 – 0.50)
Residence type	N/A	N/A	0.36 (0.17 – 0.54)
Marital status	0.04 (0.00 – 0.08)	0.08 (0.06 – 0.09)	0.05 (0.01 – 0.09)
Occupation	0.15 (0.11 – 0.18)	0.12 (0.11 – 0.14)	0.06 (0.01 – 0.11)
Health insurance	0.30 (0.27 – 0.33)	0.19 (0.17 – 0.22)	0.05 (0.01 – 0.08)

EA: enumeration area | ICC: intraclass correlation coefficient | 95% CI: 95% Confidence Interval | N/A: variable not measured at corresponding level

6.3.6 Healthcare barriers and health service utilisation

Healthcare barriers were explored in relation to health service utilisation. Distance, getting money for treatment and not wanting to go alone to health facilities were positively associated with seeking outpatient care in the four weeks prior to the survey, irrespective of all sociodemographic factors and clustering (**Figure 6.4**). Reporting distance as a healthcare barrier was most strongly associated with outpatient care (RR: 1.34; 95% CI: 1.18 – 1.51; p<0.001). There was no evidence of association between healthcare barriers and inpatient care.

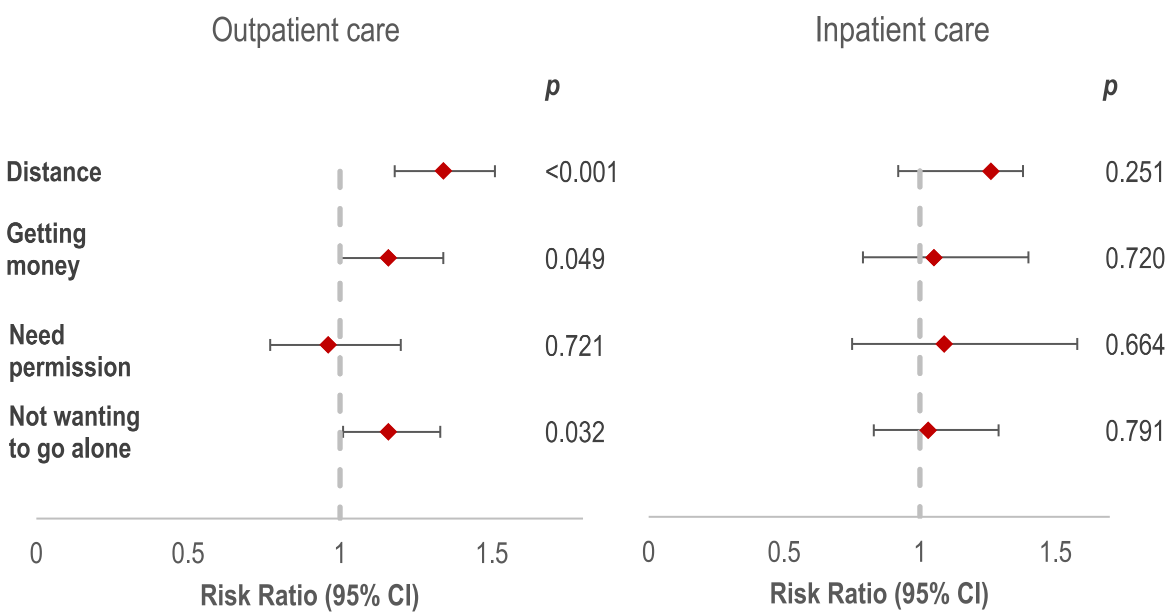


Figure 6.4: Association between healthcare barriers and outpatient care sought in the four weeks prior to the survey and inpatient care sought in the six months prior to the survey (n=9,981). Risk ratios correspond to a fully adjusted model, adjusted for age, education, wealth, residence type, marital status, occupation and health insurance status as well as accounting for household, enumeration area and regional clustering. 95% CI: 95% Confidence Interval.

6.3.7 Regional differences in accessibility

As geographical barriers to healthcare were the most widely reported by this female population, the sociodemographic determinants of reporting distance as a barrier were explored further.

Regional differences in the prevalence of reporting geographical barriers to healthcare were observed, with the highest proportion of women finding distance to be a problem in the Kavango region (55.8%), followed by the Ohangwena region (51.5%)(**Figure 6.5**). The lowest reporting of distance as a barrier was in the Erongo region at 13.2%, followed by 18.9% in Khomas.

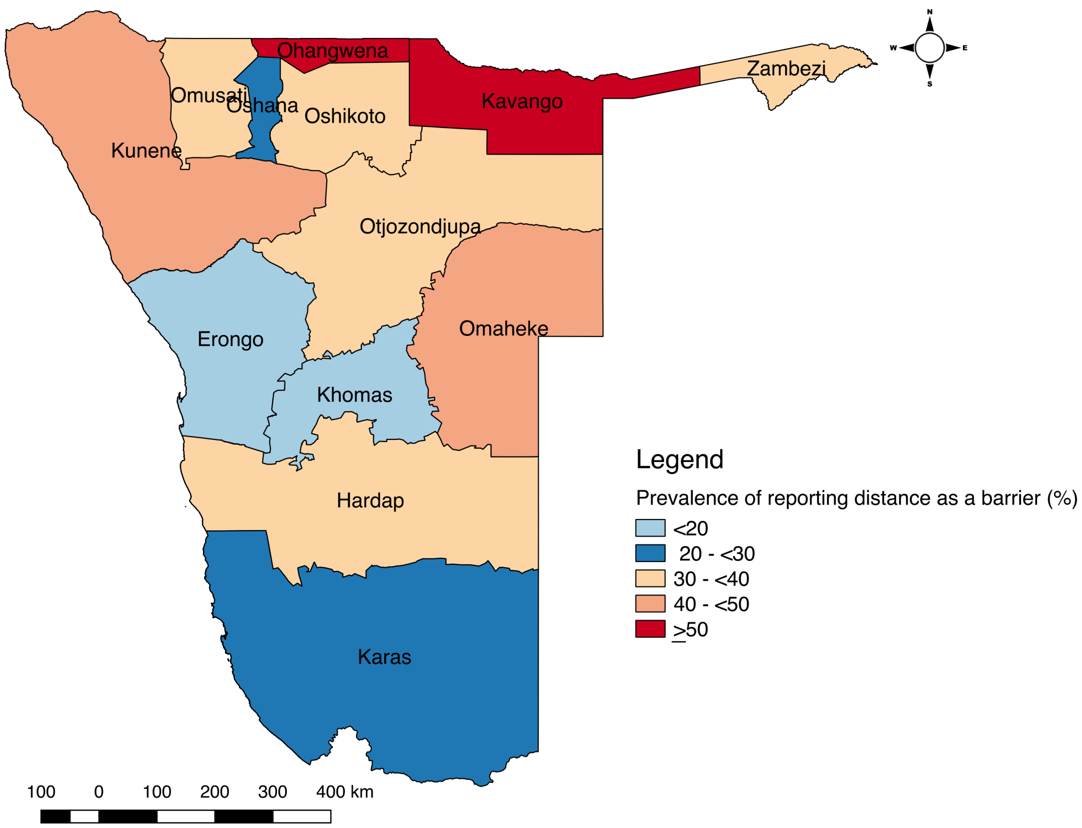


Figure 6.5: Regional prevalence of reporting of distance as a barrier to healthcare (n=9,981).

6.3.8 Sociodemographic determinants of distance barriers

The prevalence of reporting of distance barriers increased with age ($p<0.001$)(**Table 6.6**) and was substantially higher in rural areas (47.7% of vs 19.0%). The prevalence of reporting distance as a barrier to healthcare decreased with increasing levels of education and wealth, suggesting that poorer and less educated women experience greater geographical challenges accessing healthcare. Reporting of distance barriers was highest in those formerly married (40.4%) or living with a partner (40.3%). Distance was a problem for 46.0% of those in agricultural employment, possibly a reflection of urban-rural differences in perceptions of distance barriers. Distance barriers were most widely reported amongst the unemployed (38.5%) and were lowest among those in professional and manual occupations (24.8% and 25.3%, respectively). Distance was a greater problem amongst the uninsured (36.9%) compared to those with health insurance (12.5%).

In a subset of 9,975 individuals with data on ethnicity, I observed that the prevalence of reporting distance as a barrier to healthcare was highest amongst the "other" category at 44.1%, followed by the Herero population (39.6%)(**Appendix 3; Table 5**). Reporting distance as a barrier was lowest amongst the Afrikaans population at 12.1% ($p<0.001$).

Table 6.6: Factors that may contribute to reporting of distance being a problem when seeking medical help for self (n=9,981)

Sociodemographic characteristics	Distance is a problem when seeking medical help for self		
	No No. (%)	Yes No. (%)	***p***
Age group			
15 – 19	1,295 (69.9)	559 (30.2)	<0.001
20 – 24	1,175 (68.5)	541 (31.5)	
25 – 29	1,008 (67.7)	481 (32.3)	
30 – 34	869 (69.2)	387 (30.8)	
35 – 39	745 (65.5)	393 (34.5)	
40 – 44	627 (66.7)	313 (33.3)	
45 – 49	476 (63.6)	272 (36.4)	
50 – 64	500 (59.5)	340 (40.5)	
Education level			
No education	283 (39.2)	439 (60.8)	<0.001
Primary	1,209 (52.7)	1,087 (47.3)	
Secondary	4,554 (73.2)	1,667 (26.8)	
Higher	649 (87.5)	93 (12.5)	
Wealth quintile			
Lowest	622 (38.1)	1,010 (61.9)	<0.001
Second	964 (53.1)	851 (46.9)	
Middle	1,340 (65.5)	705 (34.5)	
Fourth	1,843 (78.6)	502 (21.4)	
Highest	1,926 (89.8)	218 (10.2)	
Residence type			
Urban	4,163 (81.0)	977 (19.0)	<0.001
Rural	2,532 (52.3)	2,309 (47.7)	
Marital status			
Never married	3,705 (69.7)	1,612 (30.3)	<0.001
Currently married	1,472 (69.5)	647 (30.5)	
Living with partner	995 (58.7)	672 (40.3)	
Formerly/ ever married	523 (59.6)	355 (40.4)	
Occupation			
Professional	2,875 (75.2)	948 (24.8)	<0.001
Agricultural	109 (54.0)	93 (46.0)	
Manual	278 (75.7)	94 (25.3)	
Unemployed	3,433 (61.5)	2,151 (38.5)	
Health insurance			
No	5,278 (63.1)	3,084 (36.9)	<0.001
Yes	1,417 (87.5)	202 (12.5)	
Total	6,695 (67.1)	3,286 (32.9)	

P value corresponds to a chi-squared test

In the fully-adjusted model (Model 3), those in rural areas were notably more likely to report distance barriers (RR: 1.70; 95% CI: 1.39 – 2.08; $p<0.001$)(**Table 6.7**). There was a modest positive association with age. Wealth and education were inversely associated with reporting distance as a problem for accessing healthcare. This suggests that the less wealthy and less well educated are more likely to experience problems seeking healthcare due to the distance to health facilities.

Marital status and occupation were not significantly associated with distance barriers, although the unemployed were more likely to experience distance as a problem (RR: 1.07; 95% CI: 1.02 – 1.12; $p=0.003$). Those who had health insurance were significantly less likely to experience distance barriers than the uninsured (RR: 0.69; 95% CI:0.56 – 0.84; $p=0.001$).

In a subset of 9,975 individuals with data on ethnicity, the Herero population were most likely to report distance as a barrier to healthcare (RR: 1.67; 95% CI: 1.51 – 1.84; $p<0.001$). The Afrikaans population were least likely to report distance as a barrier (**Appendix 3**; **Table 6**).

Table 6.7: Association between reporting of distance as a barrier and exposures of interest (n=9,981)

Sociodemographic characteristics	Model 1		Model 2		Model 3	
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*
Age group						
15 – 19	1.00 (reference)		1.00 (reference)		1.00 (reference)	
20 – 24	1.05 (0.93 – 1.18)	0.459	1.11 (0.97 – 1.26)	0.135	1.17 (1.03 – 1.33)	0.014
25 – 29	1.07 (0.95 – 1.21)	0.268	1.13 (1.00 – 1.29)	0.058	1.18 (1.04 – 1.35)	0.014
30 – 34	1.02 (0.90 – 1.16)	0.743	1.09 (0.92 – 1.28)	0.325	1.16 (0.99 – 1.35)	0.063
35 – 39	1.15 (1.01 – 1.30)	0.039	1.18 (1.05 – 1.33)	0.005	1.23 (1.11 – 1.36)	<0.001
40 – 44	1.10 (0.96 – 1.27)	0.160	1.16 (1.01 – 1.32)	0.038	1.22 (1.06 – 1.40)	0.006
45 – 49	1.21 (1.04 – 1.39)	0.011	1.23 (1.06 – 1.42)	0.006	1.30 (1.13 – 1.49)	<0.001
50 – 64	1.34 (1.17 – 1.54)	<0.001	1.29 (1.14 – 1.47)	<0.001	1.22 (1.09 – 1.37)	0.001
Education level						
No education	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Primary	0.78 (0.70 – 0.87)	<0.001	0.86 (0.78 – 0.95)	0.004	0.91 (0.83 – 1.00)	0.041
Secondary	0.44 (0.40 – 0.49)	<0.001	0.63 (0.56 – 0.70)	<0.001	0.77 (0.71 – 0.83)	<0.001
Highest	0.21 (0.17 – 0.26)	<0.001	0.38 (0.32 – 0.45)	<0.001	0.72 (0.60 – 0.87)	0.001
Wealth quintile						
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Second	0.76 (0.69 – 0.83)	<0.001	0.81 (0.74 – 0.88)	<0.001	0.88 (0.81 – 0.97)	0.013
Middle	0.56 (0.51 – 0.61)	<0.001	0.63 (0.55 – 0.72)	<0.001	0.75 (0.64 – 0.87)	<0.001
Fourth	0.35 (0.31 – 0.39)	<0.001	0.40 (0.34 – 0.47)	<0.001	0.55 (0.47 – 0.65)	<0.001
Highest	0.16 (0.14 – 0.19)	<0.001	0.20 (0.16 – 0.25)	<0.001	0.35 (0.28 – 0.45)	<0.001
Residence type						
Urban	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Rural	2.51 (2.33 – 2.70)	<0.001	2.62 (2.09 – 3.28)	<0.001	1.70 (1.39 – 2.08)	<0.001

Table 6.7: Association between reporting of distance as a barrier and exposures of interest (n=9,981)

Sociodemographic Characteristics	Model 1		Model 2		Model 3	
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*
Marital status						
Never married	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Currently married	1.01 (0.92 – 1.10)	0.879	0.96 (0.87 – 1.07)	0.495	0.92 (0.86 – 1.00)	0.040
Living with partner	1.33 (1.22 – 1.46)	<0.001	1.10 (1.04 – 1.17)	0.002	0.95 (0.90 – 1.01)	0.085
Formerly/ ever married	1.33 (1.19 – 1.50)	<0.001	1.20 (1.09 – 1.32)	<0.001	1.03 (0.94 – 1.12)	0.598
Occupation						
Professional	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Agricultural	1.86 (1.50 – 2.30)	<0.001	1.41 (1.16 – 1.70)	<0.001	1.15 (0.95 – 1.39)	0.155
Manual	1.02 (0.82 – 1.26)	0.862	1.06 (0.86 – 1.31)	0.567	0.98 (0.79 – 1.22)	0.881
Unemployed	1.55 (1.44 – 1.68)	<0.001	1.21 (1.13 – 1.29)	<0.001	1.07 (1.02 – 1.12)	0.003
Health insurance						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	0.34 (0.29 – 0.39)	<0.001	0.49 (0.41 – 0.60)	<0.001	0.69 (0.56 – 0.84)	0.001

Model 1: Univariable model
Model 2: Adjusted for enumeration area and household clustering
Model 3: Adjusted for all other exposures in the table and adjusted for regional, enumeration area and household clustering
RR: risk ratio | 95% CI: 95% confidence interval

6.3.9 Effect modification by residence type, wealth, education and health insurance

Due to the statistically significant association observed between rural residence type, wealth, education and health insurance and reporting distance as a barrier to healthcare, and the socioeconomic distribution of the DHS population presented in **Chapter 3**, the fully-adjusted model presented above was stratified by residence type, levels of education and wealth quintiles, and health insurance to assess effect modification (**Table 6.8–6.11**).

Sociodemographic factors and distance barriers stratified by residence type

There was no notable difference in the associations observed between urban and rural populations, except for the association between age and reporting distance as a barrier to healthcare (**Table 6.8**). There was a positive association between age and reporting distance as a barrier in rural populations but no significant association in urban populations. In the rural population, there was some evidence for a modest positive association between age and reporting of distance as a barrier (45–49 age group RR: 1.34; 95% CI: 1.12 – 1.61; p=0.002). In both urban and rural populations education and wealth were inversely associated with distance barriers. However, there was no evidence of interaction between education and residence type (p for interaction =0.087). There was, however, evidence for a significant interaction between wealth and residence type (p for interaction <0.001), with wealth more strongly inversely associated with distance barriers in rural areas.

Table 6.8: Association between sociodemographic factors and reporting distance as a barrier, stratified by residence type

Sociodemographic Characteristics	Urban		Rural		*P* for interaction
	RR (95% CI)	*p*	RR (95% CI)	*p*	
Age group					
15 – 19	1.00 (reference)		1.00 (reference)		
20 – 24	1.00 (0.83 – 1.21)	0.990	1.25 (1.09 – 1.43)	0.002	
25 – 29	1.03 (0.89 – 1.19)	0.680	1.23 (1.05 – 1.45)	0.011	
30 – 34	0.91 (0.81 – 1.02)	0.117	1.26 (1.07 – 1.49)	0.006	
35 – 39	1.07 (0.95 – 1.21)	0.262	1.29 (1.13 – 1.46)	<0.001	
40 – 44	1.00 (0.82 – 1.21)	0.986	1.30 (1.13 – 1.50)	<0.001	
45 – 49	1.17 (1.04 – 1.32)	0.007	1.34 (1.12 – 1.61)	0.002	
50 – 64	1.11 (0.90 – 1.36)	0.325	1.27 (1.13 – 1.44)	<0.001	
Education level					
No education	1.00 (reference)		1.00 (reference)		0.087
Primary	0.90 (0.69 – 1.18)	0.454	0.93 (0.89 – 1.00)	0.044	
Secondary	0.72 (0.56 – 0.91)	0.006	0.79 (0.73 – 0.85)	<0.001	
Higher	0.63 (0.43 – 0.94)	0.025	0.76 (0.56 – 1.03)	<0.001	
Wealth quintile					
Lowest	1.00 (reference)		1.00 (reference)		<0.001
Second	1.08 (0.83 – 1.40)	0.551	0.86 (0.79 – 0.93)	<0.001	
Middle	0.95 (0.71 – 1.28)	0.742	0.70 (0.61 – 0.81)	<0.001	
Fourth	0.65 (0.47 – 0.90)	0.009	0.56 (0.46 – 0.67)	<0.001	
Highest	0.40 (0.27 – 1.27)	<0.001	0.52 (0.34 – 0.80)	0.003	
Marital status					
Never married	1.00 (reference)		1.00 (reference)		
Currently married	0.96 (0.84 – 1.10)	0.581	0.92 (0.82 – 1.02)	0.112	
Living with partner	0.88 (0.79 – 0.96)	0.007	1.02 (0.95 – 1.10)	0.636	
Formerly/ ever married	1.11 (0.97 – 1.27)	0.119	1.00 (0.89 – 1.12)	0.963	
Occupation					
Professional	1.00 (reference)		1.00 (reference)		
Agricultural	1.53 (1.32 – 1.79)	<0.001	1.05 (0.85 – 1.30)	0.646	
Manual	1.02 (0.70 – 1.47)	0.935	0.98 (0.82 – 1.17)	0.808	
Unemployed	1.11 (0.97 – 1.27)	0.119	1.04 (0.97 – 1.11)	0.301	
Health insurance					
No	1.00 (reference)		1.00 (reference)		
Yes	0.60 (0.45 – 0.81)	0.001	0.77 (0.61 – 0.97)	0.026	

Risk Ratios (RR) correspond to fully adjusted models, adjusted for regional, enumeration area and household clustering and all other covariates in the table | 95% CI: 95% confidence interval | *p* for interaction based on likelihood ratio test comparing models with and without an interaction term, with wealth and education included as continuous variables
Urban n=5,140 | Rural n=4,841

Sociodemographic factors and distance barriers stratified by wealth and education

Rural residence type was statistically significantly associated with reporting of distance as a barrier to healthcare across wealth quintiles and education levels (except the lowest quintile and the no education strata)(**Table 6.9 and 6.10**). This suggests, that irrespective of all sociodemographic factors explored, rural populations are disadvantaged in accessing healthcare due to distance.

Additionally, with increasing levels of education (**Table 6.9**) and wealth (**Table 6.10**), the magnitude of association between rural residence type and reporting distance as a healthcare barrier increased. This suggests that education and wealth modify the association between residence type and distance barriers and that rural residence type is an important determinant of distance barriers in wealthier and more educated populations. However there was no evidence for a significant interaction between education and residence type (p for interaction =0.087). There was, however, evidence for a significant interaction between wealth and residence type (p for interaction <0.001).

In the highest wealth quintile, education was not significantly associated with reporting distance as a barrier, suggesting that in wealthier populations, education was a less important determinant of geographical barriers (**Table 6.10**). Likewise, in those with higher education, wealth was not significantly associated with reporting distance as a healthcare barrier but was significantly associated with distance barriers in populations with other education levels. This suggests that wealth is a less important factor influencing reporting of distance barriers in those with higher education. There was some evidence interaction between education and wealth on the association with reporting distance as a barrier in this DHS population (p for interaction =0.019).

Sociodemographic Characteristics	No education		Primary		Secondary		Higher		P for interaction
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*	
Age group									
15 – 19	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		
20 – 24	1.16 (0.96 – 1.41)	0.135	1.11 (0.92 – 1.33)	0.286	1.22 (1.06 – 1.40)	0.005	0.77 (0.39 – 1.50)	0.441	
25 – 29	1.30 (1.11 – 1.52)	0.001	1.06 (0.84 – 1.35)	0.621	1.22 (1.04 – 1.44)	0.015	0.78 (0.34 – 1.76)	0.547	
30 – 34	1.23 (0.98 – 1.55)	0.080	1.13 (0.93 – 1.37)	0.226	1.15 (0.95 – 1.40)	0.166	0.60 (0.29 – 1.21)	0.153	
35 – 39	1.06 (0.83 – 1.34)	0.650	1.17 (0.97 – 1.42)	0.108	1.29 (1.13 – 1.47)	<0.001	1.00 (0.32 – 3.16)	0.996	
40 – 44	1.33 (1.07 – 1.65)	0.010	1.13 (0.91 – 1.40)	0.271	1.23 (1.00 – 1.53)	0.055	0.64 (0.22 – 1.88)	0.415	
45 – 49	1.23 (0.96 – 1.58)	0.105	1.12 (0.89 – 1.40)	0.331	1.40 (1.21 – 1.62)	<0.001	1.13 (0.34 – 3.81)	0.844	
50 – 64	1.17 (0.94 – 1.45)	0.157	1.06 (0.94 – 1.19)	0.371	1.47 (1.25 – 1.73)	<0.001	0.66 (0.19 – 2.36)	0.525	
Wealth quintile									
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		
Second	0.96 (0.80 – 1.16)	0.682	0.88 (0.78 – 0.98)	0.025	0.84 (0.73 – 0.95)	0.008	-		0.019
Middle	0.85 (0.74 – 0.97)	0.013	0.75 (0.62 – 0.90)	0.002	0.68 (0.55 – 0.84)	<0.001	1.29 (0.71 – 2.33)	0.403	
Fourth	0.61 (0.43 – 0.87)	0.006	0.49 (0.38 – 0.64)	<0.001	0.51 (0.41 – 0.64)	<0.001	0.94 (0.72 – 1.23)	0.659	
Highest	0.12 (0.01 – 1.06)	0.056	0.46 (0.34 – 0.63)	<0.001	0.31 (0.22 – 0.43)	<0.001	0.78 (0.39 – 1.57)	0.492	
Residence type									
Urban	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		0.087
Rural	1.38 (1.00 – 1.92)	0.053	1.41 (1.15 – 1.74)	0.001	1.69 (1.37 – 2.08)	<0.001	2.63 (1.36 – 5.10)	0.004	
Marital status									
Never married	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		
Currently married	0.94 (0.82 – 1.07)	0.330	1.00 (0.90 – 1.10)	0.924	0.95 (0.84 – 1.07)	0.357	0.56 (0.34 – 0.92)	0.022	
Living with partner	0.99 (0.84 – 1.17)	0.930	1.10 (0.99 – 1.22)	0.079	0.92 (0.85 – 1.01)	0.084	0.87 (0.36 – 2.11)	0.761	
Formerly/ ever married	0.95 (0.86 – 1.04)	0.268	1.08 (1.00 – 1.17)	0.038	1.06 (0.90 – 1.24)	0.503	1.28 (0.56 – 2.94)	0.492	

Table 6.9: Association between sociodemographic factors and reporting distance as a barrier, stratified by education level

Sociodemographic Characteristics	No education		Primary		Secondary		Higher		*P* for interaction
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*	
Occupation									
Professional	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		
Agricultural	1.21 (0.64 – 2.29)	0.569	1.00 (0.85 – 1.17)	0.978	1.21 (0.96 – 1.52)	0.104	5.25 (1.18 – 24.28)	0.030	
Manual	1.01 (0.66 – 1.56)	0.949	0.83 (0.57 – 1.20)	0.313	0.99 (0.76 – 1.30)	0.966	1.48 (0.74 – 2.97)	0.273	
Unemployed	1.27 (1.05 – 1.54)	0.015	1.02 (0.94 – 1.12)	0.615	1.08 (1.00 – 1.16)	0.056	0.79 (0.52 – 1.20)	0.267	
Health insurance									
No	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		
Yes	1.07 (0.82 – 1.41)	0.609	0.74 (0.52 – 1.05)	0.090	0.70 (0.55 – 0.89)	0.003	0.47 (0.32 – 0.69)	<0.001	

Risk Ratios (RR) correspond to fully adjusted models, adjusted for regional, enumeration area and household clustering and all other covariates in the table | In Higher education strata, the lowest and second wealth quintiles were combined due to the small number of observations in the lowest wealth quintile reference category. All other estimates in the higher education strata are adjusted for the amended wealth variable | No education n=722 | Primary n=2,296 | Secondary n=6,221 | Higher n=742 | 95% CI: 95% confidence interval | *p* for interaction based on likelihood ratio test comparing models with and without an interaction term, with wealth and education included as continuous variables

Table 6.10: Association between sociodemographic factors and reporting distance as a barrier, stratified by wealth quintile

Sociodemographic Characteristics	Lowest quintile		Second quintile		Middle quintile		Fourth quintile		Highest quintile		*P* for interaction
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*	
Age group											
15 – 19	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		
20 – 24	1.33 (1.14 – 1.55)	<0.001	1.10 (0.90 – 1.33)	0.364	1.13 (0.91 – 1.41)	0.276	1.17 (0.86 – 1.60)	0.322	1.09 (0.94 – 1.26)	0.242	
25 – 29	1.31 (1.11 – 1.54)	0.002	1.07 (0.79 – 1.45)	0.651	1.10 (0.81 – 1.49)	0.541	1.23 (0.97 – 1.56)	0.083	0.94 (0.61 – 1.45)	0.791	
30 – 34	1.39 (1.11 – 1.75)	0.004	1.09 (0.83 – 1.43)	0.552	1.05 (0.78 – 1.43)	0.729	1.11 (0.79 – 1.57)	0.549	0.63 (0.46 – 0.86)	0.003	
35 – 39	1.36 (1.19 – 1.55)	<0.001	1.18 (0.93 – 1.49)	0.178	1.07 (0.79 – 1.46)	0.655	1.29 (1.08 – 1.55)	0.005	0.95 (0.60 – 1.51)	0.833	
40 – 44	1.40 (1.15 – 1.71)	0.001	1.20 (0.90 – 1.59)	0.217	1.34 (1.07 – 1.67)	0.012	0.93 (0.76 – 1.14)	0.480	0.66 (0.42 – 1.04)	0.075	
45 – 49	1.30 (1.09 – 1.56)	0.003	1.11 (0.80 – 1.54)	0.548	1.23 (0.98 – 1.54)	0.076	1.45 (1.02 – 2.07)	0.038	1.19 (0.88 – 1.62)	0.264	
50 – 64	1.18 (1.03 – 1.35)	0.014	1.11 (0.79 – 1.55)	0.561	1.31 (1.07 – 1.60)	0.009	1.44 (1.11 – 1.86)	0.006	0.67 (0.35 – 1.29)	0.234	
Education level											
No education	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		0.019
Primary	0.93 (0.81 – 1.05)	0.213	0.83 (0.69 – 0.99)	0.041	0.83 (0.72 – 0.96)	0.015	0.79 (0.55 – 1.15)	0.222	2.73 (0.33 – 22.38)	0.350	
Secondary	0.77 (0.65 – 0.90)	0.001	0.68 (0.58 – 0.81)	<0.001	0.66 (0.56 – 0.77)	<0.001	0.74 (0.54 – 1.02)	0.061	1.42 (0.21 – 9.73)	0.720	
Higher	—		0.73 (0.43 – 1.24)	0.245	0.67 (0.42 – 1.05)	0.081	0.70 (0.45 – 1.09)	0.114	1.47 (0.20 – 10.77)	0.707	
Residence type											
Urban	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		<0.001
Rural	1.40 (0.95 – 2.07)	0.086	1.36 (1.14 – 1.64)	0.001	1.42 (1.17 – 1.72)	<0.001	1.71 (1.37 – 2.14)	<0.001	2.98 (1.96 – 4.52)	<0.001	
Marital status											
Never married	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		
Currently married	0.95 (0.86 – 1.04)	0.252	1.04 (0.85 – 1.27)	0.693	0.98 (0.86 – 1.12)	0.749	0.86 (0.72 – 1.02)	0.091	0.85 (0.66 – 1.11)	0.235	
Living with partner	1.00 (0.91 – 1.10)	0.974	1.23 (1.03 – 1.45)	0.020	0.98 (0.88 – 1.09)	0.668	0.77 (0.64 – 0.92)	0.003	1.12 (0.71 – 1.76)	0.635	
Formerly/ ever married	0.98 (0.87 – 1.09)	0.666	1.01 (0.79 – 1.29)	0.938	1.09 (0.97 – 1.22)	0.172	1.11 (0.89 – 1.39)	0.363	1.46 (0.87 – 2.47)	0.155	

Table 6.10: Association between sociodemographic factors and reporting distance as a barrier, stratified by wealth quintile										
Sociodemographic Characteristics	**Lowest quintile**		**Second quintile**		**Middle quintile**		**Fourth quintile**		**Highest quintile**		***P* for interaction**
	RR (95% CI)	***p***	**RR (95% CI)**	***p***	**RR (95% CI)**	***p***	**RR (95% CI)**	***p***	**RR (95% CI)**	***p***	
Occupation											
Professional	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		
Agricultural	0.91 (0.73 – 1.12)	0.357	1.18 (0.87 – 1.58)	0.283	1.31 (0.83 – 2.04)	0.244	1.18 (0.72 – 1.95)	0.516	1.95 (1.01 – 3.76)	0.047	
Manual	1.03 (0.76 – 1.41)	0.847	1.09 (0.80 – 1.48)	0.577	0.90 (0.60 – 1.33)	0.586	0.84 (0.59 – 1.18)	0.305	1.12 (0.55 – 2.29)	0.762	
Unemployed	1.13 (1.03 – 1.25)	0.015	1.15 (1.04 – 1.26)	0.005	0.97 (0.84 – 1.13)	0.704	1.09 (0.92 – 1.29)	0.333	0.99 (0.67 – 1.47)	0.972	
Health insurance											
No	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		0.014
Yes	0.64 (0.42 – 0.97)	0.038	0.75 (0.58 – 0.96)	0.022	0.86 (0.54 – 1.36)	0.513	0.69 (0.53 – 0.90)	0.007	0.58 (0.38 – 0.88)	0.009	

Risk Ratios (RR) correspond to fully adjusted models, adjusted for regional, enumeration area and household clustering and all other covariates in the table

Lowest quintile n=1,632 | Second quintile n=1,815 | Middle quintile n=2,045 | Fourth quintile n=2,345 | Highest quintile n=2,144 | 95% CI: 95% confidence interval | — where low number of observations for higher education in the lowest wealth quintile | *p* for interaction based on likelihood ratio test comparing models with and without an interaction term, with wealth and education included as continuous variables

Sociodemographic factors and distance barriers stratified by health insurance

When stratified by health insurance status, education was inversely associated with reporting distance as a barrier in both the insured and uninsured populations (Table 6.11). Amongst the uninsured, wealthier individuals were less likely to report distance as a barrier to healthcare. There was evidence for a statistical interaction between wealth and health insurance in the association with reporting distance barriers (p for interaction =0.014). Rural residence type was associated with reporting distance as a barrier in both insured and uninsured populations but the magnitude of association was higher in the insured population (insured rural population RR: 2.18; 95% CI: 1.31 – 3.64; p=0.003).

Table 6.11: Association between sociodemographic factors and reporting distance as a barrier, stratified by health insurance

Sociodemographic Characteristics	Insured		Uninsured		*P* for interaction
	RR (95% CI)	*p*	RR (95% CI)	*p*	
Age group					
15 – 19	1.00 (reference)		1.00 (reference)		
20 – 24	1.80 (1.01 – 3.22)	0.047	1.15 (1.01 – 1.32)	0.036	
25 – 29	1.59 (0.61 – 4.13)	0.341	1.17 (1.03 – 1.34)	0.017	
30 – 34	1.90 (1.01 – 3.60)	0.048	1.13 (0.96 – 1.34)	0.144	
35 – 39	1.64 (0.89 – 3.04)	0.114	1.22 (1.10 – 1.34)	<0.001	
40 – 44	1.57 (0.88 – 2.79)	0.125	1.21 (1.04 – 1.40)	0.011	
45 – 49	2.43 (1.37 – 4.29)	0.002	1.24 (1.07 – 1.43)	0.004	
50 – 64	2.14 (1.02 – 4.49)	0.045	1.17 (1.03 – 1.32)	0.015	
Education level					
No education	1.00 (reference)		1.00 (reference)		
Primary	0.71 (0.56 – 0.89)	0.004	0.91 (0.82 – 1.00)	0.043	
Secondary	0.66 (0.48 – 0.91)	0.011	0.76 (0.68 – 0.83)	<0.001	
Higher	0.56 (0.37 – 0.84)	0.005	0.80 (0.67 – 0.96)	0.018	
Wealth quintile					
Lowest	1.00 (reference)		1.00 (reference)		0.014
Second	1.22 (0.73 – 2.05)	0.442	0.88 (0.80 – 0.97)	0.008	
Middle	1.34 (0.80 – 2.25)	0.272	0.73 (0.63 – 0.84)	<0.001	
Fourth	0.78 (0.41 – 1.50)	0.458	0.54 (0.45 – 0.64)	<0.001	
Highest	0.47 (0.21 – 1.04)	0.062	0.37 (0.29 – 0.47)	<0.001	
Residence type					
Urban	1.00 (reference)		1.00 (reference)		
Rural	2.18 (1.31 – 3.64)	0.003	1.63 (1.34 – 1.98)	<0.001	
Marital status					
Never married	1.00 (reference)		1.00 (reference)		
Currently married	0.81 (0.61 – 1.08)	0.156	0.95 (0.88 – 1.03)	0.200	
Living with partner	1.26 (0.86 – 1.85)	0.234	0.96 (0.91 – 1.02)	0.222	
Formerly/ ever married	0.95 (0.62 – 1.45)	0.800	1.05 (0.96 – 1.14)	0.308	
Occupation					
Professional	1.00 (reference)		1.00 (reference)		
Agricultural	1.20 (0.58 – 2.52)	0.622	1.14 (0.96 – 1.35)	0.130	
Manual	1.48 (0.88 – 2.48)	0.142	0.93 (0.76 – 1.16)	0.533	
Unemployed	1.31 (0.89 – 1.92)	0.170	1.05 (1.02 – 1.09)	0.002	

Risk Ratios (RR) correspond to fully adjusted models, adjusted for regional, enumeration area and household clustering and all other covariates in the table | Insured n=1,619 | Uninsured n=8,362 | 95% CI: 95% confidence interval | *p* for interaction based on likelihood ratio test comparing models with and without an interaction term, with wealth and education included as continuous variables

6.4 Discussion

In this subset of the DHS population, almost half of women (45.6%) were found to experience at least one barrier to accessing healthcare in Namibia. The leading reported healthcare barrier was the distance to health facilities, reported by 32.9% of women. Geographical inaccessibility has been widely reported as a challenge for individuals seeking healthcare across other LMICs [61, 69-76]. In this DHS population, women living in rural areas, the less wealthy and less educated were more likely to report distance as a barrier to healthcare. Age was positively associated with reporting distance as a barrier in rural areas. Interventions targeted to these populations could help to improve healthcare accessibility in Namibia but further research is needed to understand the effect of geographical barriers on health service utilisation and health outcomes in Namibia.

6.4.1 Sociodemographic determinants of geographical barriers to healthcare

Rurality

The population distribution in Namibia is highly clustered [9]; as such, health facilities may not be accessible to some of the more remote communities. This issue may be exacerbated by the lack of affordable and reliable transport options [143]. In this analysis, rural residence was associated with distance barriers to healthcare irrespective of all sociodemographic factors in this DHS population.

Rural residence type has been widely associated with challenges in accessing healthcare across SSA [73, 75, 94, 99-101]. Rural areas tend to be characterised by poorer road and transport infrastructure, informal employment, unemployment and the use of traditional healers [63, 88, 136], which may explain this relationship. In this DHS population, reporting of distance barriers also varied by region. More than 50% of women in the Kavango and Ohangwena regions, two predominantly rural regions, reported distance as a barrier to healthcare, whereas in Erongo and Khomas, the two most urban regions, less than 20% of women reported this barrier. Further research is needed to better understand the geographical patterns of distance barriers to healthcare access in Namibia on a finer scale.

The association between rural residence type and reporting distance as a barrier may be modified by wealth, with rural individuals in higher wealth quintiles more likely to report distance as a healthcare barrier, compared with those in lower quintiles. This could be partly explained by urban-rural differences in wealth distribution but more large-scale analyses are needed to better understand this relationship.

Socioeconomic factors

Socioeconomic factors were also independently associated with reporting distance as a healthcare barrier. Women with higher levels of education and wealth were less likely to report distance barriers. Poorer populations often have less disposable income and therefore may not be able to allocate funds to pay for transport to health facilities, whether this be privately owned or public transport. Transport costs have been widely identified as a barrier to healthcare [61, 73, 270, 271]. Transport costs contribute to the overall cost of healthcare and the cost of transport alone can be catastrophic, accounting for more than 10% of household expenditure [271]. In South Africa, wealthier populations have been found to be more willing to travel to health facilities [271] and in a study of 18 sub-Saharan African countries, wealth was the primary driver of health service utilisation [62]. However, the study also found that wealth was less important in comparatively wealthier countries including Namibia, South Africa and Swaziland [62]. By contrast, the findings presented in this thesis suggest that wealth is an important driver of perceived healthcare accessibility in Namibia.

Education may impact on perceptions of healthcare barriers because education influences individuals' abilities to make choices, including decisions around health. For women, education provides a foundation for basic needs such as housing and food security, which in turn are important supportive factors for health seeking behaviour [272]. With security around these basic needs, women may be more able to travel long distances to health facilities when needed. More educated women are also thought to be able to use the literacy and numeracy skills obtained through their education to become more educated about health-related matters later in life [273]. In the same vein, education may also influence the perception of the importance of specific health problems and how the positives of seeking care (e.g. getting treatment) may be weighed against the negatives (e.g. transport costs). In South Africa, the perception that an illness was not serious enough to seek medical help was the most widely reported reason for delays in obtaining treatment; however, this was especially observed amongst wealthier and insured populations [271].

In the current analysis, there was some statistical evidence for interaction between education and wealth on the association with reporting distance as a healthcare barrier. However, more large-scale data are needed to better understand this association. Wealth also appeared to modify the association between rural residence type and reporting distance as a barrier to healthcare. Those with a higher relative wealth were more likely to report distance as a problem if they lived in rural areas. This may be due to the differential distribution of wealth between urban and rural areas, as identified in Chapter 3. Further research is needed to better understand the relationship between wealth and rural residence in the context of health facility accessibility.

Age

There was a modest positive association observed between age and reporting distance as a healthcare barrier that was only observed in rural populations. This could be due to reduced mobility in older populations or could be influenced by a greater need for healthcare in older populations. In Namibia, elderly populations in rural areas have been found to resort to traditional healers because formal health facilities are too far away and transport costs to reach these facilities are high [88]. Further research is needed to understand barriers to healthcare in individuals over 64 years of age in Namibia and in both urban and rural areas.

Ethnicity

Interestingly, the Herero population were most likely to report distance as a barrier to healthcare. This population are comparatively less wealthy and less educated so are likely to be disadvantaged in accessing healthcare from a socioeconomic standpoint. Low SES was also associated with reporting distance as a barrier to healthcare. However, the Herero population were most likely to experience geographical barriers to healthcare after adjustment for socioeconomic factors, suggesting other factors not accounted for in this analysis may contribute to this association. For example, this association could be influenced by other social factors or it could be linked to geographical location. This highlights the need for more fine scale data to explore the accessibility of health facilities in Namibia relative to different population groups.

6.4.2 Health seeking and healthcare barriers

Importantly, reporting of healthcare barriers was associated with recent use of outpatient care facilities in this analysis. This could be interpreted a number of ways: first, that individuals who reported healthcare barriers had greater healthcare needs than those who did not experience these barriers, which could influence perceptions. Second, that these individuals are able to access healthcare despite reporting barriers and have used health services more than those who did not report barriers, which could question the accuracy of reported measures of healthcare barriers. Third, that the perception of healthcare barriers may be influenced by recent experiences using health services. Indeed, individual experiences, such as recent illness or visit to a health facility have been found to influence perceptions of healthcare in South Africa [271]. The temporality of these associations could not be assessed due to the cross-sectional nature of the data but further research to understand the association between health service utilisation and healthcare barriers may help to disentangle the complex relationship between healthcare barriers and healthcare access from the user perspective.

6.4.3 Limitations

A key consideration of the analyses presented in this chapter is that whilst understanding barriers to healthcare access from the user perspective is valuable, this does not necessarily translate into real-life differences in healthcare access. For example, one person reporting distance as a problem in seeking healthcare could live closer to a health facility than another individual who did not report distance as a barrier. Objective measures of proximity to health facilities may enable better comparisons of accessibility at the population-level and could help to identify the specific population sub-groups living at great distances from health facilities.

A further limitation of this analysis is the accuracy of the outcome measure, with women asked whether they considered each potential barrier a “big problem” or “no problem”. First, this does not allow for intermediate measures of healthcare barriers; for example, if any barriers were sometimes a problem but not always, which could be dependent on a number of scenarios. Second, because of this, it is possible that women may have under- or over-reported barriers to healthcare.

It is important to consider that perceptions of healthcare barriers could be influenced by a number of factors, such as individual experiences, including whether the individual has recently visited a health facility or fallen ill [271]. Indeed, in this analysis, women who reported distance as a healthcare barrier were more likely to have recently sought outpatient care. This could suggest that recent healthcare visits may influence perceptions of healthcare barriers in this population. Conversely, these findings could imply that although some women may perceive distance to be a problem in accessing healthcare, this does not necessarily prevent health service utilisation. Additional factors outside the remit of these data, such as the severity of the condition for which healthcare was sought, could also influence whether distance deters patients from seeking care or not. Ultimately, due to the cross-sectional nature of the DHS data, it was not possible to assess the temporality of association between perceived healthcare barriers and health service utilisation. This highlights the need for longitudinal data to better understand this complex relationship.

The generalisability of these findings are limited by the fact that the DHS only asks questions on perceived healthcare barriers of women. It is likely that these geographical barriers extend to the wider population but further research is needed determine whether this is the case in Namibia.

Additionally, by restricting data collection to women, it was not possible to understand the barriers experienced by men, nor was it possible to compare perceived barriers experienced by sex. Sex differences in healthcare access have been observed in other LMICs [274]. Some of the barriers explored in women, such as needing permission to visit a health facility and not wanting to go alone may be more common in women than men, but it is likely that financial and geographical barriers are also experienced by men living in the same households as the women surveyed. More appropriate data are needed to explore healthcare barriers in both men and women.

6.4.4 Implications

These findings highlight the need for further research to better understand the complexities of the relationship between rural residence type and socioeconomic factors. Additionally, longitudinal data could help to understand the association between reporting healthcare barriers and health service utilisation. Additionally, further research could explore other factors that could also be associated with reporting healthcare barriers but, due to data limitations, could not be accounted for in these analyses.

Given that these findings, consistent with others across SSA [73, 75, 94, 99-101], suggest that rural populations are disadvantaged in terms of geographical accessibility of health facilities, initiatives are needed to increase access for these populations. This could include provision of additional health facilities closer to rural populations, increasing the coverage and capacity of outreach services or could involve improvements in access to transport, both physically and financially. However, investments to improve geographical access to healthcare will need to be accompanied by strategies to encourage behaviour change to ensure populations use these services [63]. Parallel strategies to ensure that healthcare is available, of an adequate quality and meets the healthcare needs of the population will also be important.

6.4.5 Conclusions

In conclusion, sociodemographic factors, especially rural residence type, education and wealth, play an important role in perceptions of distance as a barrier to healthcare among women in Namibia. Strategies to reduce inequities in education and wealth may therefore be important for improving access to healthcare in Namibia. Crucially, approaches to increase the accessibility of healthcare in rural areas will be key to improving healthcare access in Namibia. Further quantitative research is needed to better understand geographical barriers to healthcare in Namibia. However, any initiatives to improve the accessibility and affordability of healthcare will need to be accompanied by parallel initiatives to ensure the availability, adequacy and appropriateness of care.

7. Objective measures of geographical accessibility of health facilities in Namibia

Summary

Background: Distance and long travel times to health facilities are some of the most commonly reported barriers to healthcare access in SSA. Given Namibia's sparse population, I aimed to assess the distribution of public health facilities in Namibia, the accessibility of these health facilities relative to the DHS population, and to explore the equity of healthcare accessibility across sociodemographic groups.

Methods: Data on 41,000 individuals from the 2013 Namibia DHS, combined with geographic coordinates of public health facilities, were used to investigate the distance and travel time to health facilities. The 2011 Population and Housing Census data were used to explore the population-health facility ratio. Nearest Neighbour analyses were used to investigate the geographical distribution of health facilities and Euclidean (straight-line) distance to health facilities. Travel time to health facilities was estimated using Access Mod 5.0, accounting for road speed, land cover and elevation. Multivariable mixed effects linear regression analyses were conducted to explore the sociodemographic determinants of travel time to health facilities, adjusted for regional clustering. Multivariable mixed effects Poisson regression analyses were used to assess the association between objective and subjective measures of accessibility.

Results: Health facilities were spatially clustered (Nearest Neighbour index: 0.54; z= -16.2) but were reflective of population distribution. Overall, there were 1.6 health facilities per 10,000 population. Over 10% of the population lived more than two hours from a health facility and 40% of the rural population lived more than an hour from a health facility. Men, older populations, the less wealthy, less educated and rural populations had longer travel times to health facilities. Across sociodemographic groups, rural populations lived further from health facilities but trends in travel time by sex, age and education were only observed in rural populations. Wealthier populations lived closer to health facilities in both urban and rural populations. Travel time was positively associated with reporting distance as a barrier to healthcare amongst women.

Conclusions: Accessibility of health facilities was variable amongst the DHS population, with around 20% of the population having to travel over an hour to reach a facility. Men, the less wealthy, less educated and rural populations lived further from health facilities and therefore may experience challenges in accessing healthcare. Interventions aimed these populations, particularly in rural areas, may help to reduce socioeconomic differences in healthcare accessibility in the country.

7.1 Introduction

Some of the most commonly reported barriers to healthcare access in LMICs are the distance to health facilities and associated transport costs [61, 69-76, 78]. These factors affect the geographical accessibility of healthcare at the population-level. Living further away from health facilities has been associated with neonatal, infant and child mortality [77, 79, 275, 276], maternal mortality [80, 277, 278], lower health service utilisation [84, 279], delays in diagnosis and treatment initiation, and poorer treatment adherence [81, 82, 85]. Individuals living in rural or remote areas are often particularly disadvantaged in accessing healthcare [73, 75, 94, 99-101].

Namibia's small population of around 2.5 million people is dispersed over a large geographical area approximately 842,000 Km^2 [120], with clustering of the population in certain locations [9]. A large proportion of the Namibian population have long travel times to the nearest settlement comprising more than 50,000 people [9]. Some more remote communities also lack access to permanent health infrastructure [3]. Geographical barriers are likely to be exacerbated by limited transport options in the country [143]. Outreach services are used to provide care to more remote communities; however, the coverage of these outreach services is variable across regions and different health service types [3]. As such, geographical barriers to healthcare access may hinder efforts to scale-up healthcare access to achieve UHC in Namibia.

Long distances to health facilities may affect treatment seeking behaviour in the country. Alegana *et al.* showed that travel time to health facilities greater than three hours reduced the probability of seeking treatment for childhood fever in Namibia [114]. Long distances to health facilities and high transport costs have also been found to hinder elderly rural populations from seeking formal healthcare in Namibia, resulting in the sustained use of traditional medicine [88]. Rural people living with disabilities also experience these accessibility barriers to healthcare [118]. Collectively, these findings suggest that healthcare access in Namibia is not equitable due to geographical barriers disproportionately experienced by rural and remote populations. However, these studies have focused on specific population sub-groups or disease outcomes. These factors could themselves influence accessibility of and differential demands for healthcare. Therefore, research is needed to more broadly understand healthcare access in the wider population.

Long distances to health facilities are often a greater problem for rural populations due to rural areas being less well connected by effective road and transport infrastructure [63]. However, it is important to understand the geographical barriers to healthcare beyond the general classifications of urban and rural areas. The geographical barriers experienced by rural populations are unlikely to be homogeneous; as such, more fine-scale analyses are needed to understand the specific locations where health facilities are geographically inaccessible and the characteristics of populations living in these areas. Such findings may provide a platform on which to develop further research to understand the impact of health facility inaccessibility on population health, health seeking behaviour and disease outcomes in Namibia. A greater understanding of health service accessibility may also aid in health system planning and also the development of strategies to reach disadvantaged populations.

In Chapter 6, subjective data on accessibility showed that distance to health facilities is perceived to be a problem when accessing healthcare by a third of women. However, perceptions of accessibility of health services do not necessarily reflect actual differences in geographical accessibility between respondents. As such, this chapter aims to use objective measures of accessibility, namely distance and travel time, to better understand the variations in the accessibility of health services in the DHS population.

Specifically, the aims of this chapter are:

i. To assess the geographical distribution of health facilities in Namibia in relation to the population;
ii. To estimate and compare distance and travel time to health facilities in the DHS population;
iii. To investigate predicted travel time to health facilities by population sociodemographic characteristics;
iv. To compare objective and subjective measures of accessibility by exploring the association between travel time and reporting of distance as a barrier to healthcare amongst women.

7.2 Methods

7.2.1 Data sources

Household and population data were obtained from the DHS Program for the year 2013 in Namibia [280]. Geographic coordinates of study EAs were obtained with approval from the DHS Program. Public Health Facility coordinates were obtained from the Namibia Ministry of Health and Social Services.

Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM) data were obtained from the CGIAR consortium for spatial information (CGIAR-CSI) via DIVA-GIS [139, 281]. Road data was obtained from Digital Chart of the World via DIVA-GIS. Barrier data, constituting inland water (water bodies, rivers and streams), were also sourced from Digital Chart of the World via DIVA-GIS [139]. Land cover data was obtained from Global Land Cover 2000 (GLC2000) via DIVA-GIS [139].

7.2.2 Namibia DHS 2013

Details of the study methodology for the Namibia DHS are detailed elsewhere [120] and in **Chapter 2**. The DHS constituted three questionnaires: the Household Questionnaire, Man's Questionnaire and the Woman's Questionnaire. GPS data were also collected for each survey EA. Detailed methods of the collection of GPS data in the DHS are described elsewhere and in **Chapter 2** [132]. GPS data in the DHS are collected for each EA, not for each household, to ensure confidentiality of participants [132]. The GPS coordinates are randomly displaced in order to ensure participant confidentiality. In urban areas, EAs were displaced by up to 2 Km and in rural areas, they were displaced by up to 5 Km, with 1% of rural EAs displaced by up to 10 Km [133].

7.2.3 Population data

In 2011, a population and housing census was conducted in Namibia, which provides information on the size of the population, as well as socioeconomic and demographic information [140]. Data from the Namibia 2011 Population and Housing Census main report [140] were used to explore health facilities and health facility distribution relative to the population in Namibia. Additionally, data on population density in Namibia were sourced from AfriPop 2010 and were used to assess health facility distribution relative to the distribution of the population [9].

7.2.4 Health facility distribution

Health facilities were mapped using QGIS 2.14.1 and a Nearest Neighbour analysis was conducted to assess the spatial distribution of health facilities. It was therefore possible to assess whether facilities are dispersed or clustered (**Figure 7.1**) and whether or not the effect we observe is due to random chance, indicated by a Z-score. The QGIS Nearest Neighbour tool measures the distance between each spatial feature and its nearest spatial feature. In this instance, the distance between health facilities was explored. The tool averages the distances and compares these 'observed' distances to a hypothetical 'expected' spatial distribution [282]. If the average observed distances are greater than the expected distance then the spatial distribution is considered to be dispersed (not clustered) [282]. This indicated by an index (ratio) greater than 1. However, if the observed distance is less than the expected, this is indicative of clustering and will be evidenced by an index less than 1 [282]. The tool also calculates a Z-score to determine how likely the result is to be due to random chance.

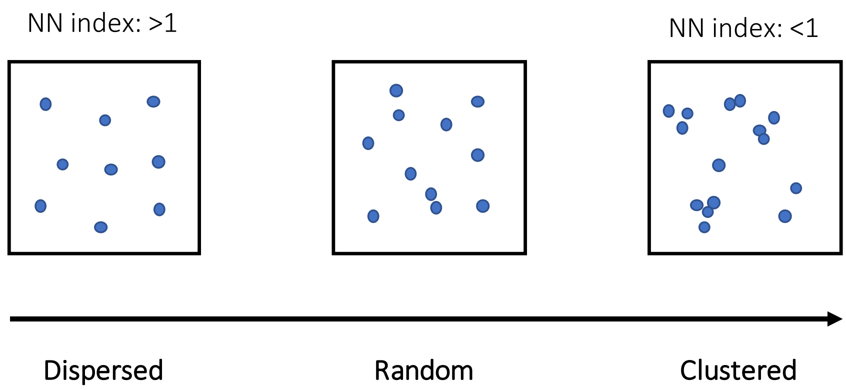


Figure 7.1: Example illustration of dispersed, random and clustered distribution of points. NN: Nearest Neighbour.

Using public health facility, 2011 Population and Housing Census and AfriPop 2010 data, the distribution of health facilities was explored in relation to the population distribution. Using Quantum GIS (QGIS) 2.14.1 software, the AfriPop 2010 population density layer was overlaid with the public health facility coordinates, allowing visual assessment of distance relative to population density. The distribution of public health facilities by region was also mapped. The number of health facilities in each region was plotted against the regional census and regional DHS population and Spearman's correlation was used to assess the correlation between the regional DHS and census population sizes and the regional number of health facilities.

Finally, the number of health facilities per 10,000 population was assessed, an indicator used to evaluate health system strengthening needs [283]. The number of health facilities per 10,000 population for each region was calculated as follows:

$$\left(\frac{Regional\ number\ of\ health\ facilities}{Regional\ census\ population\ size}\right) \times\ 10{,}000$$

7.2.5 Euclidean distance

First, the geographical area potentially covered by each health facility was assessed by generating dissolved buffers of 5 Km, 10 Km and 20 Km radius around each facility. This enabled a visual assessment of the potential geographical coverage of health facilities up to 20 Km. Second, to determine Euclidean (straight-line) distance from DHS EAs to the nearest health facility, EAs and public health facilities were mapped using QGIS 2.14.1 software. The distance between each EA and the nearest health facility was calculated using the QGIS Distance Matrix tool. In order to calculate distances specific to Namibia the coordinate reference system (CRS) was set to WGS84/UTM zone 33S. UTM projections are equal-area projections whereby the Earth's spherical surface is projected onto a two-dimensional cartesian coordinate plane. This enables the calculation of distances in metres instead of degrees. Distances were calculated in metres and are presented in kilometres (Km). Using Stata, EA distance metrics were assigned to households and their populations based on the distance value of the EA to which the households belonged, using the EA unique ID.

7.2.6 Travel time to health facilities

All spatial data preparation and manipulation was carried out using QGIS 2.14.1 software.
All spatial data layers were reprojected into the WGS84/ UTM zone 33s CRS. All raster layers (SRTM DEM and landcover) were converted from a GeoTIFF file to Erdas Imagine format using the QGIS 'Translate' tool to be compatible with Access Mod 5.0 software.

The roads vector layer was imported into QGIS and integer values were assigned corresponding to the road type: Primary Route, Secondary Route and Unknown. Flood plains and non-perennial/intermittent rivers were removed from the water and river layers so that only permanent water features were included in the analysis.

The land cover layer was clipped to the extent of Namibia's administrative boundaries using the raster 'Clipper' tool. A landcover legend file was created using Excel. The legend was generated in line with the GLC2000 legend [284].

After running the AcessMod analysis initially, the accessibility output was imported into QGIS and health facilities that were located on a barrier (buffer around rivers and water bodies) were manually moved into the nearest raster cell outside of the buffer using the 'Numerical Vertex Edit' tool, ensuring that the health facilities were still located on the correct side of the river. The new health facilities layer was saved and used for the final analysis. Two health facilities (both health centres) could not be included as they were located within a river buffer, whereby moving them on the correct side of the river would have relocated them outside of the Namibia border.

Travel time to health facilities was estimated using Access Mod 5.0, a tool developed by the WHO Department of Health Systems Governance and Financing in collaboration with the University of Geneva/Institute for Environmental Sciences/EnviroSPACE Lab, the AeHIN GIS Lab, the WHO eHealth unit (WHO/IER/KMS/EHL), the WHO department of Making Pregnancy Safer (WHO/FCH/MPS), the GEOmatics for Informed DEcisions (GEOIDE) Networks of Centres of Excellence, the Faculty of Medicine/University of Sherbrooke, and the School of Mathematical and Geospatial Sciences/RMIT University/Melbourne.

Land cover, health facilities, barriers (rivers and inland water) and road data were uploaded to Access Mod 5.0 and merged. For the merge, items were stacked in the following order from the top to the bottom of the stack: primary roads, secondary roads, unknown roads, rivers, inland water and land cover. The rivers and inland water layers were ordered below the roads so that in the instance that there is a bridge that enables passage across these water bodies, travel would be permitted in the model.

In the Access Mod "Accessibility" analysis, speeds and modes of transport were assigned to different road types and land cover, which are outlined in **Table 7.1**. Speeds were based on speeds assigned by Alegana *et al.* in a similar analysis of travel time in Namibia [114]. The analysis was repeated to assess travel time to clinics, health centres and hospitals, respectively.

Table 7.1: Modes of transport and speeds assigned to different roads and land cover classifications

Classification	Speed (Km/h)	Mode of transport
Tree cover, broadleaved, deciduous	5.00	Walking
Tree cover, broadleaved, open	5.00	Walking
Tree cover, flooded, saline water	2.00	Walking
Shrub cover, deciduous	5.00	Walking
Herbaceous cover	3.00	Walking
Sparse herbaceous or sparse shrub cover	4.00	Walking
Flooded shrub and/or herbaceous cover	2.00	Walking
Cultivated and managed areas	5.00	Walking
Bare areas (e.g. desert)	2.00	Walking
Artificial surfaces (e.g. urban areas)	5.00	Walking
Primary roads	80.00	Motorised
Secondary roads	60.00	Motorised
Unknown Roads	10.00	Bicycling

N.B: EAs located on water bodies according to the land cover layer were removed from this analysis (n=302 individuals from 6 EAs; 1.1% of EAs; 0.7% of population)

To account for random displacement, EAs were classified according to residence type (rural or urban) and buffers were generated around each EA point with a radius of 2 Km for urban EAs and 5 Km for rural EAs. The average raster values for travel time of the buffer area was assigned to each EA using the QGIS 'Zonal Statistics' tool. In Stata, DHS households were assigned the average travel time of the EA in which they were located, based on the unique EA ID.

All maps presented in this chapter are displayed in CRS WGS84 therefore scale bars are approximate.

7.2.7 Statistical analyses of distance and travel time to health facilities

All statistical analyses were carried out in Stata 14.0 software package (StataCorp: College Station, TX, USA). For this analysis, I used the dataset combining the DHS Household, Woman's and Man's data recodes to which I added the travel time and distance results based on the EA identification.

A group of 302 individuals from six EAs were not included in the analysis due to inaccurate travel time estimates. This accounted for 0.7% of the total survey population (N=41,646) and 1.1% of EAs (N=550). Individuals were excluded if they had missing data or answered "don't know" for sex, age and education, where applicable. This gave a final sample of 41,000 individuals with complete data, equivalent to 98.5% of the total household population (**Figure 7.2**)

A categorial variable for age was defined, categorising individuals into the following groups (in years): 0–5, 5–14, 15–29, 30–49, 50–64 and 65 years and over. The 65 and over group included individuals aged between 65 and 96 years. Age and education were corrected where possible using data from the individual questionnaires. Education level reflects the highest level of education attended [137], but does not necessarily mean that the level of education was completed.

Of these 41,000 individuals, 14,335 aged 15–64 also had data on occupation and were included in a sub-analysis of accessibility. A second sub-analysis was also conducted in 9,934 women aged 15–64 who answered questions pertaining to healthcare barriers as part of the Woman's Questionnaire.

In additional analyses (**Appendix 3**), I used language as proxy for ethnicity by recoding the variable for the main language spoken in the home into five groups: Afrikaans, Damara/Nama, Herero, Oshiwambo and "other", which included small populations of English, San, Kwagali and Lozi. In these additional analyses I explored the mean (IQR) travel time by ethnicity and the association between ethnicity and travel time to health facilities.

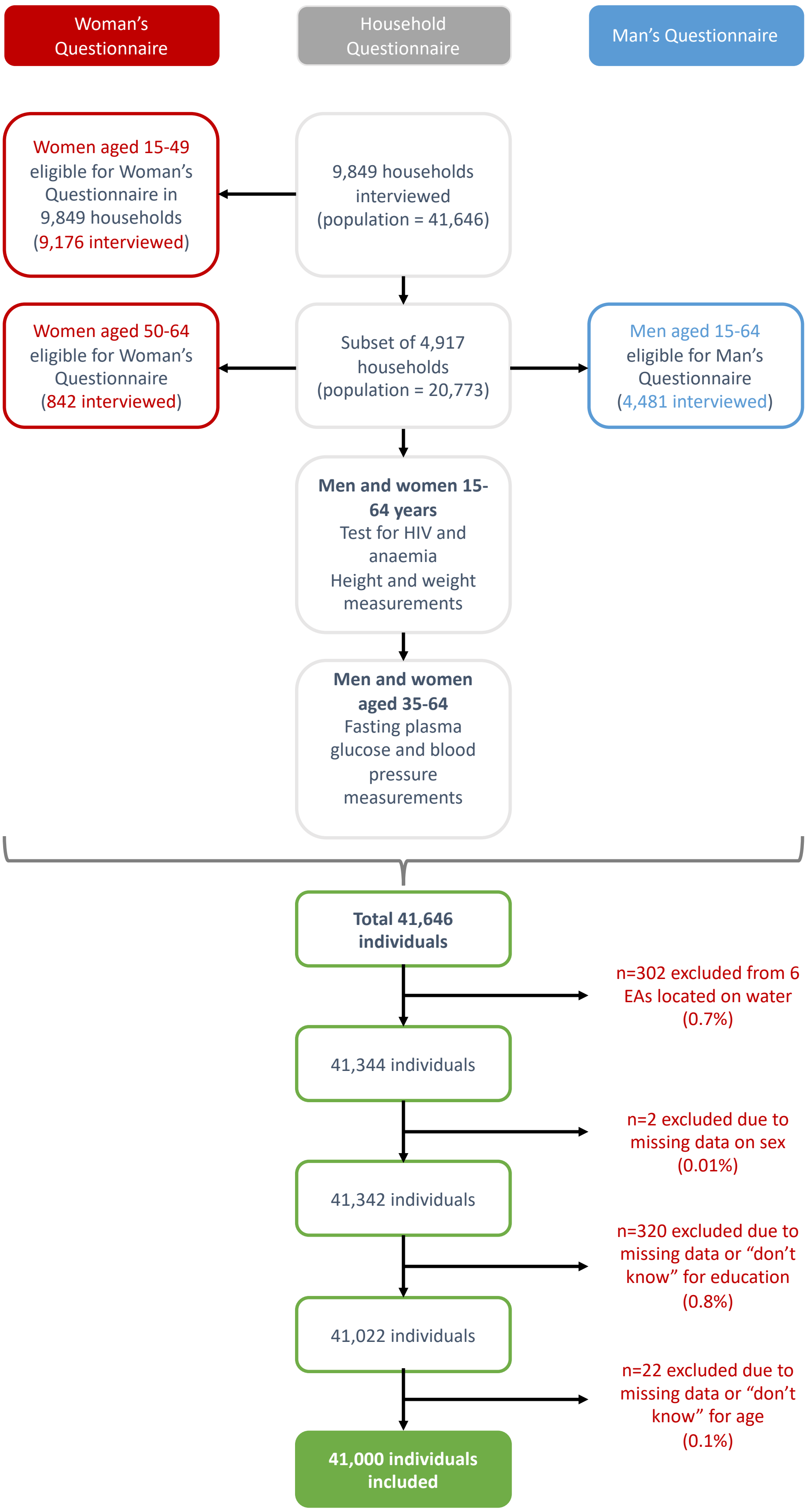


Figure 7.2: Flow chart outlining the study population used in the current analysis. Data on 41,646 individuals were collected through the Household, Woman's and Man's Questionnaires. Figure shows the number of individuals excluded at each stage based on inaccurate or missing data and the percentage of the total number of individuals this relates to.

Due to the non-normal distribution of the distance and travel time data, I present the median distance and travel time with the interquartile range (IQR). Statistical significance was tested using a Wilcoxon rank-sum (Mann-Whitney U) test for binary variables and a Kruskal Wallis test for non-binary categorical variables.

Statistical analyses of travel time to health facilities assessed:

i. The extent to which travel time to health facilities correlates with Euclidean distance to health facilities for DHS EAs;
ii. The sociodemographic factors associated with travel time to health facilities;
iii. Whether travel time was associated with reporting of distance as barrier to healthcare.

First, EA travel time and Euclidean distance were compared as continuous variables in Stata using Spearman's correlation. The data were ordered on the travel time variable. Using a scatter plot, I assessed the relationship between distance and travel time. The scatter plot indicated a monotonic relationship, thus meeting the assumptions of the Spearman's correlation test.

Second, the determinants of travel time (minutes) to health facilities were assessed using linear regression. The log travel time was used because the distribution of the residuals was positively skewed when using non-transformed travel time data. Using the log-transformed travel time, the residuals were approximately normally distributed. The univariable association between each sociodemographic factor and travel time was assessed. Next, region was included as a random effect for each univariable association. Finally, a fully-adjusted model was constructed, incrementally adding exposure variables with each model including region as a random effect. As the outcome variable was measured at the EA level and household level clustering of other sociodemographic factors was minimal or not observed, EA and household clustering were not accounted for in this analysis. The fully-adjusted model adjusted for sex, age, education, wealth and residence type. All exposures were assessed as categorical variables. Age was included as a categorical variable after linearity was assessed using a likelihood ratio test. As linear regression analyses were conducted using a log-transformed outcome, marginal effects were predicted and exponentiated. The p values presented correspond to original linear regression models. I also assessed whether there was statistical evidence of interaction between sex and wealth, sex and residence type and wealth and residence type, in regards to their association with travel time, using likelihood ratio tests to compare models with and without an interaction term.

In a sub-analysis including 14,334 individuals aged 15–64 with information on occupation, the sociodemographic determinants of travel time were also assessed as above in overall and sex-stratified models. Fully-adjusted analyses are presented, with marginal effects predicted and exponentiated. In additional analyses, I also assessed marital status as a potential determinant of travel time and presented fully-adjusted overall analyses and models stratified by sex, with marginal effects predicted and exponentiated.

Next, I assessed whether travel time was associated with reporting distance as a problem amongst women aged 15–64 years using Poisson regression analyses. This could only be explored in women as men did not answer questions pertaining to healthcare barriers. Due to the non-linearity of the travel time variable, travel time was categorised into seven categories: <15 minutes, 15–<30 minutes, 30–<45 minutes, 45–<60 minutes, 1–<2 hours, 2–<4 hours and ≥4 hours. In Model 1, I explored the univariable association between travel time and reporting of distance as a barrier to healthcare. In Model 2, a mixed effects Poisson regression analysis included region as a mixed effect. In Model 3, I additionally adjusted for other sociodemographic factors: age, education, wealth, residence type and occupation.

7.3 Results

7.3.1 The distribution of health facilities in Namibia

Overall there are 347 health facilities, constituting 270 clinics, 43 health centres and 34 hospitals. The Nearest Neighbour analysis indicated that public health facilities in Namibia are highly clustered, with a Nearest Neighbour index of 0.54, which is strongly indicative of spatial clustering (**Table 7.2**). The large Z-score of -16.2 suggests that the clustering observed is unlikely to be due to random chance.

Table 7.2: Results of the Nearest Neighbour Analysis

Number of health facilities assessed	Nearest Neighbour index	Z
347	0.54	-16.2

Despite being highly clustered, the spatial distribution of health facilities is broadly reflective of population density (**Figure 7.3**), with health facilities clustered in the north near Outapi, Oshikango and Oshakati. There are also a number of health facilities located along the northern border in Kavango, near Rundu. Other clusters occur at population hotspots in locations such as Windhoek, Swakopmund, Walvis Bay, Keetmanshoop and Lderitz.

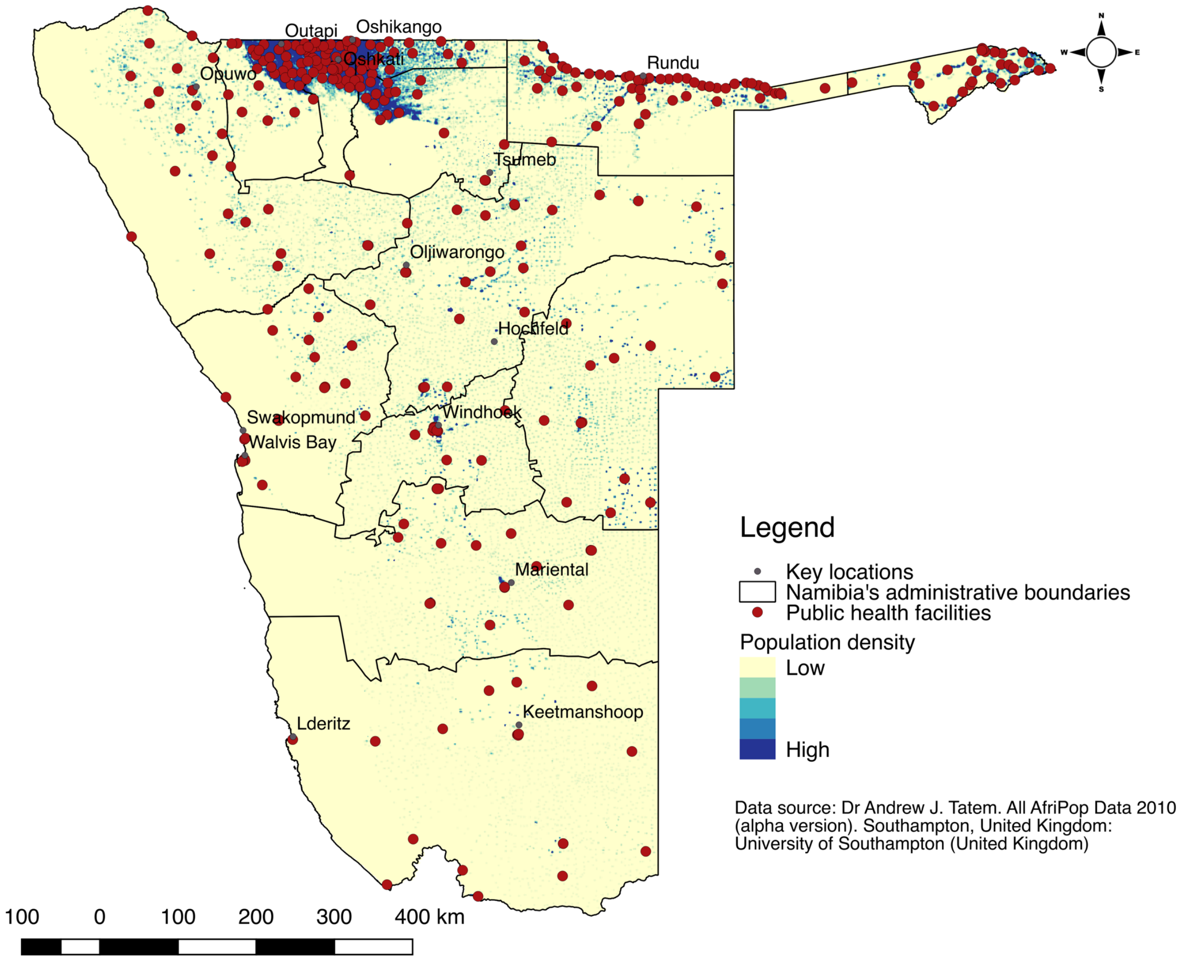


Figure 7.3: Location of public health facilities in relation to population distribution in Namibia. Population density data source: AfriPop 2010 (alpha version) Namibia [9].

The distribution of health facilities by region is presented in **Figure 7.4**, which shows the proportion of health facilities in each region. The highest proportion of health facilities are in the Kavango region at 16.7%, which equates to 58 facilities. This is followed by Omusati which has 14.4% of health facilities (n=50) and Ohangwena with 9.5% of facilities (n=33). The lowest proportion of health facilities is in Khomas with 3.8% of all facilities (n=13) and Omaheke with 4.0% of facilities (n=14). This is broadly reflective of population density in Namibia.

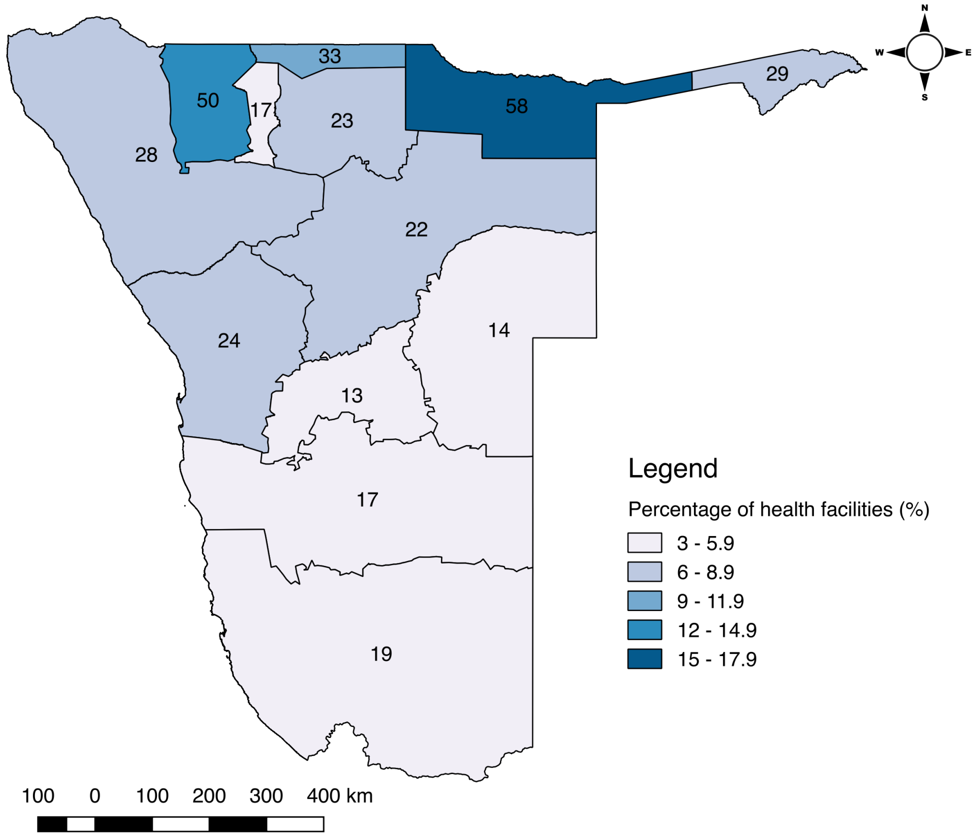


Figure 7.4: Regional distribution of public health facilities in Namibia. The proportion of health facilities in each of Namibia's 13 administrative regions. The numbers in each region polygon refer to the number of health facilities in that region.

I also explored the number of health facilities in relation to the 2011 Namibia Population and Housing Census and the DHS population (**Figure 7.5**). Scatter plots and Spearman's correlation indicated a modest positive correlation between the number of health facilities and the census population (rs=0.34, *p*=0.258) and DHS population (rs=0.55, *p*=0.053), respectively. However, these correlations were not statistically significant (*p*>0.05).

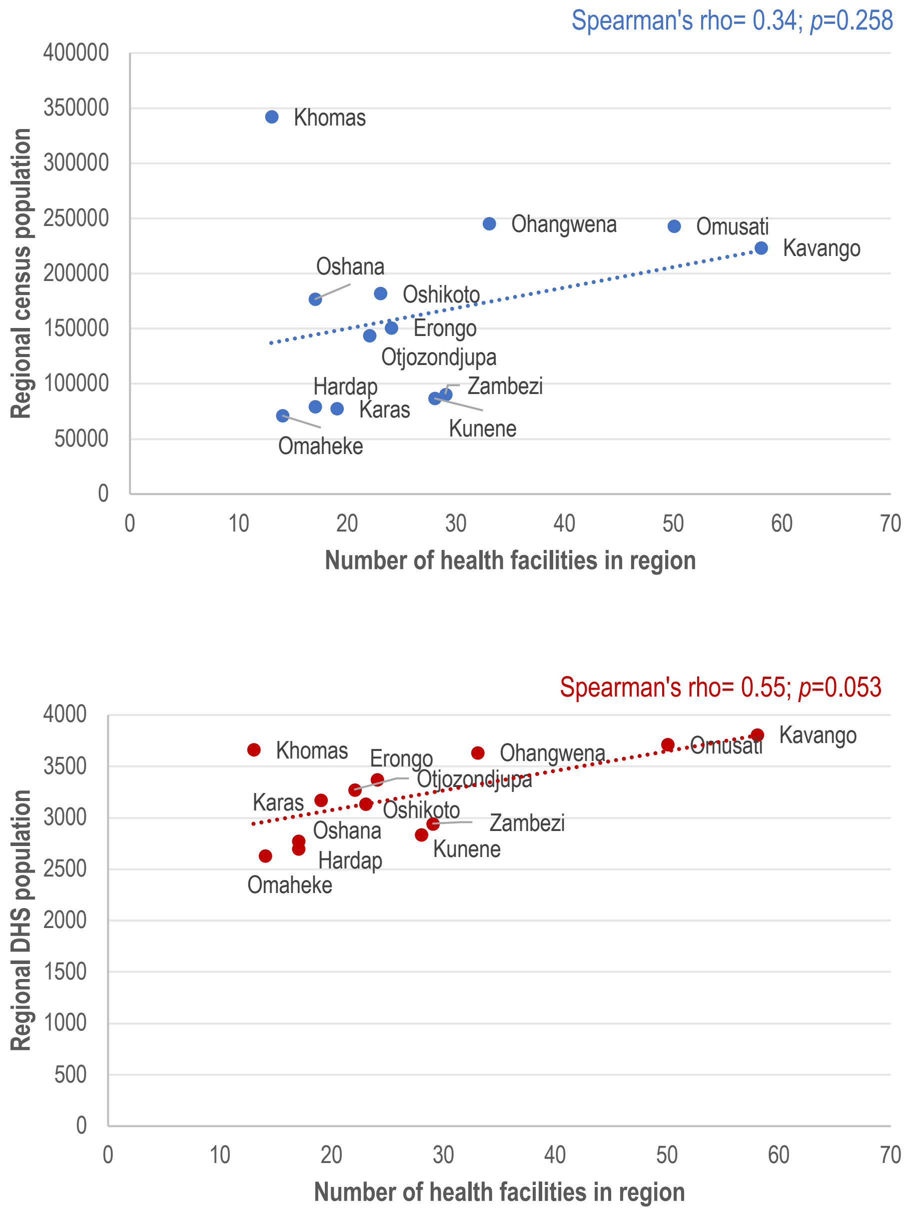
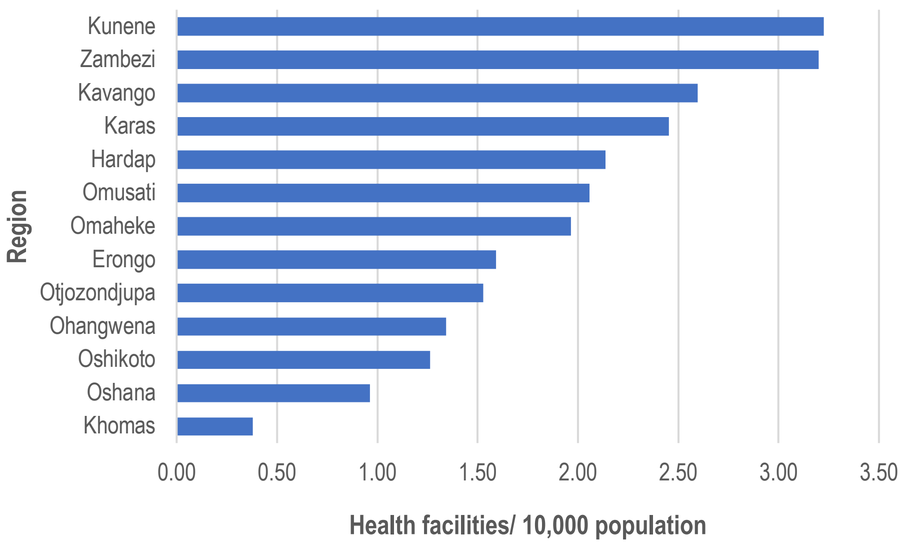


Figure 7.5: The correlation between the regional number of health facilities and the regional census and DHS population. Scatter plot showing the number of health facilities per region in relation to the Census and DHS regional populations. The correlation was tested using Spearman's correlation and is reported with the *p* value. Regional census population data were sourced from the 2011 Namibia Population and Housing Census [140].

The health facilities per 10,000 population in each region was explored using the 2011 Population and Housing Census data (**Figure 7.6A and 7.6B**). Kunene had the highest ratio of health facilities to the population with 3.22 health facilities per 10,000 population, followed by Zambezi at 3.2 facilities per 10,000 population. Khomas and Oshana had the lowest ratio of health facilities to the population at 0.38 and 0.96 facilities per 10,000 population, respectively.

A



B

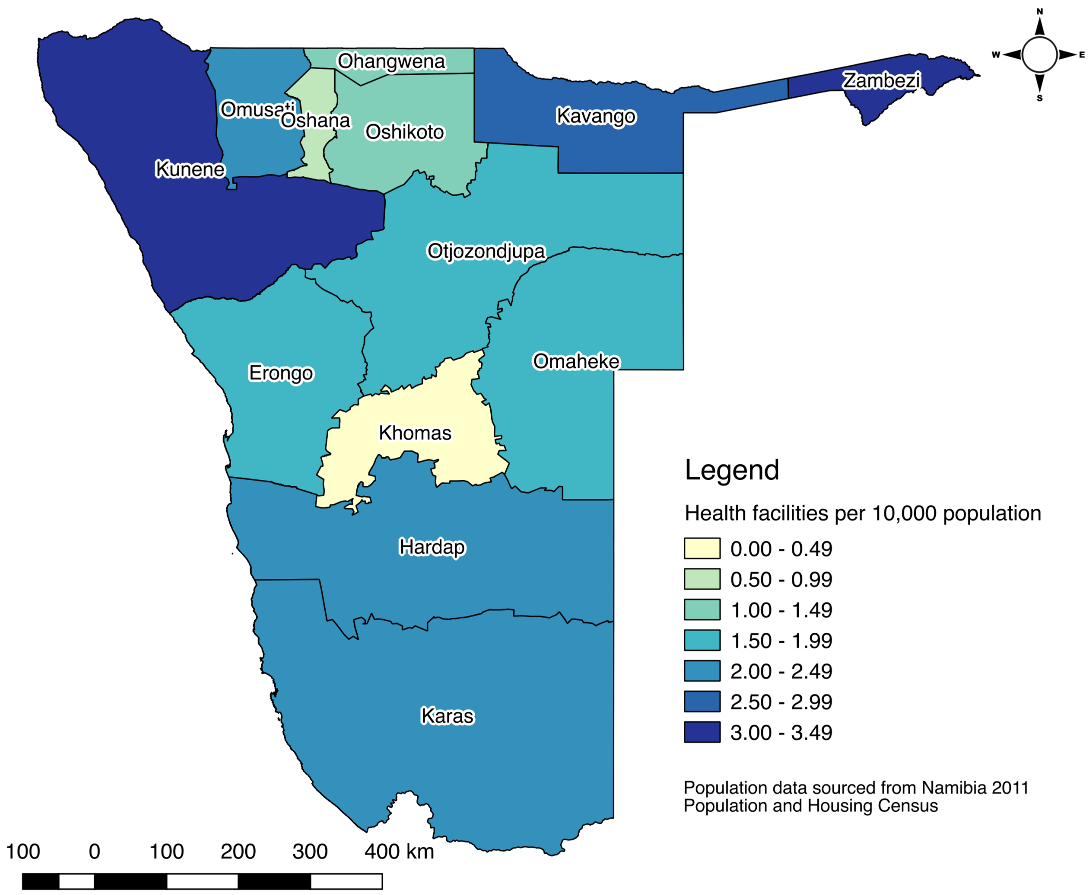


Figure 7.6: Health facilities per 10,000 population by region. A: regions ranked in order of health facility to population ratio. **B:** map showing the regional ratio of health facilities to the population.

7.3.2 Distance to health facilities

To understand health facility accessibility on a finer scale, I explored distance to health facilities. The distance to health facilities was first explored by generating 5 Km, 10 Km and 20 Km radius buffers around public health facility locations to investigate the potential geographical coverage of these services (**Figure 7.7**). The distribution of health facilities reflects key geographical locations in Namibia. However, large proportions of the country's geographical area are not within a 20 Km radius of any public health facility. An even smaller proportion of the total land mass is within 10 Km or 5 Km of a public health facility. However, due to the clustered distribution of the population, it is important to explore this in the context of the population.

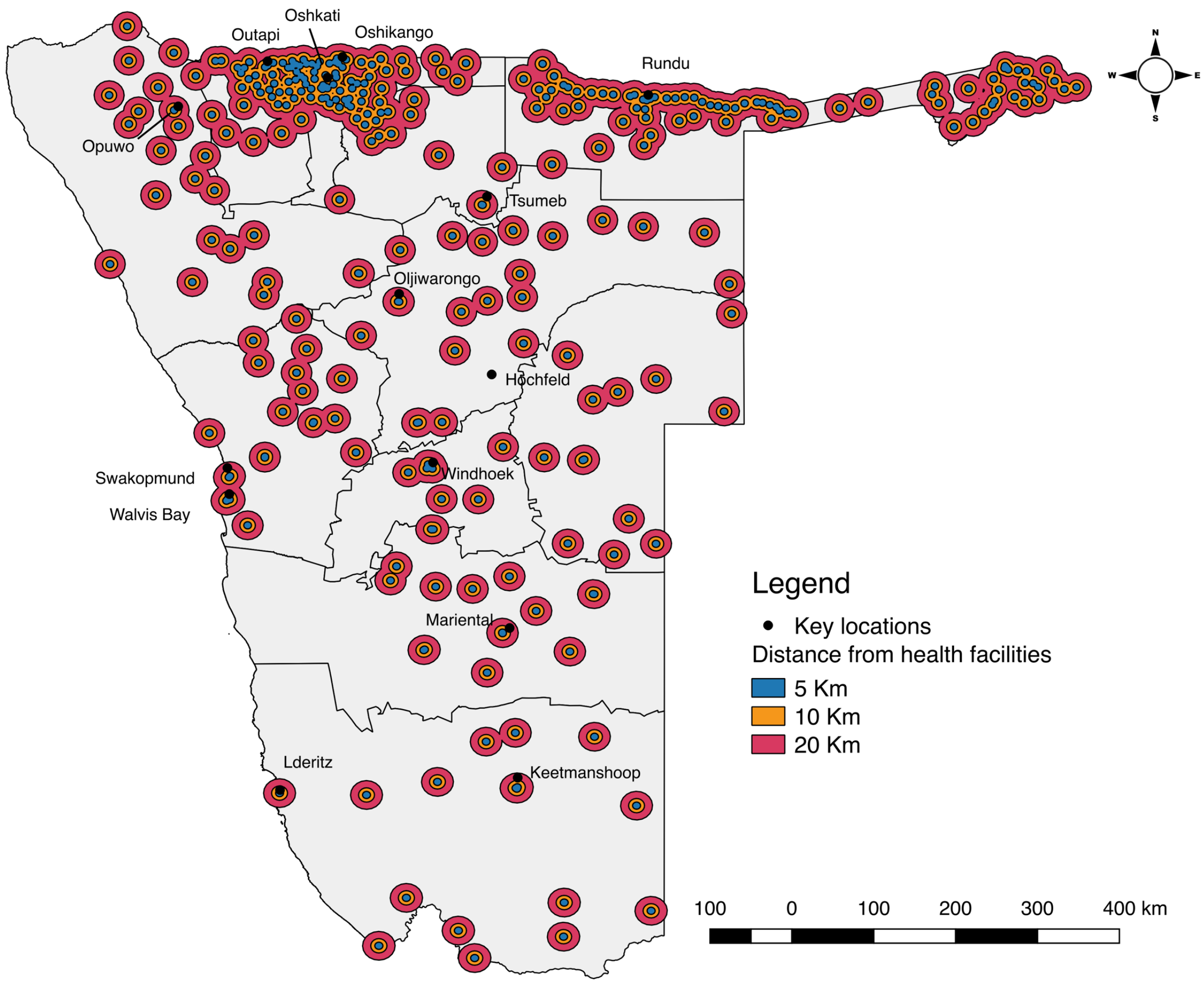


Figure 7.7: The geographical coverage of health facilities. The geographical area covered by 5 Km, 10 Km and 20 Km radii from public health facility locations.

7.3.3 DHS population

Evaluation of the geographical distribution of health facilities and the health facility-population ratio is useful for understanding the national coverage of health facilities; however, it does not enable the assessment of individual differences in healthcare access, which is key to understanding demand-side accessibility of healthcare in the country. As such, the following analyses investigate the sociodemographic patterns of accessibility in Namibia using two objective measures of accessibility: distance and travel time.

Table 7.3 shows the individuals from the DHS population that were included and excluded in the subsequent analyses by key outcomes, age and sex. A total of 41,000 individuals (98.5% of the household population) were included in the following analyses. A total of 646 individuals (1.6%) were excluded on the basis of inaccurate travel time estimates or incomplete data on age, sex and education. The 23.0% of the population in the ≥4 hours category that were excluded was due to the overestimation of travel time. For the remainder of the travel time categories the proportion of excluded individuals accounted for ≤1.4% of the population in each category. The proportion excluded was also similar between men and women at 1.7% and 1.4%, respectively. The proportion of excluded individuals was also similar across age groups, with the exception of those with education listed as “don’t know” or missing, all of whom were excluded on this basis.

Table 7.3: Individuals included and excluded from analyses using DHS data				
Key outcomes and sociodemographic characteristics	**Overall** No. (%)	**Included** No. (%)	**Excluded** No. (%)	***p***
Travel time categories				
<15 minutes	14,602 (100.0)	14,497 (99.3)	105 (0.7)	<0.001
15 - <30 minutes	7,993 (100.0)	7,943 (99.4)	50 (0.6)	
30 - <45 minutes	4,758 (100.0)	4,722 (99.2)	36 (0.8)	
45 - <60 minutes	4,288 (100.0)	4,247 (99.0)	41 (1.0)	
1 - <2 hours	4,908 (100.0)	4,860 (99.0)	48 (1.0)	
2 - <4 hours	3,737 (100.0)	3,685 (98.6)	52 (1.4)	
≥4 hours	1,360 (100.0)	1,046 (76.9)	314 (23.0)	
Distance categories				
<5 Km	25,614 (100.0)	25,147 (98.2)	467 (1.8)	<0.001
5 - <10 Km	7,846 (100.0)	7,763 (98.9)	83 (1.1)	
10 - <15 Km	2,573 (100.0)	2,544 (98.9)	29 (1.1)	
15 - <20 Km	1,456 (100.0)	1,438 (98.8)	18 (1.2)	
≥20 Km	4,157 (100.0)	4,108 (98.8)	49 (1.2)	
Sex				
Men	20,062 (100.0)	19,713 (98.3)	349 (1.7)	<0.001
Women	21,582 (100.0)	21,287 (98.6)	295 (1.4)	
Missing	2 (100.0)	0 (0.0)	2 (100.0)	
Age group				
<5	5,840 (100.0)	5,807 (99.4)	33 (0.6)	<0.001
5 - 14	10,020 (100.0)	9,821 (98.0)	199 (2.0)	
15 - 29	11,048 (100.0)	10,952 (99.1)	96 (0.9)	
30 - 49	9,033 (100.0)	8,873 (98.2)	160 (1.8)	
50 - 64	3,383 (100.0)	3,317 (98.1)	66 (2.0)	
65+	2,289 (100.0)	2,230 (97.4)	59 (2.6)	
Don't know	18 (100.0)	0 (0.0)	18 (100.0)	
Missing	15 (100.0)	0 (0.0)	15 (100.0)	
Total	41,646 (100.0)	41,000 (98.5)	656 (1.6)	

P value corresponds to a chi-squared test

7.3.4 Distance to health facilities in the DHS population

To better understand the distance to health facilities in the context of Namibia's population, I explored the distance to health facilities from DHS EAs and the sociodemographic determinants of distance to health facilities.

Euclidean (straight-line) distance was calculated and assigned to individuals based on their EA. The population distribution of Euclidean distance was positively skewed (**Figure 7.8**). This suggests that whilst the majority of individuals in the DHS live within 10 Km of a health facility, there are a number of individuals who live at greater distances and may be disadvantaged in terms of healthcare access.

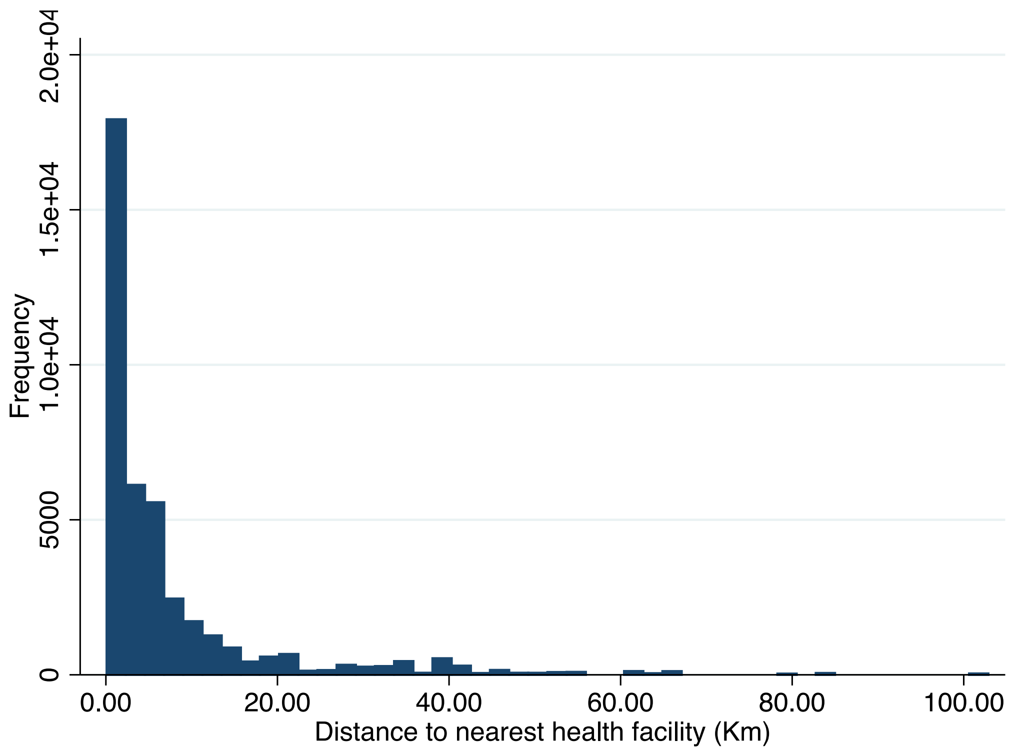


Figure 7.8: The frequency distribution of distance to the nearest health facility in the DHS population (n=41,000).

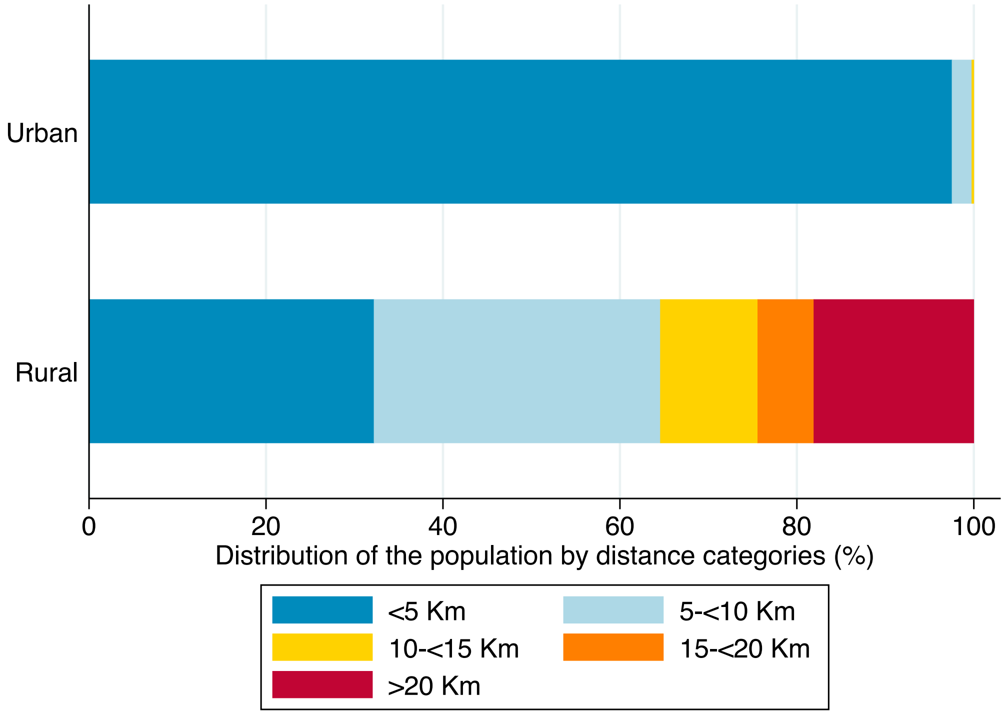
Due to the non-normal distribution of distance to health facilities, I present the median distance and IQR. The median distance to health facilities was 3.0 (6.3) Km and was higher in rural areas at 6.6 (10.1) Km compared to 1.2 (1.1) Km in urban areas (*p*<0.001)(**Table 7.4**). The maximum distance some individuals would have to travel was estimated to be 102.9 Km and this was in rural areas. The greatest distances were to health centres at a median of 25.2 (72.0) Km, followed by hospitals at 13.4 (42.3) Km.

Table 7.4: Euclidean distance to nearest health facility by residence type and health facility type (total observations: 41,000)

	Median distance (Km)	IQR	Minimum distance (Km)	Maximum distance (Km)	*p*
All health facilities	3.0	6.3	0.1	102.9	
Urban	1.2	1.1	0.1	14.2	<0.001
Rural	6.6	10.1	0.2	102.9	
Clinics	4.1	8.2	0.1	113.7	
Health Centres	25.2	72.0	0.1	215.5	
Hospitals	13.4	42.3	0.2	279.7	

P value calculated using a Wilcoxon rank-sum test | IQR: interquartile range

The distribution of the population by categories of distance varied between urban and rural areas, with distances substantially more varied in rural populations compared with urban populations (p<0.001)(**Figure 7.9**). In urban areas, 97.5% of individuals lived within 5 Km of the nearest health facility and no individuals lived more than 15 Km away. By contrast in rural areas, around a third of individuals lived within 5 Km and 10 Km of the nearest health facility, whilst 18.1% lived more than 20 Km away.



Distance categories	**All** No. (%)	**Urban** No. (%)	**Rural** No. (%)	***p***
<5 Km	25,147 (61.3)	17,828 (97.5)	7,319 (32.2)	<0.001
5 - <10 Km	7,763 (18.9)	409 (2.2)	7,354 (32.4)	
10 - <15 Km	2,544 (6.2)	41 (0.2)	2,503 (11.0)	
15 - <20 Km	1,438 (3.5)	0 (0.0)	1,438 (6.3)	
≥20 Km	4,108 (10.0)	0 (0.0)	4,108 (18.1)	
Total	41,000 (100.0)	18,278 (100.0)	22,722 (100.0)	

P value corresponds to a chi-squared test

Figure 7.9: The distribution of the urban and rural population by categories of distance to the nearest health facility and table showing the number and percentage of individuals in each category (n=41,000).

7.3.5 Travel time to health facilities

Given the limitations of just assessing Euclidean distance, travel time to health facilities, accounting for roads, barriers, elevation, land cover and the mode and speed of transport, was also explored. **Figure 7.10** shows the Access Mod 5.0 output of travel time to health facilities. The accessibility of health facilities reflects the road network in Namibia. There are large areas of the country where health facilities are likely to be inaccessible with travel times estimated to be over six hours.

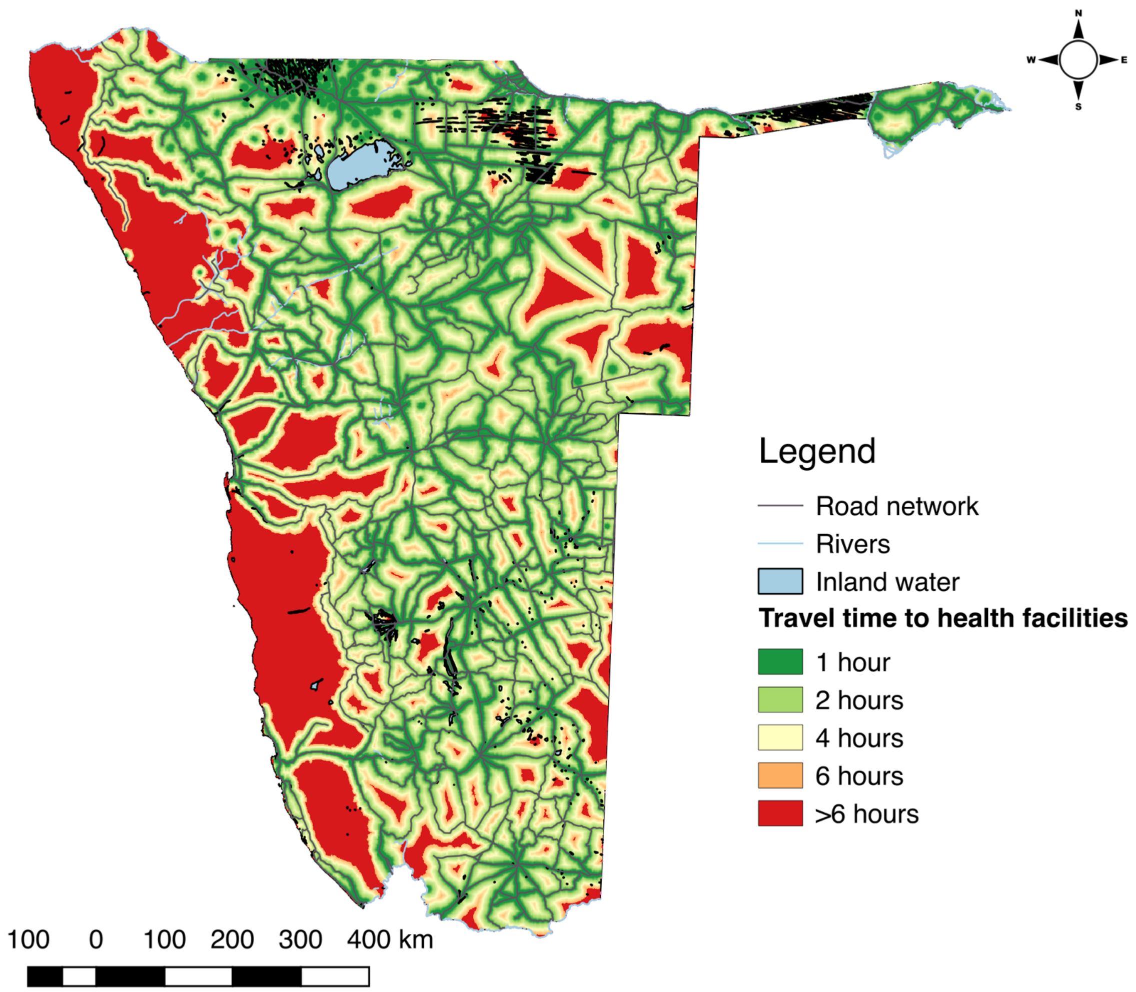


Figure 7.10: Map of travel time to health facilities in Namibia. Travel time to health facilities in Namibia accounting for elevation, land cover, roads, rivers and inland water.

The distribution of travel time to the nearest health facility in this DHS population is presented in **Figure 7.11.** The distribution of travel time to health facilities was positively skewed. This suggests that whilst the majority of individuals have short travel times to health facilities, some households have much greater travel times to reach health facilities and thus may be disadvantaged in accessing healthcare.

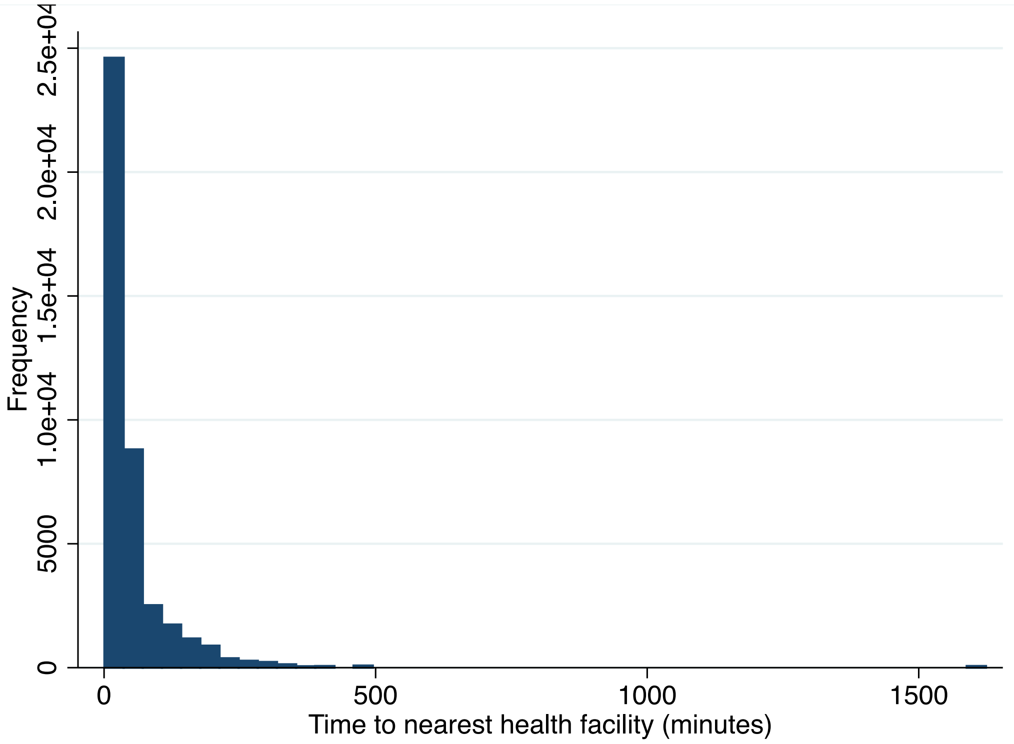


Figure 7.11: The frequency distribution of travel time to health facilities in the DHS population (n=41,000).

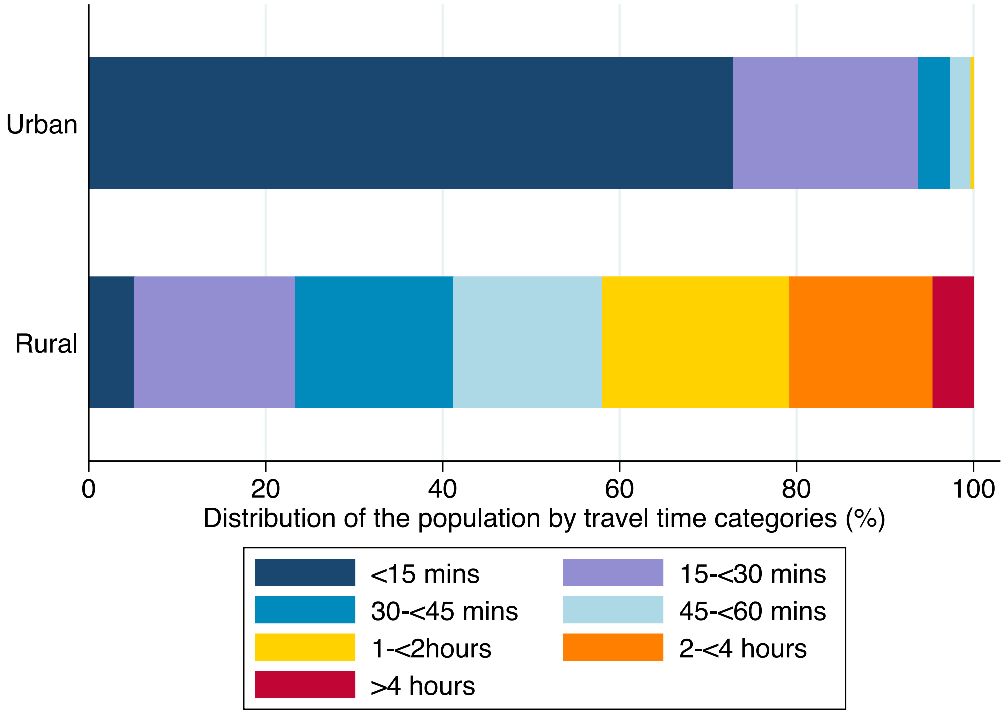
The median travel time to health facilities was 25.8 (46.4) minutes but in rural areas the average travel time was 50.6 (67.8) minutes, compared to 9.2 (9.3) minutes in urban areas (**Table 7.5**). The longest travel times were to health centres at 87.1 (118.4) minutes and the shortest travel times were to clinics at 28.8 (49.5) minutes.

Table 7.5: Average travel time to health facilities by scenario (n=41,000)

Scenario	Median travel time (minutes)	IQR	Minimum time (minutes)	Maximum time (minutes)	*p*
All health facilities	25.8	46.4	0.8	1623.8	
Urban	9.2	9.3	0.8	107.2	<0.001
Rural	50.6	67.8	3.9	1623.8	
Clinics	28.8	49.5	0.8	1688.0	
Health Centres	87.1	118.4	3.9	1623.8	
Hospitals	47.5	119.0	2.0	1833.0	

P value calculated using a Wilcoxon rank sum test to assess whether travel time estimates were significantly different between urban and rural populations | N refers to the household population | IQR: interquartile range

There were urban-rural differences in the distribution of the population by categories of travel time to health facilities (**Figure 7.12**). Travel times were substantially more variable in rural areas compared with urban areas (p<0.001). In urban areas, more than 70% of the population lived less than 15 minutes from a health facility, followed by 20.9% that lived between 15 and 30 minutes to a facility. Less than 10% of the population lived more than 30 minutes from a health facility and no households were located more than two hours from a facility. By contrast, in rural areas, just 5.2% lived less than 15 minutes from a health facility, 41.9% of the population would have to travel more than an hour to the nearest health facility and approximately 20% would to travel more than two hours.



Travel time categories	**All** No. (%)	**Urban** No. (%)	**Rural** No. (%)	***p***
<15 minutes	14,497 (35.4)	13,321 (72.9)	1,176 (5.2)	<0.001
15 - <30 minutes	7,943 (19.4)	3,812 (20.9)	4,131 (18.2)	
30 - <45 minutes	4,722 (11.5)	660 (3.6)	4,062 (17.9)	
45 - <60 minutes	4,247 (10.4)	428 (2.3)	3,819 (16.8)	
1 - <2 hours	4,860 (11.9)	57 (0.3)	4,803 (21.2)	
2 - <4 hours	3,685 (9.0)	0 (0.0)	3,685 (16.2)	
≥4 hours	1,046 (2.6)	0 (0.0)	1,046 (4.6)	
Total	41,000 (100.0)	18,278 (100.0)	22,722 (100.0)	

P value corresponds to a chi-squared test

Figure 7.12: Distribution of the urban and rural population by travel time to health facilities and table showing the number and percentage of individuals in each category (n=41,000).

The median distance and travel time to health facilities also varied by region (**Figure 7.13**). The inter-regional differences in accessibility were similar between the two measurements. Kunene had the highest median distance to health facilities (9.9 Km) and the second highest median travel time to health facilities (60.8 minutes). The median travel time in Ohangwena was highest at 61.8 minutes. The shortest distance was observed in Khomas (1.1 Km), which also had a median travel time of less than 15 minutes. The shortest travel time to health facilities was observed in Karas (8.8 minutes), which also had a median distance of less than 2 Km to a health facility.

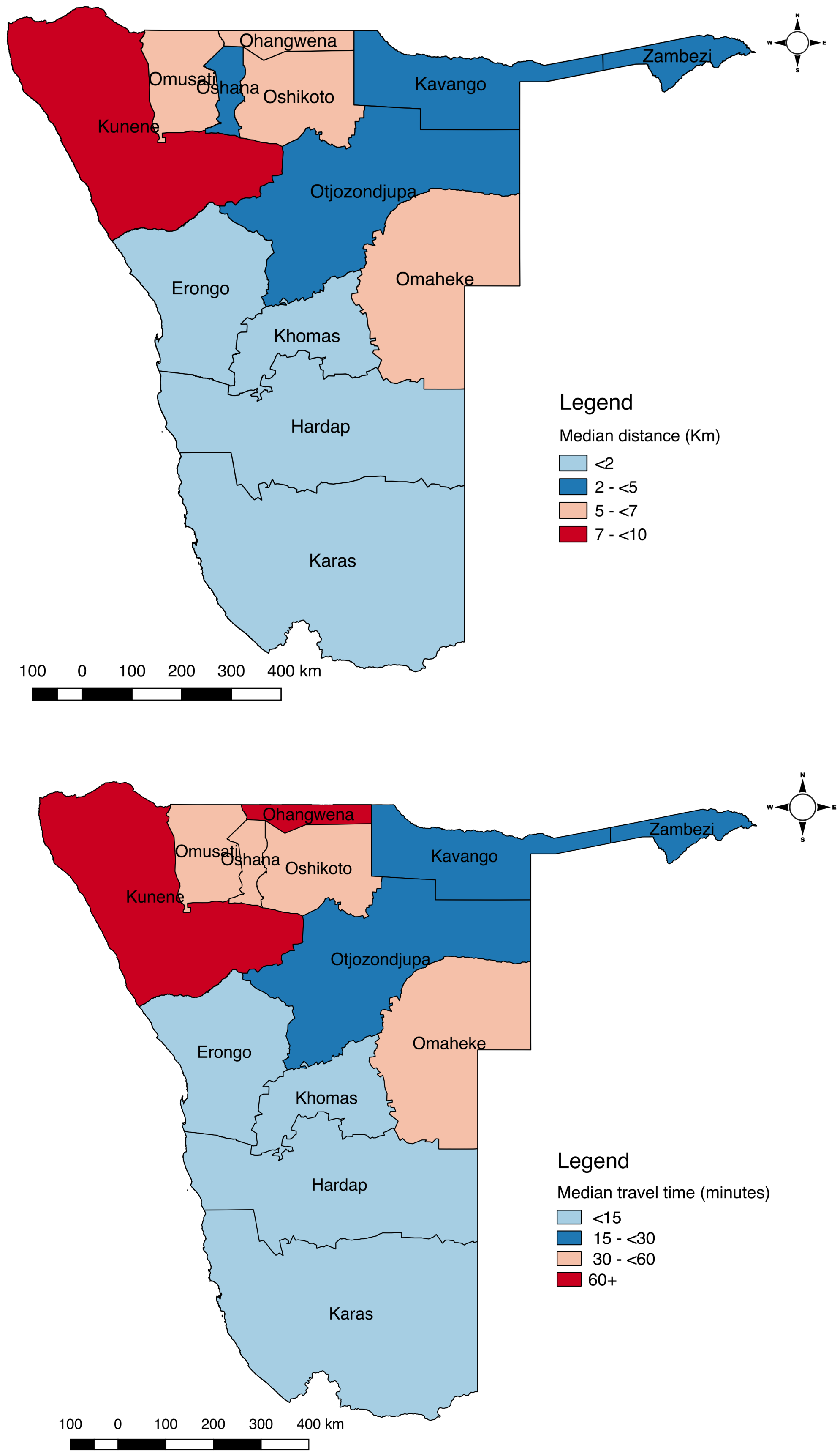


Figure 7.13: Median regional distance and travel time to health facilities in this DHS population (n=41,000).

7.3.6 Comparison of distance and travel times to health facilities

To quantifiably assess whether distance and travel time measures were comparable in relation to population distribution by different measures of accessibility, Spearman's correlation was conducted.

An overall positive correlation between the two measurements was observed. There was a monotonic relationship between distance and travel time (**Figure 7.14**). One EA located in Kunene had a travel time of 1623.8 minutes (approximately 27 hours). This is because it was not located near a major road and was located in a bare area which corresponds to the Namib Desert. There was a statistically significant correlation between distance and travel time to health facilities (rs=0.8262, p<0.001). This suggests that distance and travel time are equally useful measures of geographical accessibility of healthcare in this Namibian population.

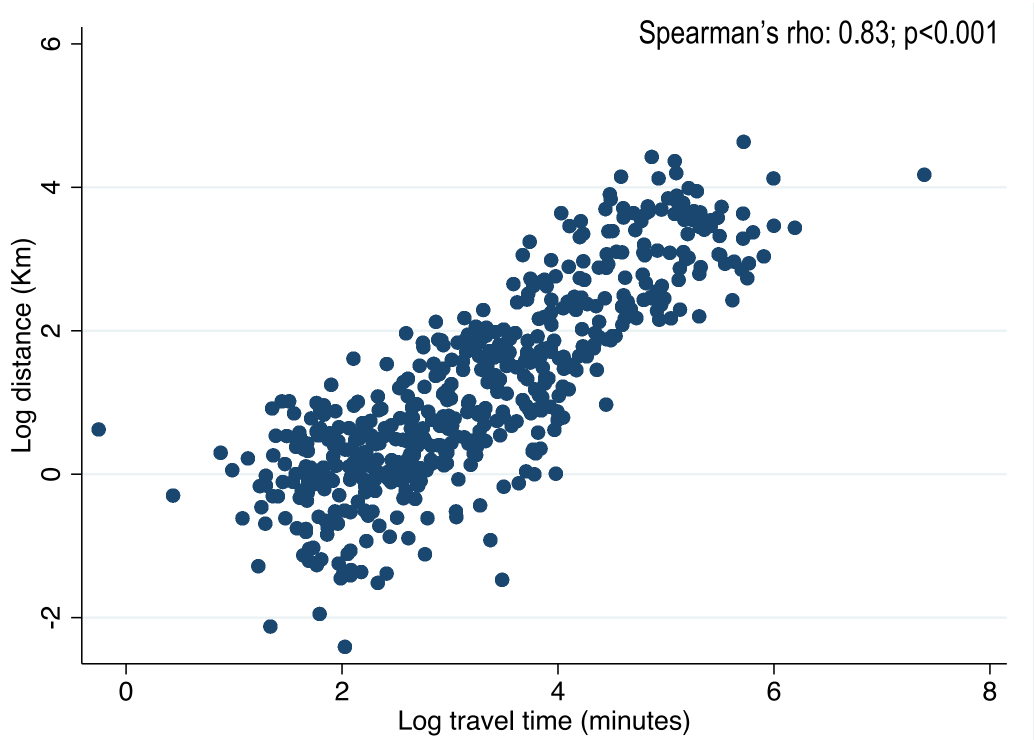


Figure 7.14: Scatter plot of the relationship between log distance to health facilities (Km) and log travel time to health facilities (minutes)(n=41,000).

7.3.7 Sociodemographic factors and travel time to health facilities

Given that the travel time measurement accounts for factors such as mode and speed of transport, waterbodies and roads and allows for EA displacement to be accounted for, I further explored the determinants of travel time over distance.

Travel time by health facility type

The median travel time to health facilities was higher in men at 26.3 minutes (IQR 50.5) than women (p<0.001)(**Table 7.7**). Similar trends were observed for travel time to clinics, health centres and hospitals. The travel time to health facilities was highest amongst the 65+ age group at 41.6 (61.0) minutes and lowest for the 30–49 age group at 19.4 (42.2).

Travel time decreased with increasing education level, suggesting that more educated individuals live closer to health facilities (p<0.001). Similarly, wealthier individuals lived closer to health facilities (p<0.001), with those in the highest wealth quintile living an average of 9.5 (10.8) minutes from a facility compared to an average travel time of 50.0 (61.3) minutes in the lowest quintile.

Individuals living in rural areas had a significantly longer median travel time to facilities than urban areas at an average of 50.6 (72.8) minutes to a facility compared to 9.2 (9.3) minutes in urban areas (p<0.001). Those with agricultural occupations (who are also likely to live in rural areas) had the greatest travel time to health facilities at 79.7 (125.3) minutes. Those in manual and professional occupations had the shortest travel times (p<0.001). Insured populations had a shorter average travel time to facilities than the uninsured population. Similar sociodemographic trends in travel time were observed across all health facility types.

In a subset of 14,374 individuals with data on ethnicity, the Herero population had the longest travel times to health facilities at 27.9 (114.6) minutes, followed by the Oshiwambo population at 26.9 (36.3) minutes (**Appendix 3; Table 7**). The Herero population also had the greatest variability in travel time estimates with an IQR of 114.6 minutes.

Table 7.7: Average time (minutes) to health facilities by sociodemographic factors (n=41,000)

Sociodemographic Characteristics	Minutes to any HF Median (IQR)	*p*	Minutes to clinic Median (IQR)	*p*	Minutes to HC Median (IQR)	*p*	Minutes to Hospitals Median (IQR)	*p*
Sex								
Men	26.3 (50.5)	<0.001	29.3 (54.0)	<0.001	93.6 (121.7)	<0.001	49.0 (123.2)	<0.001
Women	24.6 (42.6)		28.1 (42.6)		84.6 (116.7)		45.9 (111.9)	
Age group								
<5	30.5 (53.4)	<0.001	34.9 (59.9)	<0.001	98.8 (120.3)	<0.001	63.7 (131.1)	<0.001
5 – 14	28.3 (44.6)		32.2 (47.9)		92.7 (111.3)		53.9 (117.9)	
15 – 29	21.2 (40.4)		25.6 (42.7)		70.0 (115.4)		36.7 (101.5)	
30 – 49	19.4 (42.2)		23.9 (45.3)		82.7 (129.0)		35.7 (112.1)	
50 – 64	27.6 (56.4)		32.2 (60.4)		101.9 (123.7)		60.8 (133.8)	
65+	41.6 (61.0)		45.2 (62.8)		101.2 (120.0)		79.2 (129.7)	
Education level								
No education	35.5 (66.0)	<0.001	41.6 (70.7)	<0.001	114.1 (130.2)	<0.001	69.8 (143.0)	<0.001
Primary	31.6 (44.3)		35.4 (50.4)		93.9 (112.0)		60.8 (117.5)	
Secondary	17.3 (34.2)		22.6 (36.7)		65.8 (110.2)		31.1 (87.5)	
Higher	13.3 (18.2)		17.0 (19.7)		43.3 (105.2)		22.1 (47.3)	
Wealth quintile								
Lowest	50.0 (61.3)	<0.001	54.2 (66.2)	<0.001	110.1 (122.9)	<0.001	99.1 (121.6)	<0.001
Second	42.2 (51.9)		45.9 (57.4)		99.3 (125.1)		81.6 (132.3)	
Middle	32.5 (43.8)		35.1 (51.8)		97.7 (116.1)		58.7 (122.6)	
Fourth	14.1 (27.7)		20.0 (34.0)		73.3 (116.7)		28.0 (76.1)	
Highest	9.5 (10.8)		15.3 (15.0)		43.6 (107.5)		18.6 (24.4)	
Residence type								
Urban	9.2 (9.3)	<0.001	13.3 (14.3)	<0.001	51.1 (101.1)	<0.001	17.0 (21.7)	<0.001
Rural	50.6 (67.8)		55.1 (67.4)		116.5 (129.8)		115.7 (129.9)	

Table 7.7: Average time (minutes) to health facilities by sociodemographic factors (n=41,000)

Sociodemographic Characteristics	Minutes to any HF	*p*	Minutes to clinic	*p*	Minutes to HC	*p*	Minutes to Hospitals	*p*
	Median (IQR)		Median (IQR)		Median (IQR)		Median (IQR)	
Occupation[a]								
Professional	14.6 (32.1)	<0.001	20.4 (33.6)	<0.001	67.2 (116.1)	<0.001	27.8 (76.4)	<0.001
Agricultural	79.7 (125.3)		87.1 (125.5)		170.4 (191.9)		156.3 (178.3)	
Manual	14.7 (28.6)		19.3 (37.0)		67.2 (121.3)		30.9 (71.3)	
Unemployed	27.5 (42.8)		30.9 (47.0)		82.7 (114.7)		49.7 (113.6)	
Health insurance[b]								
Uninsured	25.5 (45.2)	<0.001	28.3 (48.1)	<0.001	86.9 (119.1)	<0.001	44.9 (113.3)	<0.001
Insured	13.3 (19.2)		18.1 (22.8)		62.5 (110.5)		22.6 (61.3)	

p corresponds to Wilcoxon rank-sum (Mann-Whitney U) test for binary sociodemographic factors (sex and residence type) and corresponds to a Kruskal Wallis test for sociodemographic factors with multiple categories (all other variables) | [a] Occupation only applies to those who took part in the individual surveys (n=14,335) | [b] Health insurance only applies to those who took part in the individual surveys (n=14,374) | HC: health centre

Travel time to health facilities by sociodemographic factors

Linear regression analyses were conducted to explore the relation between travel time and sociodemographic characteristics, adjusted for regional clustering and other covariates. Predicted travel time in minutes by sociodemographic factors are presented in **Table 7.8.**

In the fully-adjusted model (Model 3), women had a shorter predicted travel time to health facilities than men ($p<0.001$)(**Table 7.8**). Predicted travel time increased with categories of age and was highest in the 50–64 age group at 27.21 (22.84 – 32.42) minutes. Predicted travel time decreased with education from 27.99 (23.51 – 33.32) minutes in those with no education to 24.73 (20.78 – 29.43) minutes in those with secondary education. Travel time also decreased with increasing wealth quintile from 29.45 (24.74 – 35.06) minutes in the lowest quintile to 22.85 (19.19 – 27.21) minutes in the highest quintile. Notably, predicted travel times were substantially higher amongst rural populations compared with urban populations ($p<0.001$). In urban populations, predicted travel time was 9.56 (8.03 – 11.37) minutes, whilst in rural populations travel time was predicted to be 58.90 (49.50 – 70.07) minutes. Therefore, in this population, men, older individuals, the less educated, less wealthy and rural populations lived further from health facilities.

Table 7.8: Predicted travel time (minutes) to health facilities by sociodemographic factors

Sociodemographic Characteristics	Model 1		Model 2		Model 3	
	Predicted travel time in minutes (95% CI)	*p*	Predicted travel time in minutes (95% CI)	*p*	Predicted travel time in minutes (95% CI)	*p*
Sex						
Men	26.93 (26.50 - 27.37)		27.16 (21.17 - 34.85)		26.88 (22.59 - 31.98)	
Women	24.79 (24.41 - 25.17)	<0.001	24.67 (19.23 - 31.66)	<0.001	25.55 (21.48 - 30.40)	<0.001
Age group						
<5	29.96 (29.10 - 30.85)		28.31 (22.15 - 36.17)		25.12 (21.08 - 29.92)	
5 – 14	27.10 (26.50 - 27.72)	<0.001	25.66 (20.09 - 32.76)	<0.001	25.00 (21.00 - 29.75)	0.743
15 – 29	23.15 (22.66 - 23.65)	<0.001	24.13 (18.89 - 30.81)	<0.001	26.79 (22.51 - 31.89)	<0.001
30 – 49	22.22 (21.70 - 22.75)	<0.001	24.02 (18.80 - 30.67)	<0.001	26.96 (22.65 - 32.08)	<0.001
50 – 64	28.26 (27.19 - 29.38)	0.018	28.51 (22.29 - 36.48)	0.751	27.21 (22.84 - 32.42)	<0.001
65+	37.88 (36.13 - 39.71)	<0.001	34.13 (26.64 - 43.71)	<0.001	26.80 (22.48 - 31.96)	0.001
Education level						
No education	34.14 (33.46 - 34.84)		30.96 (24.61 - 38.94)		27.99 (23.51 - 33.32)	
Primary	28.89 (28.35 - 29.44)	<0.001	27.78 (22.08 - 34.94)	<0.001	26.11 (21.94 - 31.07)	<0.001
Secondary	19.44 (19.08 - 19.81)	<0.001	21.47 (17.07 - 27.01)	<0.001	24.73 (20.78 - 29.43)	<0.001
Higher	15.48 (14.73 - 16.27)	<0.001	19.19 (15.20 - 24.24)	<0.001	26.54 (22.24 - 31.67)	0.010
Wealth quintile						
Lowest	50.49 (49.37 - 51.63)		50.51 (42.72 - 59.71)		29.45 (24.74 - 35.06)	
Second	39.06 (38.22 - 39.93)	<0.001	36.97 (31.28 - 43.69)	<0.001	28.18 (23.68 - 33.54)	<0.001
Middle	30.02 (29.38 - 30.67)	<0.001	29.58 (25.03 - 34.95)	<0.001	27.95 (23.48 - 33.26)	<0.001
Fourth	16.72 (16.36 - 17.08)	<0.001	17.20 (14.56 - 20.33)	<0.001	23.20 (19.49 - 27.61)	<0.001
Highest	11.43 (11.17 - 11.69)	<0.001	12.64 (10.69 - 14.94)	<0.001	22.85 (19.19 - 27.21)	<0.001
Residence type						
Urban	9.98 (9.87 - 10.09)		9.02 (7.63 - 10.67)		9.56 (8.03 - 11.37)	
Rural	55.38 (54.83 - 55.94)	<0.001	61.59 (52.09 - 72.81)	<0.001	58.90 (49.50 - 70.07)	<0.001

Linear regression was conducted using log-transformed travel time as the outcome, following which marginal effects were predicted and exponentiated | *p* values correspond to original linear regression models | 95% CI: 95% confidence interval
Model 1: Univariable linear regression between sociodemographic factors and travel time to health facilities
Model 2: Univariable mixed effects linear regression between sociodemographic factors and travel time to health facilities
Model 3: Multivariable mixed effects linear regression between sociodemographic factors and travel time to health facilities, adjusted for all other covariates in the table

7.3.8 Effect modification by sex and residence type

Due to the differential distribution of travel time to health facilities by various sociodemographic factors, fully-adjusted models presented above were stratified by sex and residence type, with predicted travel time presented in **Tables 7.9 and 7.10.**

Travel time to health facilities stratified by sex

In both men and women there was a modest positive trend in travel time with increasing age groups. With the exception of higher education level, predicted travel time decreased with levels of education in both men and women. There was also an inverse trend in predicted travel time with wealth in both men and women, with a greater decline observed in men compared with women. There was also statistical evidence for interaction between wealth and sex in the association with travel time (p for interaction <0.001).

In both men and women, rural populations had substantially greater predicted travel times to health facilities than urban populations (p<0.001). However, a greater a predicted travel time in rural areas was observed in men at 61.78 (51.62 – 73.94) minutes compared with women at 56.13 (47.41 – 66.46) minutes. There was also evidence for interaction between sex and residence type in the association with travel time to health facilities (p for interaction <0.001).

Table 7.9: Predicted travel time (minutes) to health facilities by sociodemographic factors, stratified by sex (n=41,000)

Sociodemographic Characteristics	Men		Women		*P* for interaction
	Predicted travel time in minutes (95% CI)	*p*	Predicted travel time in minutes (95% CI)	*p*	
Age group					
<5	26.27 (21.89 - 31.51)		24.10 (20.31 - 28.61)		
5 – 14	25.05 (20.91 - 30.00)	0.019	24.98 (21.08 - 29.59)	0.074	
15 – 29	28.18 (23.53 - 33.75)	0.002	25.47 (21.50 - 30.18)	0.014	
30 – 49	28.13 (23.49 - 33.69)	0.002	25.85 (21.82 - 30.63)	0.002	
50 – 64	28.92 (24.09 - 34.72)	<0.001	25.91 (21.84 - 30.75)	0.002	
65+	27.83 (23.13 - 33.48)	0.043	25.89 (21.79 - 30.77)	0.004	
Education level					
No education	28.63 (23.90 - 34.29)		27.35 (23.07 - 32.41)		
Primary	27.53 (22.99 - 32.95)	0.014	24.82 (20.96 - 29.39)	<0.001	
Secondary	25.19 (21.04 - 30.17)	<0.001	24.25 (20.47 - 28.73)	<0.001	
Higher	28.05 (23.29 - 33.77)	0.488	25.20 (21.16 - 30.01)	0.005	
Wealth quintile					
Lowest	31.21 (26.04 - 37.40)		27.95 (23.58 - 33.13)		<0.001
Second	29.13 (24.32 - 34.89)	<0.001	27.30 (23.04 - 32.34)	0.136	
Middle	28.57 (23.86 - 34.22)	<0.001	27.34 (23.08 - 32.39)	0.187	
Fourth	23.92 (19.97 - 28.65)	<0.001	22.51 (19.00 - 26.67)	<0.001	
Highest	23.51 (19.62 - 28.18)	<0.001	22.18 (18.71 - 26.30)	<0.001	
Residence type					
Urban	9.59 (8.01 - 11.48)		9.53 (8.05 - 11.29)		<0.001
Rural	61.78 (51.62 - 73.94)	<0.001	56.13 (47.41 - 66.46)	<0.001	

Linear regression was conducted using log-transformed travel time as the outcome, following which marginal effects were predicted and exponentiated | *p* values correspond to original linear regression models | 95% CI: 95% confidence interval | Multivariable mixed effects linear regression between sociodemographic factors and travel time to health facilities, adjusted for all other covariates in the table and accounting for regional clustering | 95% CI: 95% confidence interval | *p* for interaction based on likelihood ratio test comparing models with and without an interaction term, with wealth and education included as continuous variables

Travel time to health facilities stratified by residence type

When stratified by residence type (**Table 7.10**), consistently across sociodemographic factors, rural populations had greater travel times to health facilities. In urban areas, travel time did not differ by sex (p<0.079) and there was no clear trend with age. Conversely, in rural areas, men had longer predicted travel times at 68.55 (53.57 – 87.71) minutes, compared with 63.88 (49.92 – 81.74) minutes in women. There was some evidence for interaction between residence type and sex in the association with travel time to health facilities (p for interaction <0.001). In rural areas, there was a modest increase in predicted travel time with categories of age.

In urban populations, there was a modest positive trend in predicted travel time with increasing levels of education. By contrast, in rural populations, predicted travel time decreased between populations with no education and those with secondary education. In both urban and rural populations, predicted travel time decreased with increasing levels of wealth; however, this trend was more notable in urban areas. There was also evidence for interaction between residence type and wealth in the association with travel time (p for interaction <0.001).

Table 7.10: Predicted travel time (minutes) to health facilities by sociodemographic factors, stratified by residence type (n=41,000)

Sociodemographic Characteristics	Urban		Rural		*P* for interaction
	Predicted travel time in minutes (95% CI)	*p*	Predicted travel time in minutes (95% CI)	*p*	
Sex					
Men	9.31 (8.17 - 10.61)		68.55 (53.57 - 87.71)		<0.001
Women	9.16 (8.04 - 10.44)	0.079	63.88 (49.92 - 81.74)	<0.001	
Age group					
<5	9.66 (8.44 - 11.05)		63.06 (49.21 - 80.80)		
5 – 14	9.20 (8.07 - 10.50)	0.025	62.58 (48.88 - 80.11)	0.748	
15 – 29	9.19 (8.06 - 10.48)	0.037	67.79 (52.95 - 86.79)	0.001	
30 – 49	9.09 (7.97 - 10.36)	0.008	69.88 (54.57 - 89.47)	<0.001	
50 – 64	9.22 (8.06 - 10.54)	0.070	69.65 (54.34 - 89.28)	<0.001	
65+	9.53 (8.28 - 10.96)	0.666	67.59 (52.71 - 86.66)	0.002	
Education level					
No education	8.99 (7.87 - 10.26)		70.97 (55.44 - 90.85)		
Primary	9.31 (8.16 - 10.61)	0.048	65.86 (51.46 - 84.29)	<0.001	
Secondary	9.26 (8.12 - 10.55)	0.128	60.27 (47.07 - 77.17)	<0.001	
Higher	9.54 (8.34 - 10.91)	0.019	66.92 (51.82 - 86.41)	0.320	
Wealth quintile					
Lowest	13.98 (12.09 - 16.16)		72.52 (56.66 - 92.84)		<0.001
Second	11.23 (9.83 - 12.82)	0.001	66.92 (52.28 - 85.65)	<0.001	
Middle	10.98 (9.62 - 12.52)	<0.001	63.13 (49.32 - 80.82)	<0.001	
Fourth	8.52 (7.47 - 9.71)	<0.001	55.20 (43.10 - 70.71)	<0.001	
Highest	8.42 (7.39 - 9.60)	<0.001	66.17 (51.41 - 85.18)	0.002	

Linear regression was conducted using log-transformed travel time as the outcome, following which marginal effects were predicted and exponentiated | *p* values correspond to original linear regression models | 95% CI: 95% confidence interval | Multivariable mixed effects linear regression between sociodemographic factors and travel time to health facilities, adjusted for all other covariates in the table and accounting for regional clustering | 95% CI: 95% confidence interval | *p* for interaction based on likelihood ratio test comparing models with and without an interaction term, with wealth and education included as continuous variables

7.3.8 Sub-analysis of sociodemographic factors and travel time to health facilities

As only 14,334 individuals aged 15 to 64 years had data on occupation, a sub-analysis was conducted to explore the relation between travel time and occupation in this population. In this population, the median travel time was 21.2 (41.6) minutes and was 50.2 (68.1) minutes in rural areas compared with 9.3 (9.3) minutes in urban areas ($p<0.001$)(**Table 7.11**). Similarly, the median distance was higher in rural areas at 6.6 (11.0) Km compared with 1.2 (1.1) Km in urban areas ($p<0.001$). The proportion of individuals increased with travel time category in rural areas up to the 1–<2 hours category. By comparison, 73% of urban populations lived within 15 minutes of a health facility and 97.5% lived within 5 Km. Estimates of distance and travel time and population distribution by categories of distance and travel time reflect that of the larger population (n=41,000).

Table 7.11: Sub-population distribution by travel time and distance to health facilities (n=14,334)

Accessibility measure	Overall	Urban	Rural	*p*
Median travel time in minutes (IQR)	21.2 (41.6)	9.3 (9.3)	50.2 (68.1)	<0.001
Median distance in Km (IQR)	2.4 (5.6)	1.2 (1.1)	6.6 (11.0)	<0.001
Travel time categories No. (%)				
<15 minutes	5,666 (39.5)	5,285 (73.0)	381 (5.4)	<0.001
15 - <30 minutes	2,804 (19.6)	1,507 (20.8)	1,297 (18.3)	
30 - <45 minutes	1,566 (10.9)	263 (3.6)	1,303 (18.4)	
45 - <60 minutes	1,317 (9.2)	165 (2.3)	1,152 (16.2)	
1 - <2 hours	1,468 (10.2)	20 (0.3)	1,448 (20.4)	
2 - <4 hours	1,182 (8.3)	0 (0.0)	1,182 (16.7)	
≥4 hours	331 (2.3)	0 (0.0)	331 (4.7)	
Distance categories No. (%)				
<5 Km	9,415 (65.7)	7,059 (97.5)	2,356 (33.2)	<0.001
5 - <10 Km	2,347 (16.4)	163 (2.3)	2,184 (30.8)	
10 - <15 Km	743 (5.2)	18 (0.3)	725 (10.2)	
15 - <20 Km	452 (3.2)	0 (0.0)	452 (6.4)	
≥20 Km	1,377 (9.6)	0 (0.0)	1,377 (19.4)	

P value corresponds to a chi-squared test for categorical measures and a Wilcoxon rank-sum (Mann-Whitney U) test for continuous measures | IQR: interquartile range

Similar trends in predicted travel time were observed in this sub-population (n=14,334) compared with the larger population (n=41,000). Women lived closer to health facilities compared with men ($p<0.001$)(**Table 7.12**). Predicted travel time decreased with increasing levels of education. There was no clear trend in predicted travel time with age in this sub-analysis ($p>0.05$). Predicted travel time was substantially higher among rural populations at 58.29 (49.11 – 69.17) minutes compared with 9.38 (7.91 – 11.14) minutes in urban populations. Predicted travel time was greatest amongst those with agricultural occupations at 28.79 (24.06 – 34.45) minutes ($p<0.001$).

Table 7.12: Predicted travel time to health facilities by sociodemographic factors in the sub-population (n=14,334)

Sociodemographic Characteristics	Predicted travel time in minutes (95% CI)	*p*
Sex		
Men	24.06 (20.27 - 28.57)	
Women	22.78 (19.21 - 27.02)	<0.001
Age group		
15-29	23.19 (19.55 - 27.52)	
30-49	23.18 (19.53 - 27.50)	0.956
50-64	23.02 (19.34 - 27.41)	0.733
Education level		
No education	26.77 (22.46 - 31.90)	
Primary	24.09 (20.29 - 28.61)	<0.001
Secondary	22.39 (18.87 - 26.56)	<0.001
Higher	22.84 (19.15 - 27.24)	<0.001
Wealth quintile		
Lowest	25.59 (21.51 - 30.44)	
Second	24.71 (20.80 - 29.36)	0.093
Middle	25.07 (21.11 - 29.77)	0.335
Fourth	20.77 (17.48 - 24.66)	<0.001
Highest	21.16 (17.80 - 25.15)	<0.001
Residence type		
Urban	9.38 (7.91 - 11.14)	
Rural	58.29 (49.11 - 69.17)	<0.001
Occupation		
Professional	23.02 (19.39 - 27.32)	
Agricultural	28.79 (24.06 - 34.45)	<0.001
Manual	22.58 (18.96 - 26.89)	0.388
Unemployed	22.95 (19.34 - 27.23)	0.828

Linear regression was conducted using log-transformed travel time as the outcome, following which marginal effects were predicted and exponentiated | *p* values correspond to original linear regression models | 95% CI: 95% confidence interval Multivariable mixed effects linear regression between sociodemographic factors and travel time to health facilities, adjusted for all other covariates in the table and accounting for regional clustering

When stratified by sex, there was no clear trend in travel time across age groups. Predicted travel time decreased with categories of education in women ($p<0.001$) but this trend was not significant in men. Predicted travel time was notably higher in rural populations in both men and women but was greater amongst men at 62.50 (52.61 – 74.24) minutes compared with 56.16 (47.36 – 66.60) minutes in women. Notably, populations with agricultural occupations had greater predicted travel time to health facilities in men alone (34.52 (28.71 – 41.49) minutes, $p<0.001$).

Table 7.13: Predicted travel time to health facilities by sociodemographic factors in the sub-population (n=14,334) stratified by sex

Sociodemographic Characteristics	Men		Women	
	Predicted travel time in minutes (95% CI)	*p*	Predicted travel time in minutes (95% CI)	*p*
Age group				
15-29	25.47 (21.46 - 30.24)		22.21 (18.74 - 26.33)	
30-49	24.45 (20.58 - 29.05)	0.088	22.59 (19.05 - 26.79)	0.281
50-64	25.41 (21.23 - 30.41)	0.943	21.96 (18.42 - 26.19)	0.679
Education level				
No education	27.43 (22.87 - 32.89)		26.49 (22.18 - 31.64)	
Primary	26.64 (22.38 - 31.70)	0.451	22.96 (19.34 - 27.26)	<0.001
Secondary	23.81 (20.06 - 28.26)	<0.001	21.77 (18.37 - 25.80)	<0.001
Higher	26.08 (21.61 - 31.47)	0.370	21.59 (18.08 - 25.79)	<0.001
Wealth quintile				
Lowest	28.52 (23.83 - 34.13)		24.47 (20.57 - 29.11)	
Second	27.48 (23.05 - 32.76)	0.322	23.53 (19.81 - 27.95)	0.115
Middle	26.20 (22.00 - 31.19)	0.026	24.56 (20.69 - 29.16)	0.884
Fourth	22.58 (18.96 - 26.90)	<0.001	20.01 (16.86 - 23.76)	<0.001
Highest	22.36 (18.72 - 26.72)	<0.001	20.55 (17.29 - 24.43)	<0.001
Residence type				
Urban	9.73 (8.19 - 11.57)		9.27 (7.81 - 10.99)	
Rural	62.50 (52.61 - 74.24)	<0.001	56.16 (47.36 - 66.60)	<0.001
Occupation				
Professional	24.18 (20.32 - 28.76)		22.31 (18.81 - 26.46)	
Agricultural	34.52 (28.71 - 41.49)	<0.001	21.89 (18.01 - 26.60)	0.708
Manual	25.18 (21.15 - 29.98)	0.176	20.23 (16.84 - 24.31)	0.011
Unemployed	23.65 (19.90 - 28.10)	0.429	22.54 (19.01 - 26.71)	0.537

Linear regression was conducted using log-transformed travel time as the outcome, following which marginal effects were predicted and exponentiated | *p* values correspond to original linear regression models | 95% CI: 95% confidence interval | Multivariable mixed effects linear regression between sociodemographic factors and travel time to health facilities, adjusted for all other covariates in the table and accounting for regional clustering | 95% CI: 95% confidence interval

When stratified by residence type, similar trends were observed to stratified analyses in the larger population. In rural areas, women had a shorter predicted travel time to health facilities than men (*p*=0.001). Predicted travel time decreased with increasing levels of education in rural populations but there was no clear trend observed in urban populations. In both urban and rural areas, predicted travel time decreased with categories of wealth and this association was more notable in urban areas. As may be expected, in rural populations alone, individuals with agricultural occupations had the greatest predicted travel time to health facilities at 76.19 (59.03 – 98.34) minutes (*p*<0.001).

Table 7.14: Predicted travel time to health facilities by sociodemographic factors in the sub-population (n=14,334) stratified by residence type

Sociodemographic Characteristics	Urban		Rural	
	Predicted travel time in minutes (95% CI)	*p*	Predicted travel time in minutes (95% CI)	*p*
Sex				
Men	9.38 (8.25 - 10.66)		68.65 (53.51 - 88.07)	
Women	9.05 (7.98 - 10.27)	0.044	64.18 (50.08 - 82.24)	0.001
Age group				
15-29	9.11 (8.03 - 10.34)		65.46 (51.07 - 83.91)	
30-49	9.17 (8.07 - 10.41)	0.712	66.09 (51.54 - 84.75)	0.621
50-64	9.29 (8.11 - 10.65)	0.514	64.32 (49.97 - 82.78)	0.548
Education level				
No education	8.52 (7.39 - 9.83)		77.02 (59.83 - 99.14)	
Primary	9.08 (7.96 - 10.34)	0.104	69.37 (54.08 - 88.97)	0.001
Secondary	9.22 (8.13 - 10.46)	0.032	61.09 (47.66 - 78.32)	<0.001
Higher	9.10 (7.96 - 10.39)	0.138	64.10 (49.17 - 83.57)	0.001
Wealth quintile				
Lowest	13.95 (11.80 - 16.48)		71.27 (55.52 - 91.48)	
Second	10.78 (9.44 - 12.31)	<0.001	66.57 (51.88 - 8542)	0.004
Middle	10.79 (9.48 - 12.28)	<0.001	63.80 (49.71 - 81.88)	<0.001
Fourth	8.46 (7.44 - 9.61)	<0.001	55.06 (42.83 - 70.77)	<0.001
Highest	8.45 (7.44 - 9.60)	<0.001	70.70 (54.29 - 92.07)	0.881
Occupation				
Professional	9.02 (7.94 - 10.24)		66.59 (51.88 - 85.47)	
Agricultural	9.64 (8.06 - 11.54)	0.316	76.19 (59.03 - 98.34)	<0.001
Manual	8.90 (7.79 - 10.15)	0.588	67.33 (52.09 - 87.03)	0.781
Unemployed	9.37 (8.25 - 10.64)	0.027	63.73 (49.72 - 81.69)	0.042

Linear regression was conducted using log-transformed travel time as the outcome, following which marginal effects were predicted and exponentiated | *p* values correspond to original linear regression models | 95% CI: 95% confidence interval | Multivariable mixed effects linear regression between sociodemographic factors and travel time to health facilities, adjusted for all other covariates in the table and accounting for regional clustering | 95% CI: 95% confidence interval

Additionally, I adjusted for marital status and stratified analyses by sex (**Table 7.15**). Overall, individuals who were currently married or living with a partner had longer travel times to health facilities. However, when stratified by sex, this association was only observed in women, with women living with a partner having the greatest predicted travel time to health facilities (24.46; 95% CI: 20.61 – 29.02 minutes; p<0.001).

Table 7.15: Predicted travel time to health facilities by sociodemographic factors in the sub-population, stratified by sex and additionally adjusted for marital status (n=14,334)

Sociodemographic Characteristics	Overall		Men		Women	
	Predicted travel time in minutes (95% CI)	*p*	Predicted travel time in minutes (95% CI)	*p*	Predicted travel time in minutes (95% CI)	*p*
Sex						
Men	24.15 (20.36 - 28.65)		—		—	
Women	22.74 (19.19 - 26.96)	<0.001	—		—	
Age group						
15-29	23.59 (19.90 - 27.98)		25.66 (21.60 - 30.48)		22.62 (19.10 - 26.78)	
30-49	22.80 (19.23 - 27.04)	0.018	24.32 (20.46 - 28.90)	0.051	22.14 (18.69 - 26.22)	0.211
50-64	22.47 (18.88 - 26.75)	0.042	25.07 (20.90 - 30.07)	0.577	21.64 (18.16 - 25.79)	0.136
Education level						
No education	26.64 (22.38 - 31.73)		27.40 (22.85 - 32.86)		26.19 (21.96 - 31.24)	
Primary	24.07 (20.29 - 28.57)	<0.001	26.65 (22.40 - 31.72)	0.477	22.88 (19.30 - 27.13)	<0.001
Secondary	22.43 (18.92 - 26.59)	<0.001	23.81 (20.06 - 28.27)	<0.001	21.84 (18.45 - 25.85)	<0.001
Higher	22.70 (19.05 - 27.06)	<0.001	26.06 (21.59 - 31.46)	0.375	21.45 (17.98 - 25.59)	<0.001
Wealth quintile						
Lowest	25.49 (21.45 - 30.30)		28.50 (23.81 - 34.10)		24.35 (20.49 - 28.94)	
Second	24.70 (20.80 - 29.32)	0.127	27.43 (23.01 - 32.70)	0.309	23.48 (19.79 - 27.86)	0.144
Middle	25.05 (21.10 - 29.72)	0.409	26.20 (22.00 - 31.20)	0.028	24.50 (20.66 - 29.06)	0.808
Fourth	20.83 (17.56 - 24.72)	<0.001	22.61 (19.89 - 26.92)	<0.001	20.12 (16.97 - 23.85)	<0.001
Highest	21.17 (17.82 - 25.15)	<0.001	22.39 (18.74 - 26.76)	<0.001	20.56 (17.32 - 24.41)	<0.001
Residence type						
Urban	9.39 (7.92 - 11.14)		9.73 (8.19 - 11.57)		9.28 (7.84 - 10.99)	
Rural	58.23 (49.1 - 69.05)	<0.001	62.49 (52.60 - 74.24)	<0.001	56.01 (47.29 - 66.34)	<0.001
Occupation						
Professional	22.97 (19.37 - 27.25)		24.14 (20.29 - 28.71)		22.26 (18.80 - 26.37)	
Agricultural	28.62 (23.93 - 34.22)	<0.001	24.51 (28.70 - 41.49)	<0.001	21.77 (17.93 - 26.43)	0.662
Manual	22.46 (18.87 - 26.72)	0.305	25.16 (21.13 - 29.96)	0.167	20.16 (16.80 - 24.19)	0.009
Unemployed	23.01 (19.41 - 27.28)	0.905	23.69 (19.94 - 28.15)	0.508	22.57 (19.06 - 26.71)	0.403

Table 7.15: Predicted travel time to health facilities by sociodemographic factors in the sub-population, stratified by sex and additionally adjusted for marital status (n=14,334)

Sociodemographic Characteristics	Overall		Men		Women	
	Predicted travel time in minutes (95% CI)	*p*	Predicted travel time in minutes (95% CI)	*p*	Predicted travel time in minutes (95% CI)	*p*
Marital Status						
Never married	22.30 (18.81 - 26.44)		24.81 (20.90 - 29.46)		21.26 (17.96 - 25.17)	
Currently married	24.44 (20.58 - 29.01)	<0.001	25.29 (21.19 - 30.18)	0.575	23.91 (20.17 - 28.38)	<0.001
Living with partner	24.74 (20.83 - 29.39)	<0.001	25.16 (21.06 - 30.06)	0.683	24.46 (20.61 - 29.02)	<0.001
Formerly/ever married	22.86 (19.18 - 27.23)	0.326	27.75 (22.74 - 33.87)	0.052	21.58 (18.12 - 25.69)	0.594

Linear regression was conducted using log-transformed travel time as the outcome, following which marginal effects were predicted and exponentiated | *p* values correspond to original linear regression models | 95% CI: 95% confidence interval | Multivariable mixed effects linear regression between sociodemographic factors and travel time to health facilities, adjusted for all other covariates in the table and accounting for regional clustering | 95% CI: 95% confidence interval

In a separate subset of 14,374 individuals with data on ethnicity, fully-adjusted analyses (not including marital status) indicated that the Afrikaans population had the longest predicted travel time to health facilities at 28.7 minutes (95% CI: 24.28 – 33.92; $p<0.001$), followed by the Damara/Nama population at 26.01 minutes (95% CI: 22.04 – 30.69; $p<0.001$)(**Appendix 3; Table 8**).

7.3.9 Comparing objective and subjective measures of inaccessibility

Given the different applications of objective and subjective measures to understanding health service accessibility, I further investigated the factors associated with reporting distance as a barrier to healthcare. I explored measures of distance and travel time to health facilities in relation to perceptions of distance as a healthcare barrier among 9,934 women with complete data.

Women who reported distance as a barrier lived further away from health facilities, both in terms of distance and time, compared with women who did not report distance as a barrier to care (**Table 7.16**). In urban areas, 69.4% of those who reported distance as a problem were estimated to live within 15 minutes of a health facility. In rural areas, almost half of women who reported distance as a barrier lived more than an hour from a health facility. The majority of individuals who did not report distance as a problem lived within an hour or 5 Km of a health facility. These findings highlight the variation between objective and subjective measures of accessibility.

Table 7.16: The distribution of women who did and did not report distance as a barrier to healthcare by travel time and distance categories (n=9,934)

	Distance is not a barrier No. (%)				**Distance is a barrier** No. (%)			
	Overall	**Urban**	**Rural**	***p***	**Overall**	**Urban**	**Rural**	***p***
Travel time categories								
<15 minutes	3,236 (48.7)	3,049 (74.1)	187 (7.4)	<0.001	766 (23.3)	672 (69.4)	94 (4.1)	<0.001
15–<30 minutes	1,352 (20.3)	814 (19.8)	538 (21.2)		641 (19.5)	239 (24.7)	402 (17.4)	
30–<45 minutes	761 (11.5)	156 (3.8)	605 (23.9)		363 (11.1)	31 (3.2)	332 (14.3)	
45–<60 minutes	535 (8.1)	80 (2.0)	455 (17.8)		391 (11.9)	27 (2.8)	364 (15.7)	
1–<2 hours	442 (6.7)	14 (0.3)	428 (16.9)		539 (16.4)	0 (0.0)	539 (23.3)	
2–<4 hours	257 (3.9)	0 (0.0)	257 (10.1)		444 (13.5)	0 (0.0)	444 (19.2)	
≥4 hours	65 (1.0)	0 (0.0)	65 (2.6)		142 (4.3)	0 (0.0)	142 (6.1)	
Distance categories								
<5 Km	5,152 (77.5)	4,016 (97.6)	1,136 (44.8)	<0.001	1,515 (46.1)	943 (97.3)	572 (24.7)	<0.001
5–<10 Km	879 (13.2)	86 (2.1)	793 (31.3)		784 (23.9)	24 (2.5)	760 (32.8)	
10–<15 Km	204 (3.1)	11 (0.3)	193 (7.6)		316 (9.6)	2 (0.2)	314 (13.6)	
15 –<20 Km	102 (1.5)	0 (0.0)	102 (4.0)		177 (5.4)	0 (0.0)	177 (7.6)	
≥20 Km	311 (4.7)	0 (0.0)	311 (12.3)		494 (15.0)	0 (0.0)	494 (21.3)	
Total	6,648 (100.0)	4,113 (100.0)	2,535 (100.0)		3,286 (100.0)	969 (100.0)	2,317 (100.0)	

P value corresponds to a chi-squared test

I further investigated the characteristics of individuals who were estimated to live within 15 minutes of a health facility yet reported distance as a healthcare barrier. The majority of these individuals were aged 15–29 years (53.0%) and were educated to secondary level (60.5%); this trend was observed in both urban and rural areas (**Table 7.17**). Overall, the prevalence of reporting distance as a barrier within 15 minutes of a facility increased with wealth. This was also observed in urban areas but not rural areas where the prevalence decreased with increasing wealth. This suggests that poorer individuals in rural areas find distance to be a barrier despite living within 15 minutes of a facility.

Table 7.17: Sociodemographic characteristics of individuals who reported distance as a barrier and lived within 15 minutes of the nearest health facility

Sociodemographic Characteristics	Overall No. (%)	Urban No. (%)	Rural No. (%)	*p*
Age group				
15–29	406 (53.0)	356 (53.0)	50 (53.2)	0.596
30–49	305 (39.8)	270 (40.2)	35 (37.2)	
50–64	55 (7.2)	46 (6.9)	9 (9.6)	
Education level				
No education	69 (9.0)	62 (9.2)	7 (7.5)	0.028
Primary	194 (25.3)	159 (23.7)	35 (37.2)	
Secondary	464 (60.6)	414 (61.6)	50 (53.2)	
Higher	39 (5.1)	37 (5.5)	2 (2.1)	
Wealth quintile				
Lowest	76 (9.9)	22 (3.3)	54 (57.5)	<0.001
Second	155 (20.2)	134 (19.9)	21 (22.3)	
Middle	184 (24.0)	171 (25.5)	13 (13.8)	
Fourth	226 (29.5)	221 (32.9)	5 (5.3)	
Highest	125 (16.3)	124 (18.5)	1 (1.1)	
Total	766 (100.0)	672 (100.0)	94 (100.0)	

P value corresponds to a chi-squared test

The median travel time to health facilities amongst women who reported distance as a barrier to healthcare increased with age from 33.0 (61.6) minutes in those aged 15–29 years to 44.9 (62.6) minutes in those aged 50–64 years (p<0.001)(**Table 7.18**). Median travel time decreased with increasing levels of education (p<0.001) and was highest in those with no education at 69.0 (115.4) minutes. Median travel time also decreased with increasing wealth quintiles (p<0.001) from 51.4 (72.0) minutes in the lowest quintile to 11.6 (17.3) minutes in the highest quintile. The median travel time was higher in rural areas compared to urban areas at 57.3 (87.5) minutes in rural areas compared to 9.8 (1.0) in urban areas (p<0.001).

Table 7.18: Median travel time by sociodemographic factors in women who reported distance as a barrier to healthcare (n=3,286)

Sociodemographic Characteristics	Median travel time/minutes (IQR)	*p*
Age group		
15–29	33.0 (61.6)	<0.001
30–49	42.5 (69.2)	
50–64	44.9 (62.6)	
Education level		
No education	69.0 (115.4)	<0.001
Primary	45.8 (66.3)	
Secondary	31.0 (51.2)	
Higher	20.4 (39.1)	
Wealth quintile		
Lowest	51.4 (72.0)	<0.001
Second	46.3 (66.4)	
Middle	33.5 (69.5)	
Fourth	19.0 (48.9)	
Highest	11.6 (17.3)	
Residence type		
Urban	9.8 (1.0)	<0.001
Rural	57.3 (87.5)	
Total	40.5 (64.3)	

P value corresponds to Wilcoxon rank-sum (Mann-Whitney U) test for binary sociodemographic factors (sex and residence type) and corresponds to a Kruskal Wallis test for non-binary categorical variables | IQR: interquartile range

I assessed the association between travel time to health facilities and reporting distance as a barrier to healthcare amongst women. In this subset of 9,934 women, travel time was positively associated with reporting distance as a barrier to healthcare irrespective of age, education, wealth and residence type in fully-adjusted models (Table 7.19). Those who lived more than four hours away from the nearest health facility were most likely to report distance as a problem (RR: 1.87; 95% CI: 1.51 – 2.33; $p<0.001$). Wealth and education were inversely associated with reporting distance as a barrier. This suggests that other factors, aside from travel time influence perceptions of distance barriers in this population.

When stratified by residence type, travel time to health facilities was only associated with reporting distance as barrier in rural areas. There was a positive association between travel time and reporting distance as a barrier in rural areas (≥4 hours RR: 2.08; 95% CI: 1.55 – 2.80; $p<0.001$). In urban areas, secondary and higher education and the two highest wealth quintiles were inversely associated with reporting distance as a barrier. In rural areas education was inversely associated with reporting distance as a barrier to healthcare (higher education level RR: 0.72; 95% CI: 0.55 – 0.94; $p=0.015$). Wealth was also significantly inversely associated with reporting distance as a barrier in rural areas (highest wealth quintile RR: 0.43; 95% CI: 0.30 – 0.68; $p<0.001$).

Table 7.19: Association between travel time to health facilities and reporting distance a barrier to healthcare for women

Background characteristics	**Overall** (n=9,934)		**Urban** (n=5,082)		**Rural** (n=4,852)	
	RR (95% CI)	***p***	**RR (95% CI)**	***p***	**RR (95% CI)**	***p***
Travel time						
<15 minutes	1.00 (reference)		1.00 (reference)		1.00 (reference)	
15 - <30 minutes	1.19 (1.05 - 1.35)	0.006	1.14 (1.00 - 1.31)	0.044	1.36 (1.09 - 1.71)	0.007
30 - <45 minutes	1.02 (0.77 - 1.34)	0.905	0.74 (0.43 - 1.28)	0.278	1.20 (0.87 - 1.66)	0.271
45 - <60 minutes	1.22 (0.98 - 1.50)	0.072	1.20 (0.83 - 1.73)	0.344	1.41 (1.18 - 1.68)	<0.001
1- <2 hours	1.56 (1.26 - 1.93)	<0.001	N/A		1.80 (1.39 – 2.31)	<0.001
2- <4 hours	1.68 (1.38 – 2.05)	<0.001	—		1.93 (1.46 - 2.55)	<0.001
≥4 hours	1.87 (1.51 - 2.33)	<0.001	—		2.08 (1.55 - 2.80)	<0.001
Age group						
15-29	1.00 (reference)		1.00 (reference)		1.00 (reference)	
30-49	1.04 (0.96 - 1.13)	0.311	0.93 (0.84 - 1.03)	0.144	1.09 (1.01 - 1.20)	0.033
50-64	1.06 (0.99 - 1.32)	0.123	1.05 (0.88 - 1.25)	0.597	1.07 (1.00 - 1.16)	0.068
Education level						
No education	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Primary	0.91 (0.83 – 0.98)	0.014	0.83 (0.66 - 1.05)	0.118	0.93 (0.87 - 1.00)	0.040
Secondary	0.75 (0.70 - 0.82)	<0.001	0.62 (0.50 - 0.77)	0.001	0.80 (0.74 - 0.87)	<0.001
Higher	0.62 (0.52 - 0.74)	<0.001	0.46 (0.33 - 0.65)	<0.001	0.72 (0.55 – 0.94)	0.015
Wealth quintile						
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Second	0.87 (0.80 - 0.95)	0.001	1.05 (0.79 - 1.40)	0.721	0.84 (0.78 - 0.91)	0.001
Middle	0.70 (0.60 - 0.81)	<0.001	0.88 (0.65 - 1.18)	0.384	0.67 (0.58 - 0.78)	<0.001
Fourth	0.50 (0.41 - 0.59)	<0.001	0.58 (0.41 - 0.82)	0.002	0.52 (0.41 - 0.64)	<0.001
Highest	0.28 (0.22 - 0.37)	<0.001	0.33 (0.23 - 0.47)	<0.001	0.43 (0.30 - 0.68)	<0.001
Residence type						
Urban	1.00 (reference)		—		—	
Rural	1.21 (0.97 - 1.51)	0.096	—		—	

Fully-adjusted multivariable mixed effects Poisson regression models, accounting for household, enumeration area and regional clustering and adjusted for all other exposures in the table, stratified by residence type | RR: risk ratio | 95% CI: 95% confidence interval | N/A: n too small | — no data

7.4 Discussion

In this chapter, I used objective measures to build upon prior analyses of healthcare accessibility in Namibia using subjective measures. Here, I observed a positive correlation between the number of health facilities relative to the population size; however, there was substantial variation in distance and travel time to health facilities. Whilst the majority of individuals in this DHS population lived within 15 minutes or 5 Km of a health facility, around 20% would have to travel for over an hour and more than 10% would have to travel for more than two hours to reach a facility. Distance and travel times to health facilities were markedly more variable in rural areas and also differed by the health facility type and the region. Travel time to health facilities was greater in men, older populations, the less educated, less wealthy and rural populations, suggesting that strategies to improve the accessibility of healthcare in Namibia could be targeted to these groups. Additionally, travel time was associated with reporting distance as a barrier to healthcare, suggesting that this objective measure is reflective of perceptions of health facility inaccessibility in this population.

7.4.1 Distribution of health facilities

Health facilities in Namibia were found to be clustered but broadly reflected the distribution of the population, which is also known to be clustered [9]. Most health facilities were located in northern regions, with Kunene, Zambezi and Kavango having the highest number of health facilities per 10,000 population. Interestingly, it was these relatively poorer regions with the highest health facility-population ratio, whereas the wealthier regions such as Khomas and Oshana had the lowest ratio of health facilities to the population. As this analysis only explored the distribution of public health facilities, it is possible that in these wealthier regions there are less public health facilities but more private facilities. There is likely to be more demand for private health services in wealthier regions. Further research is needed to better understand the distribution of private healthcare providers in Namibia.

7.4.2 Objective measures of accessibility

To investigate the accessibility of health services on a finer scale, objective measures of travel time and distance were assessed. Methodologically, the travel time measurement is superior to Euclidean distance, however, in this DHS population, the two measures were strongly correlated, suggesting that both measures were comparable in their utility to assess accessibility of health facilities in Namibia.

The population distribution by distance estimates was similar to that observed overall and in urban and rural populations in the 2015/16 Namibia Household Income and Expenditure Survey (NHIES) [285]. For example, in this DHS population 61.3% of individuals were estimated to live within 5 Km of a health facility, whilst NHIES estimated 65% of the population to live within the same distance [285]. NHIES also identified much variation in distance estimates to health facilities across Namibia, with rural populations having to travel longer distances to health facilities compared with urban populations [285].

Rurality and accessibility

Travel times to health facilities were substantially higher and were notably more variable in rural populations compared with urban populations. Those living in rural areas had significantly further to travel to health facilities on average (50.6 (67.2) minutes compared with 9.3 (9.8) minutes in urban areas). It was also estimated that almost 40% of the rural population would have to travel for more than an hour to reach a health facility. Rural populations typically experience greater barriers to healthcare [73, 75, 94, 99-101] as they are often more remote and less well connected by transport infrastructure [63]. Rural populations, despite being located further from facilities, may also be less able to afford healthcare and associated transport costs than urban populations due to urban-rural differences in wealth [286]. In Namibia, rural areas are often characterised by long distances between clinics as well as schools, other villages, markets and churches [143] and affordable transport options in these areas are also limited [143]. Additionally, just 45.9% of the rural population are estimated to live within one Km of public transport compared with 82.6% of urban populations [285]. In rural areas, men, older age groups, less educated and less wealthy populations had greater travel times to health facilities. A sub-analysis indicated that individuals with agricultural occupations had greater travel times to health facilities in rural areas and amongst men, which may partly explain the difference in these estimates between men and women in rural areas. However, further research is needed to better understand this relationship. Regardless of sociodemographic differences in travel time amongst rural populations, individuals living in rural areas lived further from health facilities than urban populations.

Sex

Men were estimated to have longer travel times to health facilities than women and this difference was only notable in rural areas. The difference in travel time by sex could be explained by a number of unknown factors that were not accounted for in this analysis. For example, women may have a greater need for health services than men [287], due to differential burdens of disease, frequency of illness or the need for use of maternal health services. Women therefore may place greater importance on living closer to health facilities. The findings of the sub-analysis suggest that differences in travel time to health facilities between men and women could be influenced by agricultural employment in men living in rural areas. Individuals working in agriculture may live in more remote areas to be close to their employment and thus live further from more built-up areas where public services are located. Marital status may explain additional variation in travel time between men and women. Married women and those living with a partner had longer travel times to health facilities, but this was not observed in men. In both men and women, unmarried (single) individuals had shorter travel times to health facilities. It could be that shorter travel times observed amongst women are driven by single women, as those who are married experience greater travel times, closer to those observed in men.

Age

Older age groups were found to have longer travel times to health facilities and this was observed in both men and women. However, this positive trend with age was only observed in rural areas. Importantly, this suggests that older populations are likely to be disadvantaged in accessing healthcare if they live in rural areas. This is important because aside from this objective measure of accessibility, elderly populations are likely to be already disadvantaged in terms of reduced mobility and independence in transport amongst older populations. Furthermore, elderly populations may have a greater need for healthcare as health status often declines with age [288]. Indeed, health service inaccessibility has been found to affect health seeking behaviour among elderly populations in rural Namibia, who to resort to traditional healers because formal health facilities are too far away and transport costs to reach these facilities are high [88]. Interventions, such as increasing affordable transport options especially for elderly populations to reach health facilities may help to facilitate care seeking behaviour in these older rural populations in Namibia; however, more large-scale, context-specific research would help to better inform such interventions.

Wealth and education

In this population, wealthier individuals had shorter predicted travel times to health facilities and this was observed in both urban and rural populations as well as men and women. This is similar to findings in other settings; for example, in South Africa, poorer populations had longer travel times to health facilities [271]. Less educated populations also had longer travel times to health facilities and this was consistent in men and women, and was more notable in rural populations.

The trends in travel time to health facilities observed with education and wealth could be explained by a number of factors. In terms of the travel time metric, wealthier households may be located closer to roads. One of the factors included in the wealth index variable was whether the household owned a vehicle. Therefore wealthier households with a vehicle most likely are located near a road which would reduce their travel time, based on this measure. Further research is needed to explore the role of wealth in choice and use of transport to health facilities. Additional research is also needed to better understand the association between education and healthcare accessibility.

Ethnicity

The Herero population had the longest estimated travel time to health facilities but in fully-adjusted models, the predicted travel time was highest in the Afrikaans population. More data are needed to fully-understand the patterns of travel time to health facilities by ethnicity. Different ethnic groups are located in geographically distinct areas of the country. One explanation for the longer travel times in the Afrikaans population could be that they are largely located in central regions of the country around Windhoek and Khomas. It is possible that travel times are overestimated in this region because this analysis only includes public health facilities and not private facilities, which are likely to be located in wealthier regions such as Khomas.

7.4.3 Comparing objective and subjective measures of accessibility

Travel time was positively associated with reporting distance as a barrier to healthcare. However, some women who lived within 15 minutes of a health facility still reported distance as a barrier. The mode of transport may influence perceptions of distance. As travel time estimates were partly based on motorised transport they do not take into account the time it would take to travel on foot alone. The prevalence of reporting distance as a barrier within 15 minutes of a facility increased with education and wealth. This is possibly due to wealthier and more educated individuals having higher expectations about the proximity of health facilities, or placing more importance on their health and health seeking. However, overall travel time was positively associated with reporting distance as a barrier to healthcare, irrespective of sociodemographic factors. Further research is needed to better understand the factors that influence perceptions of distance as a barrier to healthcare, beyond sociodemographic characteristics.

7.4.4 Limitations

Whilst objective measures of travel time and distance to health facilities are useful tools to assess health service accessibility, these methods are not without limitations and should be interpreted with caution. Euclidean distance estimates do not take into account the distance by road networks or geographical barriers to transport such as water bodies. Therefore the distance required to travel to reach the health facility is likely to be underestimated. As EAs were displaced by up to 2 Km for urban EAs and up to 5 Km for rural EAs, the specificity of the distances is limited and measurements may be over- or under-estimated by up to 5 Km. This method did not account for EA displacement.

Travel time estimates improve upon this method by accounting for speed and mode of travel, land cover, elevation, geographical barriers and road networks. However, the accuracy of this method is dependent on the resolution of the input datasets used. For example, in this analysis a major road network dataset was used, but this may not include all roads that may facilitate transport to health facilities. I also only accounted for permanent rivers and waterbodies and excluded features such as flood plains. Therefore, travel time may be under-estimated during times of flooding. Furthermore, the travel speeds assigned are arbitrary and may vary. However, using this method, EA displacement could be accounted for.

Both distance and travel time estimates are useful for understanding the proximity of the DHS population to health facilities, however, a number of other factors could influence healthcare accessibility that were beyond the scope of this analysis. Travel times were estimated based on the use of motorised transport along major roads, thus this method makes assumptions that this mode of transport is an option and is used. However, the option to use motorised transport relies on the individual having access to and using a privately owned vehicle or public transport. Household vehicle ownership information was available but not all individuals may be able to use this as a mode of transport. Public transport may take longer than travel using a private vehicle if multiple stops have to be made or less direct routes are taken to facilitate multiple pick-ups. Furthermore, if public transport is available it may not be affordable for all individuals. Unaffordable public transport has been established as a barrier to healthcare [61, 73, 270]. In South Africa, use of private modes of transport was more common among wealthier populations, suggesting that socioeconomic differences in transport options may result in differential access to healthcare for different socioeconomic groups [271]. If motorised transport is not used at all, travel time estimates would be considerably greater, thus these estimates present a "best case" for travel time to health facilities in Namibia.

A further limitation of this analysis is that with the available data it was only possible to explore access to public health facilities. This analysis did not take the location of private health facilities into account, which may explain some of the variation health facility accessibility observed. However, including private health facilities would also introduce a number of assumptions about the ability of individuals to afford private healthcare. Additionally, this analysis did not account for the presence of mobile clinics and temporary outreach services that may facilitate access to healthcare for more remote and rural populations.

In this analysis it was assumed that individuals would choose to visit the nearest health facility, which is not always the case [289-291]. Furthermore, depending on the healthcare needs of the individual they may need to use a specific type of health facility (e.g. clinic versus hospital) and therefore this may result in different estimates. Different scenarios were generated for different health facility types to explore this. Additionally, short travel time or distances to health facilities does not necessarily translate into health service utilisation; further research is needed to explore this association in Namibia.

There was also potential for selection bias to be introduced due to the restriction of the population based on inaccurate travel time estimates. This is because all EAs excluded on this basis were located in a similar geographical areas in Erongo. However, the population excluded on this basis only accounted for 1.1% of EAs and 0.7% of the population.

7.4.5 Implications

Understanding the geographical accessibility of health facilities is important for health system planning in Namibia. These analyses highlight the variation in the accessibility of healthcare between populations and underscore the need to improve accessibility of healthcare for rural populations in Namibia. Further research is needed to estimate travel time in different scenarios based on transport options, such as walking only, public transport, private vehicle or a combination of methods. Additional research could also aim to better understand the association between sex, agricultural employment and travel time to health facilities. Further research could also aim to better understand the role of wealth in accessibility.

The longer travel times observed in less wealthy populations could also be exacerbated by the fact that wealthier populations are also more likely to be able to afford transport; transport costs have been widely reported as a barrier to healthcare [61, 73, 271]. For poorer populations transport costs could even be catastrophic [271]. Additionally, it is often rural populations who are less able to afford healthcare and associated transport costs [286].

With the acknowledgement that health services may be inaccessible to certain, mostly rural, populations, strategies could be developed to improve accessibility for these populations. Health service provision could be scaled-up through the development of new health facilities in underserved areas. Naturally, building new health facilities comes at a great financial cost but these findings present a case for needs-based financing of rural health facilities in Namibia. However, given the human resource constraints described [2], this may not be a viable option for

Namibia. Namibia already utilises outreach services to reach remote communities; however, the remit of the services that can be provided remotely may be limited. Other strategies could include additional provision of emergency and ambulance services; for example, bicycle ambulance initiatives have been employed in some parts of Namibia [143]. Additionally, providing affordable or subsidised transport services for elderly or disabled populations could be help to increase healthcare accessibility for these populations.

For non-urgent care, mobile health (mHealth) and telemedicine initiatives could be employed to help to improve healthcare access in rural areas. Such technology has been used in other LMICs to support adherence to treatment programmes, to facilitate community health worker communication and decision making and to measure the coverage of health programmes (e.g. immunisation programmes) and health education [292-297]. Importantly, initiatives to improve health service accessibility will need to be accompanied by behaviour change strategies to ensure that these initiatives are used by the population they are designed to target.

Other initiatives to improve the accessibility of health facilities could include improvements to transport infrastructure. It has been suggested that the lack of transport in Namibia could pose a barrier to healthcare access [143]. Not only are transport options limited in Namibia, transport costs contribute to the overall cost of healthcare and therefore geographical inaccessibility presents a barrier to healthcare from a physical and financial perspective [143]. Mechanisms to improve the affordability of transport could also help to improve healthcare access, especially given the findings that poorer populations are likely to live further away from health facilities, thus may be in greater need of affordable transport. Subsidised transport for poorer populations or for specific health needs, such as delivering at a health facility during pregnancy, could help to reduce geographical healthcare barriers.

7.4.6 Conclusions

In conclusion, objective and subjective measures collectively indicated health facilities are inaccessible to some populations in Namibia. The accessibility of health services in Namibia is variable between regions, urban and rural areas and between sociodemographic groups. Travel time to health facilities is greater for rural populations, men, older individuals, the less educated and less wealthy, and is associated with reporting distance as a barrier to healthcare for women. Initiatives are needed to particularly address the inaccessibility of healthcare for remote and rural populations and could include improvements in transport infrastructure, scaling-up health services to reach more remote communities and designing mHealth initiatives to act as a first point of contact for health advice.

8. Sociodemographic patterns of health insurance coverage

Summary

Introduction: Health insurance has been found to increase healthcare utilisation and reduce catastrophic health expenditures in a number of countries; however, coverage is often unequally distributed among populations. Namibia provides a distinctive opportunity to explore the patterns of health insurance coverage in an upper-middle income country, which are not fully understood. This chapter aimed to assess the relation between health insurance and health service utilisation in a Namibian population and to better understand the sociodemographic factors associated with health insurance in the country. Such findings may help to inform health policy and planning to improve financial access to healthcare in Namibia.

Methods: Using data on 14,443 individuals, aged 15 to 64 years, from the 2013 Namibia DHS, the association between health insurance and health service utilisation was investigated using multivariable mixed effects Poisson regression analyses. Models adjusted for sociodemographic covariates (age, sex, education, wealth, residence type, occupation and marital status) and regional, enumeration area and household clustering. Additional multivariable mixed effects Poisson regression analyses were conducted to explore the association between key sociodemographic factors and health insurance, adjusted for other covariates and regional, enumeration area and household clustering. Effect modification by sex, education level and wealth quintile was also explored.

Results: Just 17.5% of this population were insured (men: 20.3%; women: 16.2%). In multivariable analyses, education (higher education RR: 3.98; 95% CI: 3.11 – 5.10; $p<0.001$) was significantly positively associated with health insurance, independent of other sociodemographic factors. Female sex (RR: 0.83; 95% CI: 0.74 – 0.94; $p=0.003$) and wealth (highest wealth quintile RR: 13.47; 95% CI: 9.06 – 20.04; $p<0.001$) were also independently associated with insurance. There was a complex interaction between sex, education and wealth in the context of health insurance. With increasing education level, women were more likely to be insured *(p* for interaction <0.001), and education had a greater impact on the likelihood of health insurance in lower wealth quintiles.

Conclusions: In this population, health insurance coverage was low and was independently associated with sex, education and wealth. These findings suggest that education may play a key role in health insurance coverage and may be important for bridging gaps in health insurance coverage for women and the less wealthy. These findings may help to inform the targeting of strategies to improve financial protection from healthcare-associated costs in Namibia.

8.1 Introduction

Universal Health Coverage (UHC) is defined by the WHO to be where "…all people obtain the health services they need without suffering financial hardship when paying for them" [55]. However, the number of people globally facing catastrophic payments on health is rising [4]. Around 800 million people are estimated to spend more than 10% of household expenditure on health and around 100 million people are being pushed into extreme poverty every year due to OOP expenditures on health [4].

The Namibian Government is committed to achieving UHC. As an upper-middle income country, with a small population of around 2.5 million people, Namibia's total health expenditure (THE) as a percentage of GDP and per capita health expenditure are comparatively high relative to other sub-Saharan African countries [47, 90, 298]. Healthcare in Namibia is funded through Government funding, prepaid private expenditure, OOP expenditure and donor funding [47]. In 2014/15, 64% of THE was provided by the Namibian Government, which equated to around 13% of government expenditure for the fiscal year [47]. Additionally, household expenditures on health fall well below the level indicative of catastrophic health expenditures [299]. However, despite its strong financial position, Namibia may still face challenges in achieving UHC. Namibia experiences substantial wealth inequality across the population [18], which may affect the ability of individuals and households to afford healthcare [300]. Additionally, THE is unevenly distributed, with 36% of THE providing health insurance that covers less than one fifth of the population [47]. Given these inequities in health financing in Namibia, additional financial resources may be needed to realise UHC [47].

Health insurance and other pre-financing mechanisms have been identified as important components of UHC strategies [108, 301-303]. Health insurance has been associated with health-seeking behaviour across SSA and has been found to reduce OOP expenditures, catastrophic spending on health, financial barriers to healthcare, and to protect against poverty in a number of developing countries [304-313]. In Namibia, health insurance has been associated with cancer screening [314-316], timely antenatal care visits and skilled attendance at birth [317, 318], as well as reductions in the economic consequences of HIV-associated health costs [319]. However, the impact of health insurance on health-seeking behaviour more broadly is less well understood in the country. In addition to understanding the coverage of health insurance in a population, it is also important to assess equity in health insurance coverage. Inequalities in Namibia, such as the country's high income inequality, notable unemployment rate and variable access to and completion of education [5, 17, 18, 136], may directly or indirectly impact upon the ability of households to afford healthcare or health insurance. Wealth and education have been widely associated with having insurance in other settings [320-326]; by comparison, the sociodemographic factors associated with health insurance in Namibia have not been well described.

As health insurance is one strategy that could help to achieve UHC, it will be important to assess equity in health insurance coverage across different sociodemographic groups. A better understanding of the sociodemographic factors that are associated with health insurance coverage may help to inform the design and implementation of strategies to improve financial protection from healthcare-associated costs. As such, this chapter aims to:

i. Estimate the coverage of health insurance by sociodemographic factors in Namibia;
ii. Explore the association between health insurance and health service utilisation;
iii. Investigate the relationship between health insurance and financial barriers to healthcare; and
iv. Assess the sociodemographic factors associated with health insurance in Namibia.

8.2 Methods

8.2.1 Data sources

Data from the 2013 Namibia DHS were used to understand the distribution and determinants of health insurance and health service utilisation in Namibia. The methods of the 2013 Namibia DHS are described in detail elsewhere [176] and in **Chapter 2**. In summary, the DHS included three surveys: the Household Questionnaire, Woman's Questionnaire and Man's Questionnaire.

The DHS data are useful for understanding the factors associated with health insurance due to the extensive data collected on sociodemographic factors as well as health insurance coverage, health-seeking behaviour (including inpatient and outpatient care) and financial barriers to care seeking. Questions related to health insurance were asked as part of the Woman's and Man's Questionnaires. Individuals were asked if they were covered by health insurance and, if so, what type of health insurance they were covered by [176]. Questions related to inpatient and outpatient care seeking were asked to the respondent who answered the Household Questionnaire and included information about the reason for seeking healthcare, the number of visits and the cost of the care. Questions pertaining to healthcare barriers, including "getting money for treatment" as a problem when seeking healthcare, were asked as part of the Woman's Questionnaire only. Education level reflects the highest level of education attended [137], but does not necessarily mean that the level of education was completed.

8.2.2 Statistical analyses

All analyses were carried out using Stata 14 software package (StataCorp: College Station, TX, USA). The Household, Woman's and Man's datasets were merged and data were cleaned. Of the 14,499 individuals who took part in the Woman's and Man's surveys, a subset of 14,443 (99.6%) individuals (9,985 women and 4,458 men) with information on age, sex, education level, occupation, wealth, residence type, region, marital status and health insurance were included in these analyses. Individuals with occupations classed as "other" were also excluded (n=7; <1%).

Age was recoded into five-year groups, with those aged 50 to 64 years included in one category. Occupation was recoded into four categories: Professional (including clerical, sales, services), agricultural (including self-employed and employee), manual (including skilled and unskilled) and unemployed. Marital status was recoded to include individuals who were divorced, widowed or no longer living with their partner in the "formerly/ever married" category. To explore outpatient health seeking behaviour, a variable for whether individuals did or did not seek outpatient care in the four weeks preceding the survey was generated. This was done based on the line number of the individual who sought care. Individuals whose line number matched that of the variable for the line number of the person seeking outpatient care were coded as "1" and those whose line numbers did not match were coded as "0" (not having sought outpatient care). This was repeated for inpatient care in a separate analysis. For outpatient care, the variable for the health facility visited was recoded into Government health facilities, private health facilities, other/outreach point/community health worker, pharmacy/shop and traditional healer. For inpatient care the categories were Government health facility, private health facility and "other".

Categorical data are presented as a frequency and percentage. *P* values were calculated using a chi-squared test for categorical variables. First, the prevalence and distribution of health insurance coverage by sociodemographic characteristics was explored. Health insurance coverage by different insurance types was also explored and included employer-provided, social security, private and "other" insurance, and how this differed by sex. Adjusted prevalence of health insurance, outpatient care and inpatient care were estimated using marginal standardisation.

Next, the association between health insurance and health service utilisation was investigated. This involved two separate outcomes: whether an individual sought outpatient care in the four weeks preceding the survey; and whether an individual sought inpatient care in the six months preceding the survey. These questions were asked as part of the Household Questionnaire. The household member was identified by a line number; therefore, their health seeking behaviour can be linked to information collected as part of the Woman's or Man's Questionnaires. I explored the distribution of individuals who sought inpatient and outpatient care, respectively, by health insurance status and sociodemographic characteristics: health insurance, age, sex, education, wealth, residence type, marital status and occupation. The healthcare provider where care was sought was also explored for both inpatient and outpatient care.

For both outcomes (sought outpatient care and sought inpatient care), univariable Poisson regression analyses were first carried out (Model 1) to assess the association between each respective outcome and health insurance, and other potentially confounding sociodemographic factors of interest (age, sex, education, wealth, residence type, marital status and occupation). In Model 2, region, EA and household were included as mixed effects. Finally, in the fully-adjusted multivariable mixed effects model (Model 3), I adjusted for regional, EA and household clustering and all sociodemographic factors, in addition to the primary exposure of interest: health insurance. In mixed effects models, 95% confidence intervals (95% CIs) were generated using cluster-robust standard errors.

In a sub-analysis, the association between health insurance and financial barriers to healthcare was investigated. This analysis involved a subset of 9,984 women with complete data on health insurance, age, education, wealth, residence type, occupation, marital status and whether getting money for treatment was a problem when seeking healthcare. The prevalence of health insurance in this sub-population by sociodemographic factors and reporting financial healthcare barriers was assessed. Next, the association between health insurance and financial healthcare barriers was explored. In Model 1, the univariable association between health insurance and the financial barrier outcome was explored using Poisson regression. In Model 2, region, EA and household were included as mixed effects to account for the potential effect of clustering. Finally, Model 3 involved a multivariable mixed effects analysis, whereby the association between health insurance and financial barriers was explored, adjusting for age, education, wealth, residence type, marital status and occupation and accounting for regional, EA and household-level clustering.

In the overall population (n=14,443), multivariable mixed effects Poisson regression analyses were also used to explore the sociodemographic factors associated with health insurance. In Model 1, I assessed the univariable association between health insurance and each of the exposures of interest: age, sex, education, wealth, occupation, residence type and marital status. In Model 2, region, EA and household were included as mixed effects. Model 3 was a multivariable mixed effects model, which adjusted for all exposures listed above and adjusted for clustering at the regional, EA and household level. In mixed effects models, 95% CIs were generated using cluster-robust standard errors. Effect modification was assessed by stratifying fully-adjusted analyses (Model 3) by sex, education and wealth. I also assessed whether there was statistical evidence of interaction between sex and education, sex and wealth, and education and wealth, in regards to their association with health insurance, using likelihood ratio tests to compare models with and without an interaction term.

In additional analyses (**Appendix 3**), I used language as proxy for ethnicity by recoding the variable for the main language spoken in the home into five groups: Afrikaans, Damara/Nama, Herero, Oshiwambo and "other", which included small populations of English, San, Kwagali and Lozi. In these additional analyses I explored the prevalence of health insurance, outpatient and inpatient care, and affordability as a barrier to healthcare by ethnicity and the association between ethnicity and health insurance, outpatient care and inpatient care.

8.3 Results

8.3.1 DHS population

Of the 14,449 individuals who took part in the individual Woman's and Man's surveys, 14,443 (99.6%) had complete data for all key variables of interest and thus were included in the main analyses presented in this chapter (**Table 8.1**). A total of 56 participants (0.4%) were excluded on the basis that they had incomplete records. Of those individuals, seven had missing data on health insurance, seven answered "don't know" for occupation, 47 had missing data on occupation. There was overlap between individuals with incomplete data in relation to the exclusion criteria.

Table 8.1: The distribution of the included and excluded population by outcomes of interest and key sociodemographic factors

Sociodemographic characteristics	Overall No. (%)	Included No. (%)	Excluded No. (%)	*p*
Overall	14,499 (100.0)	14,443 (99.6)	56 (0.4)	
Health insurance				
No	11,961 (100.0)	11,921 (99.7)	40 (0.3)	<0.001
Yes	2,531 (100.0)	2,522 (99.6)	9 (0.4)	
Missing	7 (100.0)	0 (0.0)	7 (100.0)	
Outpatient care				
No	13,141 (100.0)	13,088 (99.6)	53 (0.4)	0.302
Yes	1,358 (100.0)	1,355 (99.8)	3 (0.2)	
Inpatient care				
No	13,869 (100.0)	13,818 (99.6)	51 (0.4)	0.092
Yes	630 (100.0)	625 (99.2)	5 (0.8)	
Sex				
Men	4,481 (100.0)	4,458 (99.5)	23 (0.5)	0.099
Women	10,018 (100.0)	9,985 (99.7)	33 (0.3)	
Age group				
15 – 19	2,740 (100.0)	2,734 (99.8)	6 (0.2)	0.179
20 – 24	2,491 (100.0)	2,485 (99.8)	6 (0.2)	
25 – 29	2,108 (100.0)	2,100 (99.6)	8 (0.4)	
30 – 34	1,778 (100.0)	1,769 (99.5)	9 (0.5)	
35 – 39	1,600 (100.0)	1,589 (99.3)	11 (0.7)	
40 – 44	1,346 (100.0)	1,341 (99.6)	5 (0.4)	
45 – 49	1,063 (100.0)	1,056 (99.6)	7 (0.7)	
50 – 64	1,373 (100.0)	1,369 (99.7)	4 (0.3)	

P value corresponds to a chi-squared test

The DHS is designed to be nationally-representative of the population [327]; however, due to survey design, in this subset of 14,443 individuals from the 2013 Namibia DHS, 69.1% were women (Table 8.2). The population size decreased with increasing age group. The majority of individuals were educated to secondary level (60.2%). The largest proportion of the population was in the fourth wealth quintile (23.4%) and the smallest in the lowest quintile (15.7%). There was an equal distribution by residence type, as to be expected from the study design (urban: 50.9% and rural: 49.1%). This is broadly reflective of Namibia's population. Most participants were never married (55.0%), with 21.4% currently married and 16.3% living with their partner. Around 50% were unemployed, whilst 35.3% were in professional employment. Similar sociodemographic patterns were observed between men and women.

Table 8.2: Distribution of the population by sociodemographic characteristics, stratified by sex

Sociodemographic Characteristics	Overall No. (%)	Men No. (%)	Women No. (%)	*p*
Sex				
Men	4,458 (30.9)	—	—	
Women	9,985 (69.1)	—	—	
Age group				
15 – 19	2,734 (18.9)	880 (19.7)	1,854 (18.6)	<0.001
20 – 24	2,485 (17.2)	769 (17.3)	1,716 (17.2)	
25 – 29	2,100 (14.5)	609 (13.7)	1,491 (14.9)	
30 – 34	1,769 (12.3)	512 (11.5)	1,257 (12.6)	
35 – 39	1,589 (11.0)	451 (10.1)	1,138 (11.4)	
40 – 44	1,341 (9.3)	400 (9.0)	941 (9.4)	
45 – 49	1,056 (7.3)	308 (6.9)	748 (7.5)	
50 – 64	1,369 (9.5)	529 (11.9)	840 (8.4)	
Education level				
No education	1,213 (8.4)	491 (11.0)	722 (7.2)	<0.001
Primary	3,470 (24.0)	1,172 (26.3)	2,298 (23.0)	
Secondary	8,688 (60.2)	2,466 (55.3)	6,222 (62.3)	
Higher	1,072 (7.4)	329 (7.4)	743 (7.4)	
Wealth quintile				
Lowest	2,301 (15.9)	668 (15.0)	1,633 (16.4)	0.004
Second	2,678 (18.5)	861 (19.3)	1,817 (18.2)	
Middle	3,048 (21.1)	1,003 (22.5)	2,045 (20.5)	
Fourth	3,381 (23.4)	1,036 (23.2)	2,345 (23.5)	
Highest	3,035 (21.0)	890 (20.0)	2,145 (21.5)	
Residence type				
Urban	7,351 (50.9)	2,210 (49.6)	5,141 (51.5)	0.034
Rural	7,092 (49.1)	2,248 (50.4)	4,844 (48.5)	
Marital status				
Never married	7,947 (55.0)	2,628 (59.0)	5,319 (53.3)	<0.001
Currently married	3,093 (21.4)	974 (21.9)	2,119 (21.2)	
Living with partner	2,347 (16.3)	678 (15.2)	1,669 (16.7)	
Formerly/ever married	1,056 (7.3)	178 (4.0)	878 (8.8)	
Occupation				
Professional	5,092 (35.3)	1,267 (28.4)	3,825 (38.3)	<0.001
Agricultural	644 (4.5)	442 (9.9)	202 (2.0)	
Manual	1,435 (9.9)	1,063 (23.8)	372 (3.7)	
Unemployed	7,272 (50.4)	1,686 (37.8)	5,586 (55.9)	
Total	14,443 (100.0)	4,458 (100.0)	9,985 (100.0)	

8.3.2 Health insurance coverage

Overall, 17.5% of this DHS population had health insurance. A higher proportion of men were insured compared to women (20.3% vs 16.2%, $p<0.001$)(**Table 8.3**). There was a positive relationship between age and health insurance coverage, ranging from 10.0% in those aged 15-19 to 30.8% in both those aged 40–44 and 45–49 years. In these descriptive analyses, the coverage of health insurance increased with levels of education and wealth ($p<0.001$). It was also observed that health insurance coverage was higher in urban dwellers at 25.7% compared to 8.9% in the rural population ($p<0.001$). Those who were currently married had the highest coverage of health insurance at 36.8% ($p<0.001$). As may be expected, health insurance coverage was most prevalent in those in professional employment 30.8%; however, surprisingly, 7.3% of the unemployed were insured. In a subset of 14,436 individuals with data on ethnicity, health insurance coverage was notably higher amongst the Afrikaans population at 41.6% ($p<0.001$) and was lowest in the Damara/Nama populations at 12.9% (**Appendix 3; Table 9**).

Table 8.3: Distribution of health insurance coverage by sociodemographic characteristics (n=14,443)

Sociodemographic Characteristics	**Health Insurance Coverage** No. (%)		
	No	**Yes**	***p***
Sex			
Men	3,556 (79.8)	902 (20.3)	<0.001
Women	8,365 (83.8)	1,620 (16.2)	
Age group			
15-19	2,462 (90.1)	272 (10.0)	<0.001
20-24	2,220 (89.3)	265 (10.7)	
25-29	1,810 (86.2)	290 (13.8)	
30-34	1,421 (80.3)	348 (19.7)	
35-39	1,254 (78.9)	335 (21.1)	
40-44	988 (73.7)	353 (26.3)	
45-49	731 (69.2)	325 (30.8)	
50+	1,035 (75.6)	334 (24.4)	
Education level			
No education	1,165 (96.0)	48 (4.0)	<0.001
Primary	3,257 (93.9)	213 (6.1)	
Secondary	7,140 (82.2)	1,548 (17.8)	
Higher	359 (33.5)	713 (66.5)	
Wealth quintile			
Lowest	2,265 (98.4)	36 (1.6)	<0.001
Second	2,559 (95.6)	119 (4.4)	
Middle	2,767 (90.8)	281 (9.2)	
Fourth	2,749 (81.3)	632 (18.7)	
Highest	1,581 (52.1)	1,454 (47.9)	
Residence type			
Urban	5,463 (74.3)	1,888 (25.7)	<0.001
Rural	6,458 (91.1)	634 (8.9)	
Marital status			
Never married	6,988 (87.9)	959 (12.1)	<0.001
Currently married	1,956 (63.2)	1,137 (36.8)	
Living with partner	2,084 (88.8)	263 (11.2)	
formerly/ever married	893 (84.6)	163 (15.4)	
Occupation			
Professional	3,523 (69.2)	1,569 (30.8)	<0.001
Agricultural	537 (83.4)	107 (16.6)	
Manual	1,123 (78.3)	312 (21.7)	
Unemployed	6,738 (92.7)	534 (7.3)	
Total	11,921 (82.5)	2,522 (17.5)	

P value corresponds to a chi-squared test

Crude and adjusted prevalence estimates for health insurance, outpatient care and inpatient care are presented in **Table 8.4.** Crude and age- and sex-adjusted prevalence estimates for all outcomes were the same.

Table 8.4: Crude and adjusted prevalence of health insurance, outpatient and inpatient care

	Crude prevalence % (95% CI)	**Adjusted prevalence** % (95% CI)
Health insurance	17.5 (16.89 – 18.1)	17.5 (16.8 – 18.1)
Sought outpatient care	9.4 (8.9 – 9.9)	9.4 (8.9 – 9.9)
Sought inpatient care	4.3 (4.0 – 4.7)	4.3 (4.0 – 4.7)

Adjusted prevalence estimates are adjusted for age and sex | 95% CI: 95% confidence interval | Outpatient care refers to individuals who sought outpatient care in the four weeks prior to the survey | Inpatient care refers to individuals who sought inpatient care in the six months prior to the survey

The majority of the insured population had employer-provided insurance (54.5%); 29.4% had social security insurance and 21.4% were covered by private insurance (**Figure 8.1**). More than 60% of women had employer-provided insurance compared to just over 40% of men (*p*<0.001). A higher proportion of men than women had social security insurance (*p*<0.001).

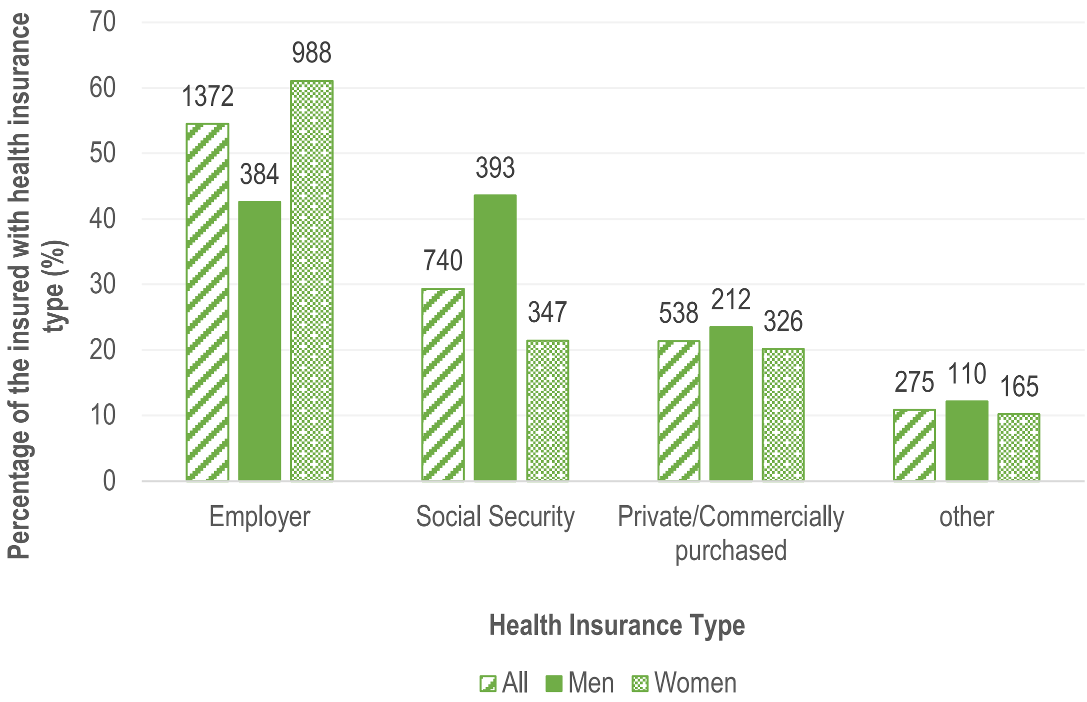


Figure 8.1: The proportion of insured individuals with each type of health insurance, stratified by sex. Number labels correspond to the number of individuals.

8.3.3 Health insurance and health service utilisation

To better understand the role of health insurance in health service utilisation, health insurance was assessed as a determinant of utilisation of inpatient (six months prior to the survey) and outpatient care (four weeks prior to the survey). A total of 1,355 individuals sought outpatient care in the previous four weeks (9.4%; 7.6% of men and 10.2% of women), whilst 625 individuals sought inpatient care (4.3%; 5.1% of women and 2.6% of men)(**Table 8.5**). A higher proportion of those with health insurance sought outpatient and inpatient care compared with the uninsured (p<0.001).

A higher proportion of women sought care than men (10.2% vs 7.6%) and outpatient care seeking increased with age (p<0.001), education level (p<0.001) and wealth (p<0.001). The prevalence of inpatient care increased with education level (p=0.002). No difference in inpatient care by wealth or residence type was observed (p>0.05).

In a subset of 14,436 individuals with data on ethnicity, the Afrikaans population had the highest proportion of outpatient visits at 12.6%, whilst the Damara/Nama population had the lowest proportion of outpatient visits at 7.8% (p<0.001) (**Appendix 3**; **Table 9**). However, in this population subset, the Damara/Nama had the highest proportion of inpatient care visits (5.6%), with the Oshiwambo population having the smallest proportion of inpatient care visits at 3.8% (p=0.004).

Table 8.5: The distribution of individuals who sought outpatient and inpatient care* by sociodemographic characteristics (n=14,443)

Sociodemographic Characteristics	**Sought Outpatient care** No. (%)			**Sought Inpatient care** No. (%)		
	No	**Yes**	***p***	**No**	**Yes**	***p***
Health insurance						
No	10,916 (91.6)	1,005 (8.4)	<0.001	11,440 (96.0)	481 (4.0)	<0.001
Yes	2,172 (86.1)	350 (13.9)		2,378 (94.3)	144 (5.7)	
Sex						
Men	4,119 (92.4)	339 (7.6)	<0.001	4,343 (97.4)	115 (2.6)	<0.001
Women	8,969 (89.8)	1,016 (10.2)		9,475 (94.9)	510 (5.1)	
Age group						
15 – 19	2,616 (95.7)	118 (4.3)	<0.001	2,670 (97.7)	64 (2.3)	<0.001
20 – 24	2,338 (94.1)	147 (5.9)		2,393 (96.3)	92 (3.7)	
25 – 29	1,913 (91.1)	187 (8.9)		1,985 (94.5)	115 (5.5)	
30 – 34	1,579 (89.3)	190 (10.7)		1,665 (94.1)	104 (5.9)	
35 – 39	1,424 (89.6)	165 (10.4)		1,510 (95.0)	79 (5.0)	
40 – 44	1,178 (87.8)	163 (12.2)		1,277 (95.2)	64 (4.8)	
45 – 49	898 (85.0)	158 (15.0)		1,011 (95.7)	45 (4.3)	
50 – 64	1,142 (83.4)	227 (16.6)		1,307 (95.5)	62 (4.5)	
Education level						
No education	1,111 (91.6)	102 (8.4)	<0.001	1,180 (97.3)	33 (2.7)	0.014
Primary	3,133 (90.3)	337 (9.7)		3,323 (95.8)	147 (4.2)	
Secondary	7,916 (91.1)	772 (8.9)		8,300 (95.5)	388 (4.5)	
Higher	928 (86.6)	144 (13.4)		1,015 (94.7)	57 (5.3)	
Wealth quintile						
Lowest	2,086 (90.7)	215 (9.3)	<0.001	2,207 (95.9)	94 (4.1)	0.878
Second	2,446 (91.3)	232 (8.7)		2,557 (95.5)	121 (4.5)	
Middle	2,795 (91.7)	253 (8.3)		2,919 (95.8)	129 (4.2)	
Fourth	3,074 (90.9)	307 (9.1)		3,227 (95.5)	154 (4.6)	
Highest	2,687 (88.5)	348 (11.5)		2,908 (95.8)	127 (4.2)	
Residence type						
Urban	6,643 (90.4)	708 (9.6)	0.295	7,012 (95.4)	339 (4.6)	0.087
Rural	6,445 (90.9)	647 (9.1)		6,806 (96.0)	286 (4.0)	
Marital status						
Never married	7,406 (93.2)	541 (6.8)	<0.001	7,672 (96.5)	275 (3.5)	<0.001
Currently married	2,681 (86.7)	412 (13.3)		2,931 (94.8)	162 (5.2)	
Living with partner	2,129 (90.7)	218 (9.3)		2,211 (94.2)	136 (5.8)	
Formerly/ ever married	872 (82.6)	184 (17.4)		1,004 (95.1)	52 (4.9)	
Occupation						
Professional	4,500 (88.4)	592 (11.6)	<0.001	4,841 (95.1)	251 (4.9)	0.047
Agricultural	580 (90.1)	64 (9.9)		622 (96.6)	22 (3.4)	
Manual	1,313 (91.5)	122 (8.5)		1,382 (96.3)	53 (3.7)	
Unemployed	6,695 (92.1)	577 (7.9)		6,973 (95.9)	299 (4.1)	
Total	13,088 (90.6)	1,355 (9.4)		13,818 (95.7)	625 (4.3)	

P value corresponds to a chi-squared test

*Outpatient care sought in four weeks prior to survey and inpatient care sought in six months prior to survey

An equal proportion of insured individuals sought healthcare from private and Government providers for inpatient care (both 49.7%). By contrast, a higher proportion of the uninsured population visited a Government facility for both inpatient and outpatient care, whilst a higher proportion of the insured population visited a private facility for outpatient care (50.0% private; 22.3% Government, *p*<0.001)(**Figures 8.2A and 8.2B**).

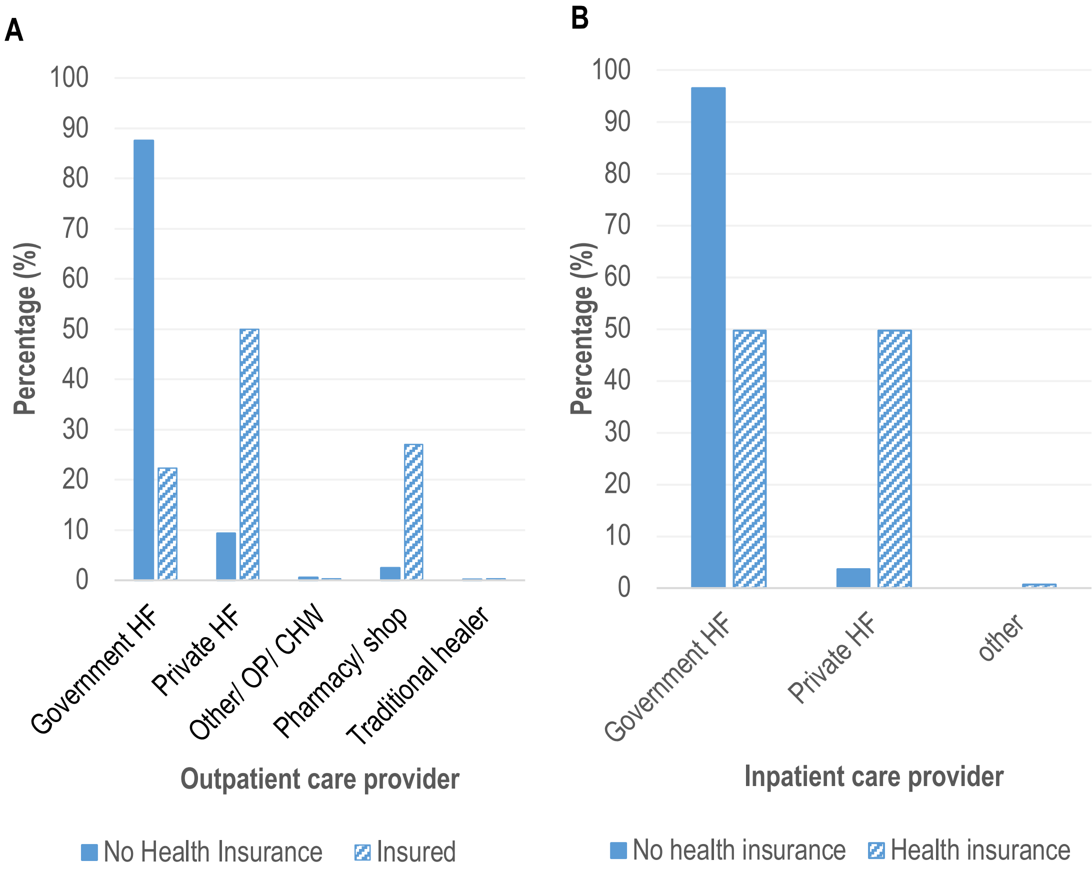


Figure 8.2: The type of healthcare provider where inpatient and outpatient care was sought by health insurance coverage | 2A insured n=350 uninsured n=1,005; **2B** insured n=143 uninsured n=479 | HF: health facility | OP: outreach point | CHW: community health worker.

To explore the association between health insurance and outpatient and inpatient care, respectively, multivariable mixed effects models were used to account for clustering and covariates. Health insurance was positively associated with seeking outpatient (Model 3 RR: 1.28; 95% CI: 1.08 – 1.52; *p*=0.005) and inpatient care (Model 3 RR: 1.52; 95% CI: 1.26 – 1.82; *p*<0.001)(**Figure 8.3**). This suggests a role for health insurance in health service utilisation. Importantly, women were more likely to seek inpatient and outpatient care, irrespective of insurance status and other sociodemographic factors (**Tables 8.6 and 8.7**).

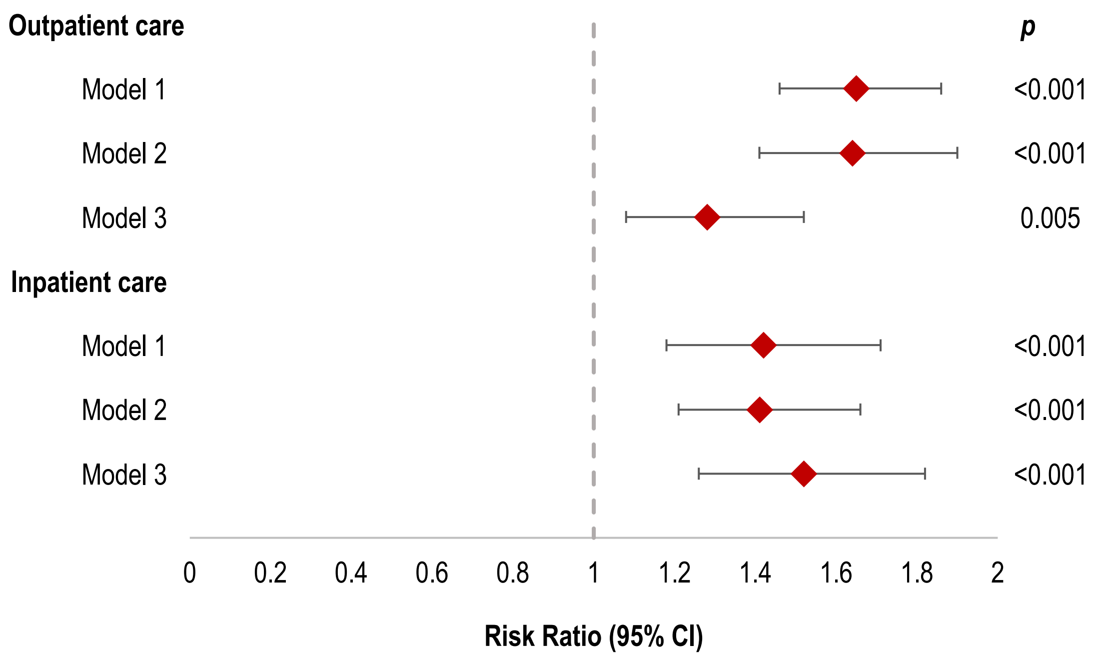


Figure 8.3: The association between health insurance and inpatient and outpatient care (N=14,443) | Model 1: univariable association between health insurance and inpatient and outpatient care, respectively | **Model 2:** univariable mixed effects model accounting for regional, area unit and household clustering |**Model 3:** multivariable mixed effects model, accounting for regional, area unit and household clustering and adjusting for age, education, wealth, residence type, marital status and occupation | 95% CI: 95% confidence interval.

Table 8.6: Association between exposures of interest and seeking outpatient care in the four weeks prior to the survey (n=14,443)

Exposures of interest	Model 1		Model 3	
	RR (95% CI)	*p*	RR (95% CI)	*p*
Health Insurance				
No	1.00 (reference)		1.00 (reference)	
Yes	1.65 (1.46 – 1.86)	<0.001	1.28 (1.08 – 1.52)	0.005
Sex				
Men	1.00 (reference)		1.00 (reference)	
Women	1.33 (1.18 – 1.51)	<0.001	1.31 (1.14 - 1.50)	<0.001
Age group				
15 – 19	1.00 (reference)		1.00 (reference)	
20 – 24	1.37 (1.08 – 1.75)	0.011	1.30 (1.01 – 1.69)	0.046
25 – 29	2.06 (1.64 – 2.60)	<0.001	1.87 (1.38 – 2.54)	<0.001
30 – 34	2.49 (1.98 – 3.13)	<0.001	2.14 (1.77 – 2.60)	<0.001
35 – 39	2.41 (1.90 – 3.05)	<0.001	2.02 (1.57 – 2.59)	<0.001
40 – 44	2.82 (2.22 - 3.57)	<0.001	2.25 (1.69 – 3.01)	<0.001
45 – 49	3.47 (2.73 – 4.40)	<0.001	2.69 (2.10 – 3.45)	<0.001
50 – 64	3.84 (3.08 – 4.80)	<0.001	3.15 (2.37 – 4.19)	<0.001
Education level				
No education	1.00 (reference)		1.00 (reference)	
Primary	1.16 (093 – 1.44)	0.202	1.28 (1.10 – 1.48)	0.002
Secondary	1.06 (0.86 – 1.30)	0.601	1.32 (1.12 – 1.54)	0.001
Higher	1.60 (1.24 – 2.06)	<0.001	1.46 (1.11 – 1.94)	0.008
Wealth quintile				
Lowest	1.00 (reference)		1.00 (reference)	
Second	0.93 (0.77 – 1.12)	0.424	0.94 (0.75 – 1.17)	0.558
Middle	0.89 (0.74 – 1.07)	0.202	0.87 (0.72 – 1.05)	0.146
Fourth	0.97 (0.82 – 1.16)	0.748	0.90 (0.70 – 1.15)	0.393
Highest	1.23 (1.04 – 1.45)	0.018	0.97 (0.74 – 1.28)	0.836
Residence type				
Urban	1.00 (reference)		1.00 (reference)	
Rural	0.95 (0.85 – 1.05)	0.319	0.99 (0.80 - 1.23)	0.952
Marital status				
Never married	1.00 (reference)		1.00 (reference)	
Currently married	1.96 (1.72 – 2.22)	<0.001	1.17 (0.98 – 1.40)	0.081
Living with partner	1.36 (1.17 – 1.60)	<0.001	1.12 (0.95 – 1.34)	0.188
Formerly/ ever married	2.56 (2.17 – 3.03)	<0.001	1.59 (1.28 – 1.98)	<0.001
Occupation				
Professional	1.00 (reference)		1.00 (reference)	
Agricultural	0.86 (0.66 – 1.11)	0.233	1.00 (0.84 – 1.18)	0.949
Manual	0.73 (0.60 – 0.89)	0.002	0.89 (0.77 – 1.02)	0.089
Unemployed	0.68 (0.61 – 0.77)	<0.001	0.93 (0.85 – 1.02)	0.099

RR: risk ratio | 95% CI: 95% confidence interval | Model 1: Univariable model | Model 3: Adjusted for regional, enumeration area and household clustering and all other covariates in the table | Model 2 as described in methods not shown

Table 8.7: Association between exposures of interest and inpatient care in the six months prior to the survey (n=14,443)

Exposures of interest	Model 1		Model 3	
	RR (95% CI)	*p*	RR (95% CI)	*p*
Health Insurance				
No	1.00 (reference)		1.00 (reference)	
Yes	1.42 (1.18 – 1.71)	<0.001	1.52 (1.26 – 1.82)	<0.001
Sex				
Men	1.00 (reference)		1.00 (reference)	
Women	1.98 (1.62 – 2.42)	<0.001	1.95 (1.55 – 2.45)	<0.001
Age group				
15 – 19	1.00 (reference)		1.00 (reference)	
20 – 24	1.58 (1.15 – 2.18)	0.005	1.50 (1.07 – 2.10)	0.018
25 – 29	2.34 (1.72 – 3.18)	<0.001	2.09 (1.54 – 2.83)	<0.001
30 – 34	2.51 (1.84 – 3.43)	<0.001	2.19 (1.40 – 3.43)	0.001
35 – 39	2.12 (1.53 – 2.95)	<0.001	1.82 (1.13 – 2.94)	0.014
40 – 44	2.04 (1.44 – 2.88)	<0.001	1.77 (1.29 – 2.44)	<0.001
45 – 49	1.82 (1.24 – 2.67)	0.002	1.58 (1.11 – 2.25)	0.011
50 – 64	1.94 (1.36 – 2.74)	<0.001	1.88 (1.24 – 2.86)	0.003
Education level				
No education	1.00 (reference)		1.00 (reference)	
Primary	1.56 (1.07 – 2.27)	0.022	1.70 (1.05 – 2.75)	0.031
Secondary	1.64 (1.15 – 2.34)	0.006	1.82 (1.11 – 2.97)	0.017
Higher	1.95 (1.27 – 3.00)	0.002	1.96 (1.13 – 3.40)	0.017
Wealth quintile				
Lowest	1.00 (reference)		1.00 (reference)	
Second	1.11 (0.85 – 1.45)	0.464	1.06 (0.86 – 1.31)	0.590
Middle	1.04 (0.79 – 1.35)	0.794	0.92 (0.70 – 1.20)	0.538
Fourth	1.12 (0.86 – 1.44)	0.406	0.88 (0.69 – 1.13)	0.321
Highest	1.02 (0.79 – 1.34)	0.860	0.67 (0.51 – 0.88)	0.004
Residence type				
Urban	1.00 (reference)		1.00 (reference)	
Rural	0.87 (0.75 – 1.02)	0.095	0.87 (0.70 – 1.09)	0.236
Marital status				
Never married	1.00 (reference)		1.00 (reference)	
Currently married	1.51 (1.25 – 1.84)	<0.001	1.21 (1.00 – 1.47)	0.048
Living with partner	1.68 (1.36 – 2.06)	<0.001	1.41 (1.10 – 1.81)	0.006
Formerly/ ever married	1.42 (1.06 – 1.91)	0.020	1.15 (0.87 – 1.52)	0.339
Occupation				
Professional	1.00 (reference)		1.00 (reference)	
Agricultural	0.69 (0.45 – 1.07)	0.099	1.01 (0.60 – 1.69)	0.975
Manual	0.75 (0.56 – 1.01)	0.056	1.06 (0.79 – 1.41)	0.715
Unemployed	0.83 (0.71 – 0.99)	0.034	1.11 (0.97 – 1.28)	0.141

RR: risk ratio | 95% CI: 95% confidence interval
Model 1: Univariable model | Model 3: Adjusted for regional, enumeration area and household clustering and all other covariates in the table | Model 2 as described in methods not shown

8.3.4 Health insurance and reporting needing money as a healthcare barrier in women

In order to understand the impact of health insurance on financial healthcare barriers, health insurance coverage was further explored in a subset of 9,984 women with information on age, education, wealth, residence type, marital status, occupation and whether or not getting money for treatment was a barrier to healthcare.

In this population, 9% of the insured population reported financial barriers to healthcare, compared with 33.7% of the uninsured population ($p<0.001$)(**Table 8.8**). Reporting needing money for treatment was more prevalent the lower the level of education (no education 56.9% vs higher education 8.6%; $p<0.001$). Similarly, the prevalence of reporting financial barriers to healthcare declined with increasing wealth quintile. This barrier was higher in rural populations at 39.5% compared with 20.4% in urban populations ($p<0.001$). The prevalence of financial barriers were highest in those formerly married (39.9%, $p<0.001$) and the unemployed (36.5%, $p<0.001$).

In a subset of 9,978 individuals with data on ethnicity, the highest proportion of individuals who reported needing money for treatment as a problem were in the "other" group at 51.3%, followed by the Herero (29.3%) and Damara/Nama (29.2%; $p<0.001$) (**Appendix 3; Table 9**).

Table 8.8: The proportion of individuals who reported financial barriers to healthcare access by sociodemographic characteristics (n=9,984)

Sociodemographic Characteristics	Getting money for treatment is a problem		*p*
	No	**Yes**	
	No (%)	No (%)	
Health Insurance			
No	5,547 (66.3)	2,817 (33.7)	<0.001
Yes	1,475 (91.1)	145 (9.0)	
Age group			
15 – 19	1,334 (72.0)	520 (28.1)	<0.001
20 – 24	1,216 (70.9)	500 (29.1)	
25 – 29	1,065 (71.4)	426 (28.6)	
30 – 34	907 (72.2)	349 (27.8)	
35 – 39	794 (69.8)	344 (30.2)	
40 – 44	648 (68.9)	293 (31.1)	
45 – 49	527 (70.5)	221 (29.6)	
50 – 64	531 (63.2)	309 (36.8)	
Education level			
No education	311 (43.1)	411 (56.9)	<0.001
Primary	1,267 (55.1)	1,031 (44.9)	
Secondary	4,765 (76.6)	1,456 (23.4)	
Higher	679 (91.4)	64 (8.6)	
Wealth quintile			
Lowest	699 (42.8)	933 (57.2)	<0.001
Second	1,058 (58.2)	759 (41.8)	
Middle	1,453 (71.1)	592 (29.0)	
Fourth	1,887 (80.5)	458 (19.5)	
Highest	1,925 (89.7)	220 (10.3)	
Residence type			
Urban	4,092 (79.6)	1,049 (20.4)	<0.001
Rural	2,930 (60.5)	1,913 (39.5)	
Marital status			
Never married	3,858 (72.6)	1,460 (27.5)	<0.001
Currently married	1,571 (74.1)	548 (25.9)	
Living with partner	1,065 (63.8)	604 (36.2)	
Formerly/ ever married	528 (60.1)	350 (39.9)	
Occupation			
Professional	3,039 (79.5)	785 (20.5)	<0.001
Agricultural	140 (69.3)	62 (30.7)	
Manual	293 (78.8)	79 (21.2)	
Unemployed	3,550 (63.6)	2,036 (36.5)	
Total	7,022 (70.3)	2,962 (29.7)	

P value corresponds to chi-squared test | estimates refer to women only

Health insurance was inversely associated with reporting financial barriers to healthcare in this population (Model 3 RR: 0.55; 95% CI: 0.48 – 0.64; p<0.001), irrespective of other sociodemographic factors and clustering (**Figure 8.4**). This suggests that health insurance may be protective against financial barriers to healthcare.

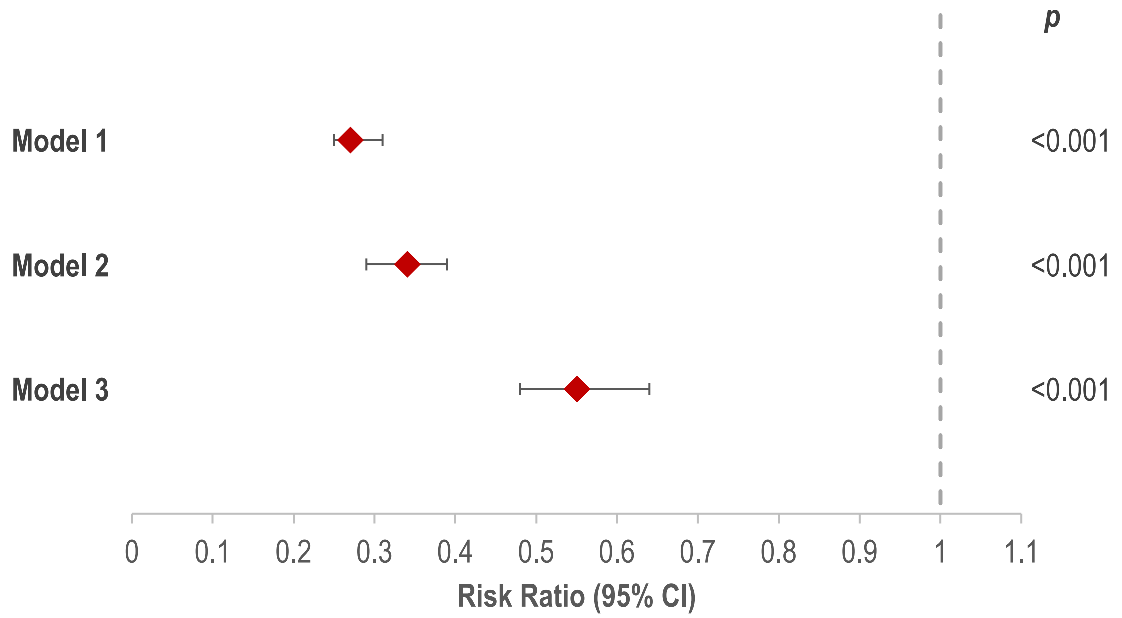


Figure 8.4: Association between health insurance and financial barriers to healthcare (n=9,984) | Model 1: univariable association between health insurance and reporting needing money for treatment as a problem when seeking care | **Model 2:** univariable mixed effects model, accounting for regional, enumeration area and household clustering | **Model 3:** multivariable mixed effects model, additionally adjusted for age, education, wealth, residence type, marital status and occupation | 95% CI: 95% confidence interval.

Additionally, an inverse association between financial barriers to healthcare and education and wealth were observed (**Figure 8.5A and 8.5B**), irrespective of other sociodemographic factors.

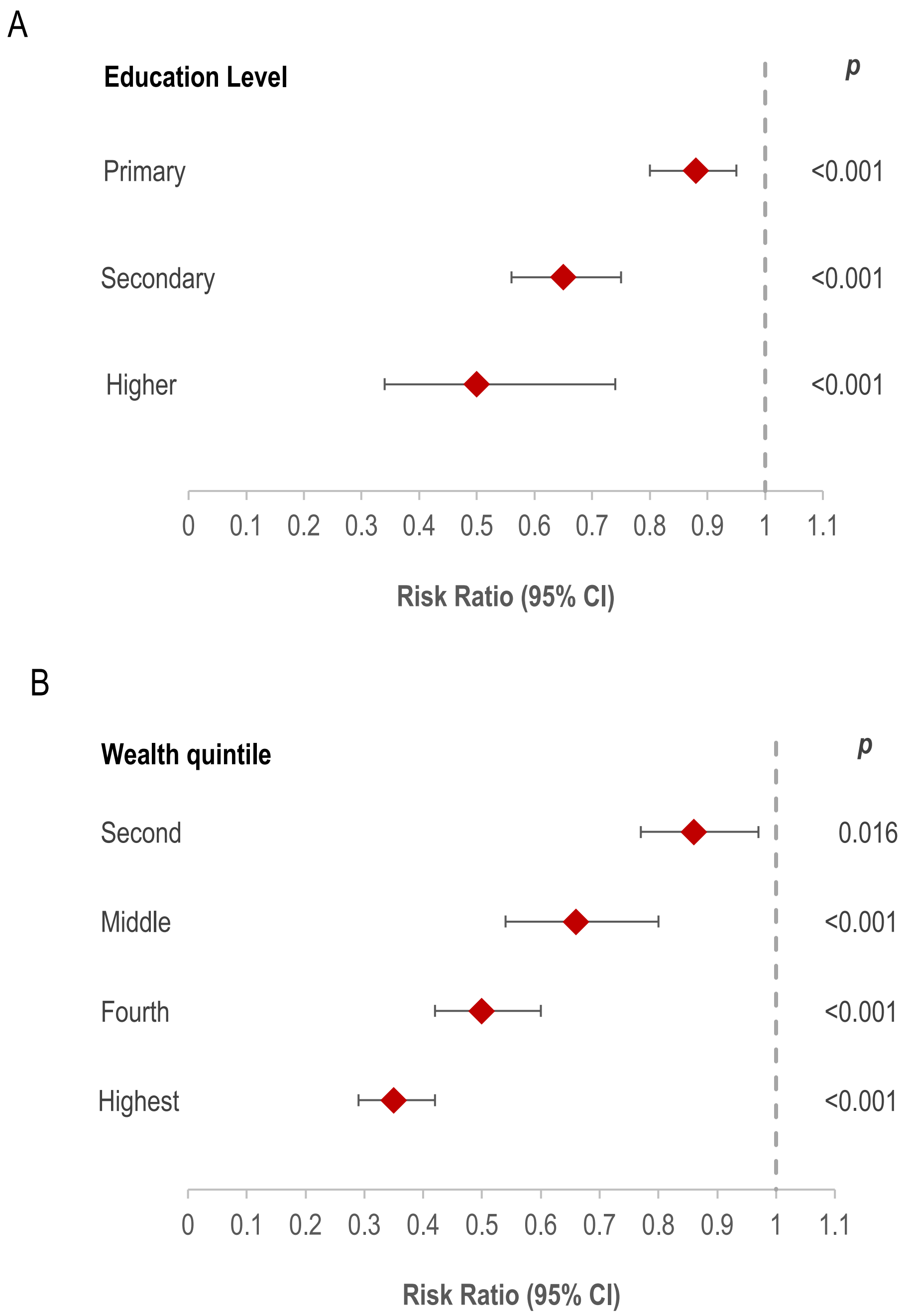


Figure 8.5: Association between wealth and education and reporting financial barriers to healthcare amongst women (n=9,984) | A: Association between education and reporting needing money for treatment as a barrier to healthcare, with 'no education' as the reference | **B:** Association between education and reporting needing money for treatment as a barrier to healthcare, with the lowest wealth quintile as the reference | Both models are adjusted for other sociodemographic factors and regional, enumeration area and household clustering| 95% CI: 95% confidence interval.

8.3.5 Sociodemographic determinants of health insurance coverage

As an association between health insurance and health service utilisation and financial healthcare barriers was observed, I aimed to explore the sociodemographic factors associated with being insured. In multivariable mixed effects Poisson regression analyses (Model 3), women were significantly less likely to be insured than men (RR: 0.83; 95% CI: 0.74 – 0.94; p=0.003), irrespective of age, education, wealth, residence type, marital status and occupation and clustering (**Table 8.9**). Education and wealth were both independently associated with health insurance. In a subset of 14,436 individuals with data on ethnicity, the fully-adjusted model indicated no clear association between ethnicity and health insurance status (**Appendix 3; Table 10**).

Table 8.9: Association between sociodemographic factors and health insurance coverage (n=14,443)

Sociodemographic Characteristics	Model 1		Model 2		Model 3	
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*
Sex						
Men	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Women	0.80 (0.74 – 0.87)	<0.001	0.79 (0.71 – 0.88)	<0.001	0.83 (0.74 – 0.94)	0.003
Age group						
15 – 19	1.00 (reference)		1.00 (reference)		1.00 (reference)	
20 – 24	1.07 (0.91 – 1.27)	0.421	0.99 (0.80 – 1.23)	0.951	0.64 (0.54 – 0.75)	<0.001
25 – 29	1.39 (1.18 – 1.64)	<0.001	1.30 (1.00 – 1.68)	0.049	0.70 (0.60 – 0.82)	<0.001
30 – 34	1.98 (1.69 – 2.32)	<0.001	1.80 (1.40 – 2.32)	<0.001	0.83 (0.73 – 0.96)	0.010
35 – 39	2.12 (1.81 – 2.49)	<0.001	1.97 (1.45 – 2.68)	<0.001	0.89 (0.75 – 1.06)	0.200
40 – 44	2.65 (2.26 – 3.10)	<0.001	2.28 (1.67 – 3.10)	<0.001	0.98 (0.82 – 1.16)	0.784
45 – 49	3.09 (2.63 – 3.63)	<0.001	2.66 (1.98 – 3.57)	<0.001	1.13 (0.93 – 1.38)	0.233
50 – 64	2.45 (2.09 – 2.88)	<0.001	2.35 (1.80 – 3.07)	<0.001	1.08 (0.87 – 1.33)	0.503
Education level						
No education	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Primary	1.55 (1.13 – 2.12)	0.006	1.53 (1.13 – 2.07)	0.006	1.28 (0.99 – 1.66)	0.060
Secondary	4.50 (3.38 – 6.00)	<0.001	3.44 (2.73 – 4.34)	<0.001	2.35 (1.91 – 2.88)	<0.001
Higher	16.81 (12.55 – 22.51)	<0.001	9.42 (6.14 – 14.47)	<0.001	3.98 (3.11 – 5.10)	<0.001
Wealth quintile						
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Second	2.84 (1.96 – 4.12)	<0.001	2.89 (1.76 – 4.75)	<0.001	2.52 (1.54 – 4.13)	<0.001
Middle	5.89 (4.17 – 8.34)	<0.001	6.03 (4.07 – 8.95)	<0.001	4.44 (2.90 – 6.82)	<0.001
Fourth	11.95 (8.54 – 16.72)	<0.001	12.86 (8.97 – 18.43)	<0.001	7.58 (5.05 – 11.39)	<0.001
Highest	30.62 (22.00 – 42.62)	<0.001	30.86 (21.84 – 43.60)	<0.001	13.47 (9.06 – 20.04)	<0.001
Residence type						
Urban	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Rural	0.35 (0.32 – 0.38)	<0.001	0.42 (0.35 – 0.50)	<0.001	1.03 (0.90 – 1.17)	0.676
Marital status						
Never married	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Currently married	3.05 (2.80 – 3.32)	<0.001	2.67 (2.19 – 3.24)	<0.001	1.68 (1.46 – 1.93)	<0.001
Living with partner	0.93 (0.81 – 1.06)	0.287	1.06 (0.89 – 1.26)	0.522	1.06 (0.94 – 1.19)	0.354
Formerly/ever married	1.28 (1.08 – 1.51)	0.004	1.40 (1.24 – 1.58)	<0.001	1.13 (1.04 – 1.24)	0.005
Occupation						
Professional	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Agricultural	0.54 (0.44 – 0.66)	<0.001	0.79 (0.69 – 0.91)	0.001	0.89 (0.76 – 1.05)	0.168
Manual	0.71 (0.63 – 0.80)	<0.001	0.79 (0.70 – 0.90)	<0.001	0.86 (0.78 – 0.95)	0.003
Unemployed	0.24 (0.21 – 0.26)	<0.001	0.32 (0.23 – 0.44)	<0.001	0.44 (0.35 – 0.55)	<0.001

RR: risk ratio derived from Poisson regression analyses | 95% CI: 95% confidence intervals
Model 1: univariable association between exposure and having health insurance
Model 2: same as model one with region, enumeration area and household included as random effects (mixed effects Poisson regression)
Model 3: additionally adjusted for all covariates included in the table (multivariable mixed effects Poisson regression)

To further explore the role of sociodemographic factors in health insurance coverage, I conducted multivariable mixed effects analyses, stratified by sex, education and wealth. When stratified by sex, education was more strongly associated with health insurance in women than in men (**Table 8.10**). Further, as education level increased, women were more likely to be insured (**Figure 8.6** and **Table 8.11**). There was evidence for a significant interaction between sex and education (*p* for interaction <0.001).

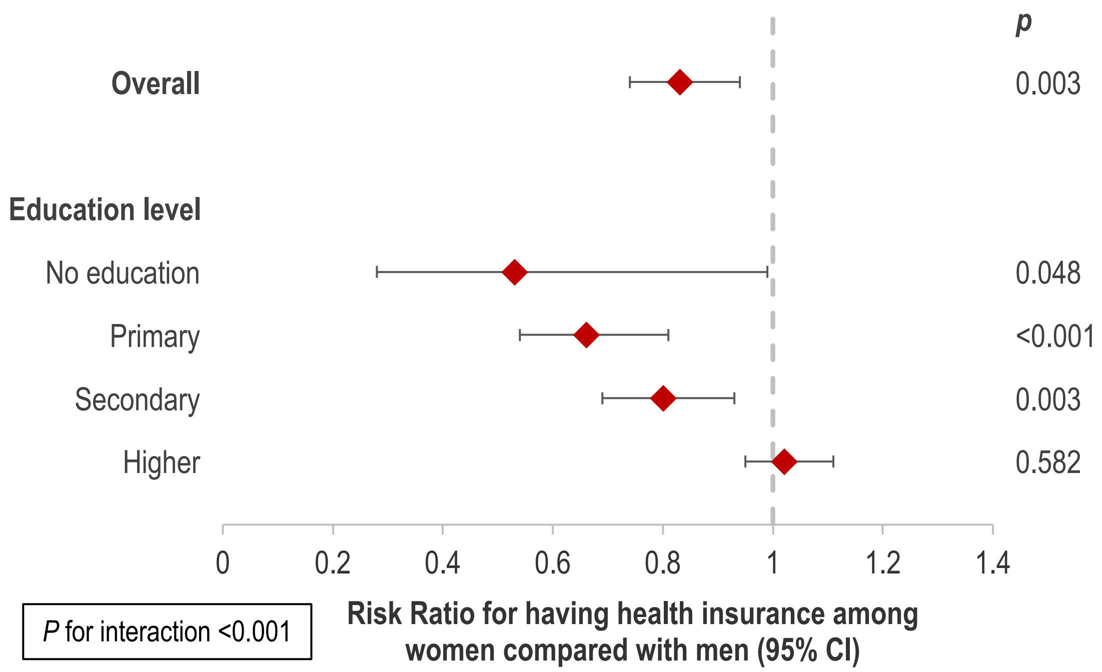


Figure 8.6: The association between health insurance and sex, stratified by education level (n=14,443). Risk Ratios correspond to the risk of health insurance among women compared with men (reference), overall and stratified by education level | *p* for interaction based on likelihood ratio test comparing models with an without an interaction term | 95% CI: 95% confidence interval.

Table 8.10: Association between sociodemographic factors and health insurance stratified by sex

Sociodemographic Characteristics	Men		Women		*p* for interaction
	RR (95% CI)	*p*	RR (95% CI)	*p*	
Age group					
15 – 19	1.00 (reference)		1.00 (reference)		
20 – 24	0.63 (0.49 – 0.81)	0.001	0.63 (0.51 – 0.79)	<0.001	
25 – 29	0.80 (0.60 – 1.06)	0.118	0.65 (0.54 – 0.79)	<0.001	
30 – 34	0.88 (0.70 – 1.10)	0.252	0.80 (0.65 – 0.98)	0.033	
35 – 39	0.92 (0.70 – 1.22)	0.577	0.88 (0.72 – 1.07)	0.190	
40 – 44	1.04 (0.76 – 1.43)	0.809	0.94 (0.78 – 1.13)	0.506	
45 – 49	1.17 (0.89 – 1.54)	0.269	1.09 (0.87 – 1.37)	0.457	
50 – 64	1.10 (0.82 – 1.49)	0.509	1.08 (0.87 – 1.35)	0.481	
Education level					
No education	1.00 (reference)		1.00 (reference)		<0.001
Primary	1.25 (0.90 – 1.75)	0.184	1.48 (0.91 – 2.41)	0.118	
Secondary	1.93 (1.38 – 2.71)	<0.001	3.19 (2.29 – 4.44)	<0.001	
Higher	2.77 (1.97 – 3.91)	<0.001	5.83 (3.98 – 8.55)	<0.001	
Wealth quintile					
Lowest	1.00 (reference)		1.00 (reference)		0.012
Second	4.17 (2.08 – 8.38)	<0.001	1.89 (1.16 – 3.10)	0.011	
Middle	6.84 (3.70 – 12.62)	<0.001	3.59 (2.15 – 5.99)	<0.001	
Fourth	11.09 (5.86 – 21.01)	<0.001	6.33 (3.79 – 10.57)	<0.001	
Highest	18.32 (9.35 – 35.91)	<0.001	11.75 (7.38 – 18.72)	<0.001	
Residence type					
Urban	1.00 (reference)		1.00 (reference)		
Rural	0.93 (0.77 – 1.12)	0.462	1.11 (0.96 – 1.28)	0.178	
Marital status					
Never married	1.00 (reference)		1.00 (reference)		
Currently married	1.55 (1.35 – 1.79)	<0.001	1.74 (1.50 – 2.02)	<0.001	
Living with partner	1.40 (1.17 – 1.68)	<0.001	0.82 (0.72 – 0.94)	0.005	
Formerly/ ever married	1.14 (0.86 – 1.51)	0.377	1.14 (1.02 – 1.27)	0.026	
Occupation					
Professional	1.00 (reference)		1.00 (reference)		
Agricultural	0.84 (0.69 – 1.02)	0.082	0.84 (0.59 – 1.19)	0.321	
Manual	0.76 (0.69 – 0.82)	<0.001	0.89 (0.73 – 1.07)	0.219	
Unemployed	0.33 (0.25 – 0.44)	<0.001	0.48 (0.38 – 0.61)	<0.001	

RR: risk ratio obtained from Poisson regression analyses | 95% CI: 95% confidence intervals | *p* for interaction based on likelihood ratio test comparing models with and without an interaction term, with wealth and education included as continuous variables

Results correspond to fully adjusted models adjusted for all covariates in the table and accounting for regional, enumeration area and household clustering

Men n= 4,458 | Women n= 9,985

Table 8.11: Association between sociodemographic factors and health insurance stratified by education level

Sociodemographic characteristics	No education		Primary education		Secondary education		Higher education		*p* for interaction
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*	
Sex									
Men	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		<0.001
Women	0.53 (0.28 – 0.99)	0.048	0.66 (0.54 – 0.81)	<0.001	0.80 (0.69 – 0.93)	0.003	1.02 (0.95 – 1.11)	0.582	
Age group									
15 – 19	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		
20 – 24	—	—	0.56 (0.21 – 1.48)	0.241	0.52 (0.43 – 0.62)	<0.001	0.88 (0.60 – 1.31)	0.534	
25 – 29	—	—	0.76 (0.37 – 1.59)	0.472	0.56 (0.46 – 0.68)	<0.001	1.18 (0.82 – 1.68)	0.377	
30 – 34	—	—	1.44 (0.64 – 3.29)	0.381	0.71 (0.60 – 0.84)	<0.001	1.26 (0.87 – 1.83)	0.230	
35 – 39	—	—	1.35 (0.67 – 2.69)	0.400	0.81 (0.66 – 0.99)	0.038	1.19 (0.83 – 1.70)	0.355	
40 – 44	—	—	1.84 (0.91 – 3.71)	0.089	0.86 (0.70 – 1.05)	0.146	1.23 (0.92 – 1.64)	0.157	
45 – 49	—	—	2.51 (1.19 – 5.32)	0.016	0.93 (0.73 – 1.18)	0.533	1.37 (0.97 – 1.93)	0.075	
50 – 64	—	—	2.20 (0.99 – 4.92)	0.054	0.89 (0.72 – 1.09)	0.257	1.28 (0.87 – 1.87)	0.209	
Wealth quintile									
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		0.002
Second	2.01 (1.26 – 3.20)	0.003	3.63 (1.80 – 7.34)	<0.001	2.05 (1.12 – 3.75)	0.020	0.63 (0.08 – 4.70)	0.647	
Middle	5.16 (1.49 – 17.84)	0.010	5.02 (2.42 – 10.41)	<0.001	3.49 (2.05 – 5.95)	<0.001	1.08 (0.37 – 3.21)	0.885	
Fourth	9.56 (3.19 – 27.53)	<0.001	8.29 (3.60 – 19.09)	<0.001	5.66 (3.50 – 9.16)	<0.001	1.53 (0.47 – 4.99)	0.477	
Highest	13.40 (4.66 – 38.49)	<0.001	9.84 (3.76 – 25.79)	<0.001	11.70 (7.25 – 18.89)	<0.001	2.00 (0.60 – 6.62)	0.257	
Residence type									
Urban	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		
Rural	0.71 (0.41 – 1.23)	0.222	0.88 (0.61 – 1.27)	0.501	0.99 (0.85 – 1.15)	0.851	1.21 (1.07 – 1.38)	0.003	

Table 8.11: Association between sociodemographic factors and health insurance stratified by education level

Sociodemographic characteristics	No education		Primary education		Secondary education		Higher education		p for interaction
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*	
Marital status									
Never married	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		
Currently married	3.39 (1.65 – 6.95)	0.001	2.42 (1.58 – 3.70)	<0.001	1.92 (1.62 – 2.27)	<0.001	1.21 (1.07 – 1.37)	0.003	
Living with partner	1.27 (0.49 – 3.29)	0.630	1.54 (1.07 – 2.22)	0.020	1.08 (0.92 – 1.27)	0.341	0.95 (0.79 – 1.15)	0.609	
Formerly/ ever married	1.42 (0.44 – 4.56)	0.557	1.67 (0.96 – 2.91)	0.069	1.11 (0.98 – 1.26)	0.102	1.16 (1.05 – 1.29)	0.004	
Occupation									
Professional	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		
Agricultural	1.30 (0.78 – 2.18)	0.321	0.65 (0.40 – 1.05)	0.077	0.91 (0.79 – 1.06)	0.215	0.94 (0.81 – 1.10)	0.458	
Manual	0.71 (0.52 – 0.97)	0.031	1.10 (0.91 – 1.34)	0.322	0.81 (0.70 – 0.93)	0.002	0.69 (0.56 – 0.84)	<0.001	
Unemployed	0.43 (0.21 – 0.91)	0.028	0.28 (0.17 – 0.46)	<0.001	0.43 (0.35 – 0.52)	<0.001	0.59 (0.45 – 0.77)	<0.001	

RR: risk ratio obtained from Poisson regression analyses | 95% CI: 95% confidence intervals | *p* for interaction based on likelihood ratio test comparing models with and without an interaction term, with wealth and education included as continuous variables | Results correspond to fully adjusted analyses, adjusting for all covariates in the table and regional, enumeration area and household clustering | No education n=1,213 | Primary education n=3,470 | Secondary education n=8,688 | Higher education n=1,072 | missing results for age in "no education" category due to lack of observations

Wealth was found to modify the association between education and health insurance, with education being more strongly associated with insurance in lower wealth quintiles (**Figure 8.7** and **Table 8.11**)(*p* for interaction =0.002). Therefore, education is likely to play a particularly important role in health insurance coverage in less wealthy households. Due to convergence issues, I was unable to stratify by the lowest wealth quintile.

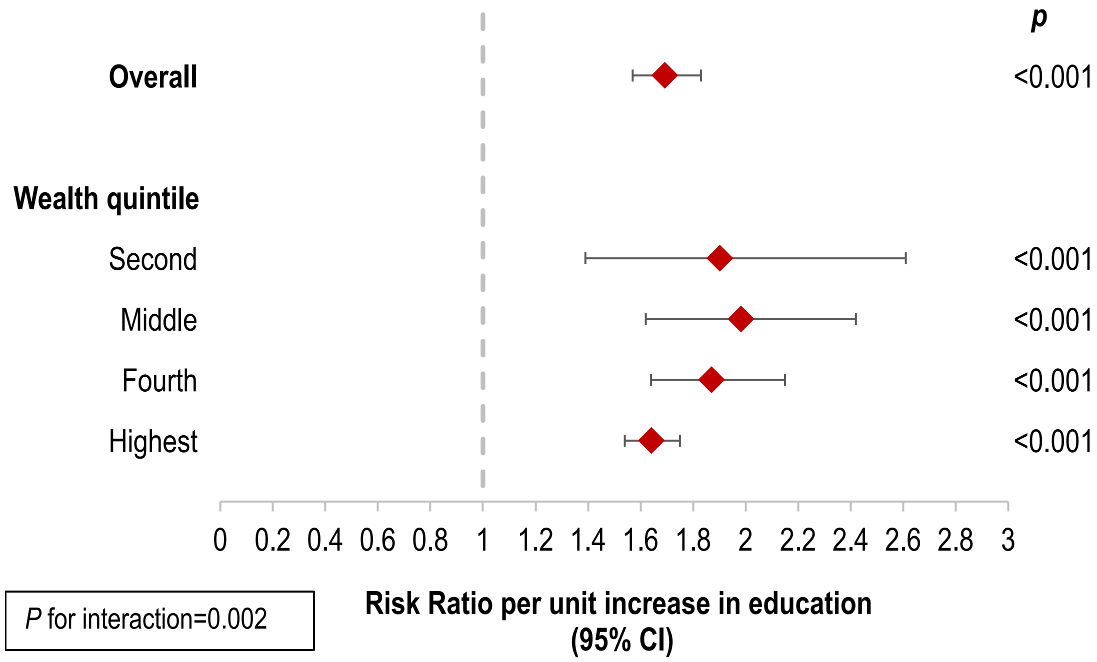


Figure 8.7: The association between health insurance and education, stratified by wealth quintile (n=14,443). Forest plot showing the greater impact of education on insurance in lower wealth quintiles | Risk ratios correspond to the risk of health insurance per unit increase in education overall and stratified by wealth quintile | *p* for interaction based on likelihood ratio test comparing models with an without an interaction term | 95% CI: 95% confidence interval.

Table 8.12: Association between sociodemographic factors and health insurance stratified by wealth quintile

Sociodemographic Characteristics	Second quintile		Middle quintile		Fourth quintile		Highest quintile		*p* for interaction
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*	
Sex									
Men	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		0.012
Women	0.65 (0.42 – 1.02)	0.061	0.72 (0.55 – 0.95)	0.020	0.77 (0.58 – 1.04)	0.083	0.89 (0.80 – 1.00)	0.053	
Age group									
15 – 19	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		
20 – 24	1.21 (0.53 – 2.78)	0.657	0.95 (0.53 – 1.69)	0.863	0.71 (0.54 – 0.95)	0.019	0.55 (0.43 – 0.70)	<0.001	
25 – 29	1.15 (0.48 – 2.78)	0.755	1.15 (0.67 – 1.97)	0.610	0.89 (0.62 – 1.28)	0.532	0.57 (0.48 – 0.67)	<0.001	
30 – 34	2.16 (0.81 – 5.77)	0.125	1.15 (0.71 – 1.84)	0.574	0.90 (0.67 – 1.21)	0.486	0.69 (0.59 – 0.80)	<0.001	
35 – 39	2.22 (0.72 – 6.82)	0.164	1.49 (0.85 – 2.62)	0.165	1.11 (0.84 – 1.47)	0.472	0.70 (0.58 – 0.83)	<0.001	
40 – 44	1.99 (0.63 – 6.29)	0.239	2.12 (1.20 – 3.76)	0.010	1.30 (1.03 – 1.66)	0.029	0.70 (0.60 – 0.82)	<0.001	
45 – 49	4.17 (1.29 – 13.45)	0.017	2.46 (1.52 – 4.00)	<0.001	1.57 (1.21 – 2.04)	0.001	0.74 (0.59 – 0.92)	0.008	
50 – 64	2.49 (0.70 – 8.82)	0.159	2.09 (1.15 – 3.79)	0.015	1.71 (1.25 – 2.34)	0.001	0.74 (0.61 – 0.90)	0.002	
Education level									
No education	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		0.002
Primary	2.48 (1.33 – 4.61)	0.004	1.47 (0.86 – 2.53)	0.162	1.06 (0.78 – 1.44)	0.699	0.88 (0.40 – 1.92)	0.740	
Secondary	4.10 (1.91 – 8.80)	<0.001	2.76 (1.72 – 4.43)	<0.001	1.67 (1.24 – 2.25)	0.001	2.09 (1.18 – 3.69)	0.011	
Higher	9.50 (2.86 – 31.51)	<0.001	7.27 (3.76 – 14.05)	<0.001	4.19 (3.18 – 5.52)	<0.001	3.24 (1.81 – 5.78)	<0.001	
Residence type									
Urban	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		
Rural	0.62 (0.40 – 0.97)	0.035	1.06 (0.75 – 1.50)	0.748	1.02 (0.86 – 1.21)	0.805	1.06 (0.95 – 1.18)	0.321	

Table 8.12: Association between sociodemographic factors and health insurance stratified by wealth quintile

Sociodemographic Characteristics	Second quintile		Middle quintile		Fourth quintile		Highest quintile		*p* for interaction
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*	
Marital status									
Never married	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		
Currently married	3.03 (2.02 – 4.55)	<0.001	1.97 (1.56 – 2.49)	<0.001	1.55 (1.27 – 1.90)	<0.001	1.80 (1.55 – 2.08)	<0.001	
Living with partner	1.15 (0.71 – 1.84)	0.571	0.91 (0.62 – 1.33)	0.624	0.96 (0.71 – 1.31)	0.804	1.19 (1.11 – 1.29)	<0.001	
Formerly/ ever married	0.94 (0.45 – 1.99)	0.880	0.99 (0.73 – 1.35)	0.954	1.04 (0.77 – 1.42)	0.783	1.29 (1.09 – 1.52)	0.003	
Occupation									
Professional	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)		
Agricultural	1.00 (0.47 – 2.10)	0.989	1.19 (0.81 – 1.77)	0.372	0.62 (0.42 – 0.91)	0.016	0.90 (0.78 – 1.03)	0.126	
Manual	0.94 (0.50 – 1.76)	0.842	0.86 (0.68 – 1.10)	0.227	0.77 (0.56 – 1.06)	0.108	0.87 (0.77 – 0.98)	0.026	
Unemployed	0.19 (0.11 – 0.34)	<0.001	0.32 (0.23 – 0.44)	<0.001	0.30 (0.23 – 0..38)	<0.001	0.60 (0.49 – 0.73)	<0.001	

RR: risk ratio derived from Poisson regression analyses | 95% CI: 95% confidence intervals | *p* for interaction based on likelihood ratio test comparing models with and without an interaction term, with wealth and education included as continuous variables

Results correspond to fully adjusted analyses, adjusting for all covariates in the table and regional, enumeration area and household clustering

N.B. Lowest Wealth Quintile not shown due to non-convergence

Second quintile n=2,678 | Middle quintile n=3,048 | Fourth quintile n=3,381 | Highest quintile n=3,035

8.4 Discussion

The findings presented in this chapter suggest that health insurance plays a role in financial healthcare access and health service utilisation in Namibia; however, just 17.5% of this DHS population were insured, leaving a large proportion of the population potentially disadvantaged when accessing healthcare. Additionally, sex, education and wealth were independently associated with health insurance. Education also modified the association between health insurance and sex and wealth, whereby education was more strongly associated with health insurance in the less wealthy and women. Furthermore, the likelihood of women being insured increased with education level. These findings may be valuable for informing interventions to improve financial access to healthcare in Namibia.

8.4.1 Sociodemographic determinants of health insurance

The findings that wealth and education are associated with having health insurance are consistent with those from other settings [320-326]. Wealthier households often have more disposable income to afford insurance. In Namibia, a country with a high income inequality, poorer households can only allocate minor shares of expenditure to healthcare [300]. Furthermore, the structure of many health insurance schemes globally favours wealthier populations; for example, high annual premiums instead of instalment payment options and reimbursement mechanisms, which mean healthcare must first be paid for OOP [106].

The association between sex and health insurance is complex; by contrast to these findings, studies in Ghana and South Africa identified men to be less likely to have health insurance than women [320, 322]. It has also been suggested that women, as care-givers, are more conscious of the importance of healthcare and insurance and may be more likely to seek healthcare [322, 328]. Similarly, in this analysis, women were more likely to have sought healthcare than men but this health seeking attitude was not reflected in the patterns of health insurance coverage. However, the association between sex and health insurance may be explained by education.

Education, as well as being an independent determinant of health insurance in this Namibian population, also modified the association between sex and wealth, respectively, and health insurance. Greater educational attainment increased the likelihood of women being insured. Additionally, when women were educated to higher level there was no difference in insurance compared to men, irrespective of wealth and other sociodemographic factors. This indicates that progression through the education system is especially important for women being insured and is consistent with previous findings that secondary or higher educational attainment is linked to increased coverage of health insurance in other sub-Saharan African populations [323, 324]. It was also observed that education level was more strongly associated with health insurance in relatively poorer populations. This underscores the value and impact of education on health insurance. Education may influence health insurance coverage in a number of ways. Education could improve knowledge and attitudes towards health seeking and the value of health insurance. In Namibia, education has been associated with willingness to join and pay for low-cost health insurance [329] and has been linked to increased awareness about insurance schemes in other LMICs [330, 331]. Therefore, education may empower women and relatively poorer individuals to make choices, including decisions around health [332].

8.4.2 The role of health insurance in healthcare access

Importantly, health insurance was also found to be associated with health service utilisation in this DHS population. Previous studies in Namibia and other LMICs have also found health insurance to be associated with seeking healthcare [304-307, 316, 318]. This emphasises the importance of health insurance for healthcare access. Additionally, in this analysis, health insurance was protective against reporting financial barriers to healthcare, suggesting that health insurance is likely to be important for reducing the financial burden of healthcare-associated costs, irrespective of other sociodemographic factors including wealth. Together, these findings highlight the importance of scaling-up access to health insurance in Namibia in order to reduce financial barriers to healthcare access in the country.

8.4.3 Limitations

Due to the cross-sectional nature of the data, it was not possible to assess the temporality of association between sociodemographic factors and health insurance nor between health insurance and recent outpatient care. Wealth was also measured at the household level, restricting our understanding of the effects of individual wealth on health insurance. Other factors beyond the scope of this analysis may also influence health insurance coverage, such as the likelihood that the consumer will become ill or current medical conditions [106, 333]. It was also not possible to explore the willingness to pay for health insurance.

Due to DHS sampling strategies, a greater number of women were included in this analysis than men. Additionally, these analyses only included individuals aged 15–64 years of age. This may limit the generalisability of these findings to the wider population. However, there was no notable variation in prevalence estimates in weighted analyses (**Appendix 5**).

8.4.4 Implications

Education and public engagement have been identified as key strategies for the uptake and acceptability of health insurance in other settings [334, 335]. Improving access to, and the quality of, education is an important component of multiple government strategies in Namibia [5, 336, 337] and the current findings further support the country's commitments to improving education. Although access to education in Namibia is high overall, including for women, attendance and the quality of education is variable and often inadequate in lower-income communities, marginalised populations and in remote or rural areas [5]. Whilst a high percentage of the Namibian population complete primary education, transition to and completion of secondary and higher education could be improved [5]. The findings presented suggest that improvements in educational attainment may help individuals to better manage their health but further research is needed to better understand this relationship.

These findings have implications for the design and implementation of strategies to scale-up health insurance coverage or improve financial protection for more vulnerable populations. Health insurance could be scaled-up through community engagement, utilising the media and other advocacy tools [338, 339]. Furthermore, mechanisms to make health insurance more affordable through subsidisation, for example, may help to increase uptake [303, 329]. Employer-provided schemes, which accounted for more than half of insurance in this population, could be expanded to the informal sector. For example, one study in Namibia found that employers on commercial farms were receptive to providing a co-pay insurance plan for their employees [340]. Existing health insurance schemes could also be adapted to be more accessible to poorer populations [106]. An alternative solution in countries like Namibia, where around a fifth of healthcare is financed via private health insurance, is that Governments could target public financing to populations less able or likely to participate in voluntary insurance schemes [341].

Whilst pre-financing mechanisms like health insurance have been effective in a number of settings [304-313], their success is not ubiquitous. Individuals may still incur OOP expenditures for drugs and tests not covered by insurance schemes [311, 312]. Some voluntary health insurance schemes may also be selective with regards to the individuals they enrol, possibly excluding those considered to have higher health risks [342]. Furthermore, even where poorer individuals are enrolled in health insurance schemes, they are often less likely to use health services compared to wealthier individuals [343]. Additionally, having numerous health insurance options means that the risk pool may become fragmented, which could result in variations in the quality and quantity of access to healthcare [307, 308]. Further research is needed to evaluate the effectiveness of insurance schemes and the quality and appropriateness of care received as a result of being insured in Namibia and elsewhere.

8.4.5 Conclusions

In conclusion, health insurance is an important component of healthcare utilisation in Namibia, but inequalities in the coverage of these schemes means that many individuals could be at a disadvantage when accessing healthcare. Specifically, women and those with lower levels of education and wealth were less likely to be covered by health insurance. These findings suggest that, in Namibia, education may be important for bridging gaps in health insurance coverage for women and the less wealthy but further research is needed to fully understand this relationship. These findings could inform the design and implementation of interventions to scale-up health insurance or provide greater financial protection from healthcare-associated costs for uninsured populations. Additional research is also needed to evaluate the effectiveness of insurance schemes and the quality of care received as a result of being insured in Namibia and elsewhere if UHC is to be realised.

9. Discussion

9.1 Overview

Namibia, an upper-middle income country with substantial income inequity, aims to improve population health and human development as part of the country's National development agenda [5]. To achieve these goals, public health strategies will need to be supported and informed by research which addresses the current knowledge gaps surrounding the double burden of disease, risk factors, and the population-level factors that influence healthcare access, which is integral to improving population health.

This thesis aimed to better understand the burden of disease, access to healthcare and the coverage of public health interventions in a Namibian population. Specifically, I investigated the prevalence, determinants and co-morbidity of chronic diseases, the coverage of malaria control interventions, the perceptions of healthcare barriers, objective measures of geographical inaccessibility and the coverage of health insurance in Namibian populations The findings presented in this thesis may help to inform healthcare policy and planning in Namibia, particularly related to the urban-rural and socioeconomic variations in population health and healthcare access observed in this DHS population, and provide a platform for further research.

9.2 Summary and implications of findings

9.2.1 Socioeconomic inequalities

Although it is widely understood that socioeconomic inequalities are particularly prominent among Namibia's population, in Chapter 3 I explored the distribution of wealth, education and unemployment, specifically in the DHS population. The findings suggested that Namibia's socioeconomic inequalities were reflected in this DHS population, with urban-rural and inter-regional variations in wealth, education and employment. Throughout the analyses presented in this thesis, a socioeconomic gradient of access to healthcare, health insurance coverage and disease burden was observed, suggesting that socioeconomic variations are likely to undermine improvements in population health and human development in Namibia.

9.2.2 Prevalence and distribution of HIV, cardiometabolic risk factors and co-morbidities

In Chapter 4, I explored the prevalence and distribution of HIV and cardiometabolic disease risk factors in the Namibia DHS population. HIV prevalence was 13.9% amongst those aged 15–64 years and was higher among women, the less wealthy and the less educated. In those aged 35–64 years, 36.9% had hypertension, 5.4% had hyperglycaemia, 22.3% were overweight and 20.2% were obese. Men, the less wealthy and less educated had a higher risk of hypertension in this population and obesity was associated with hypertension and hyperglycaemia. I additionally assessed the co-morbidity of these chronic diseases in Namibia. Co-morbidity and multi-morbidity of HIV, hypertension and hyperglycaemia was low suggesting that these conditions do not converge in the same populations in Namibia. Whilst, urban and less educated populations were less likely to have HIV and hypertension, risk profiles differed by sex and there was limited geographical overlap in populations with these conditions. However, more research is needed to better understand the convergence of NCDs and infectious diseases in Namibian populations. With the high and increasing prevalence of NCD risk factors reported in Namibia, it will be important to monitor the burdens of these conditions to identify high-risk populations in the country and explore the association between cardiometabolic risk factors and onset of other outcomes such as stroke or myocardial infarction. This additional research could inform regional and national health service provision and resource allocation to manage the double burden of disease in Namibia.

9.2.3 Coverage of malaria control interventions

Given the recent rise in malaria cases in Namibia, in Chapter 5 I aimed to investigate the coverage of malaria control interventions in Namibia, in the context of transmission intensity and government vector control targets. The government aimed, by 2013, for 95% of households in high transmission areas to be covered vector control interventions. In this DHS population, less than half of households in these areas had an ITN or IRS. Vector control coverage was associated with high transmission areas, suggesting interventions were targeted to high-risk households. However, coverage was well below the 95% target. These findings highlight the importance of monitoring and evaluation of vector control programmes to ensure a high coverage of interventions, particularly in high-risk regions, to prevent onward transmission of malaria in Namibian populations and eventually achieve elimination.

9.2.4 Perceptions of barriers to healthcare in women

As access to healthcare is important for progress in population health, in Chapter 6, I explored the prevalence of reporting healthcare barriers amongst women. I found that almost half of women experienced at least one barrier to healthcare with 32.9% reporting distance to health facilities a barrier and 29.7% reporting getting money for treatment to be as a problem. Women living in rural areas, and those who were less wealthy and less educated were more likely to report distance as a barrier. These findings suggest a socioeconomic gradient of healthcare access, with poorer and less educated individuals facing the greatest challenges. Consistent with the wider literature [73, 75, 94, 99-101], rural dwellers experienced greater challenges in physically accessing health facilities. This points to the need to reduce inequalities in education and wealth in Namibia in order to improve healthcare access, and further highlights the urban-rural differences in healthcare access in the country.

9.2.5 Geographical accessibility of health facilities

To expand upon findings that distance was perceived to be a healthcare barrier amongst women, in Chapter 7, I used objective measures of distance and travel time to explore the accessibility of health facilities in the DHS population. It was estimated that 10% of the population would have to travel more than 20 Km and almost 20% of the population would have to travel for over an hour to a health facility. However, there was substantial variation in both accessibility metrics amongst rural populations. An estimated 40% of the rural population would have to travel for over an hour to a facility compared with 73% of the urban population having to travel less than 15 minutes to a facility. Men, older, less educated, less wealthy and rural populations lived further away from health facilities. There is a need to improve access to health services for rural populations, whether this be through increasing the availability of services closer to rural areas or improving transport options to reach existing facilities.

9.2.6 Coverage of health insurance in Namibia

In Chapter 8, I assessed the coverage of health insurance, which is thought to make healthcare more affordable, thus increasing health service utilisation. However, just 17.5% of the DHS population were found to be insured, leaving a large proportion of the population potentially vulnerable to financial shocks as a result of healthcare-associated costs. Women were less likely to be insured than men and health insurance was associated with education and wealth. Education modified the association between sex and health insurance, with the likelihood of women being insured increasing with education level. Education was also more strongly associated with health insurance in women and the less wealthy, suggesting that education pays an important part in health insurance coverage when financial resources may be less readily available. These findings further support the need to improve equality in wealth and education in Namibia to increase access to health insurance or other risk-pooling mechanisms which, in turn, may help to support health seeking behaviour.

9.3 Strengths and limitations

The strengths and limitations of each analysis have been discussed in the respective chapters. In this section, I expand on these aspects of the thesis.

9.3.1 Strengths

One of the key strengths of this thesis is the large sample size in which analyses were conducted in Chapters 3–8. This enabled reasonable statistical power to estimate prevalence and risk ratios. Furthermore, the DHS population was broadly representative of the general population, with similar population distributions by region, residence type and sex as those observed in the 2011 Population and Housing Census [123]. As such, the findings of this thesis can be broadly generalised to Namibia's population as a whole.

Another strength of this thesis is that DHS surveys are standardised enabling comparison with other countries. Additionally, all analyses were conducted using publicly-available data, which are also available for a number of countries globally. Therefore, these analyses could be replicated in other countries in SSA or elsewhere, further enabling comparisons between countries.

In Chapters 4–8, multivariable mixed effects analyses that adjusted for sociodemographic covariates and accounted for clustering at the regional, EA and household level, where possible, were conducted. The exceptions to this were in Chapter 5, which adjusted for EA and regional clustering only and in Chapter 7, which adjusted for regional clustering only. Confidence intervals were generated based on cluster-robust standard errors in mixed effects models [344]. Where appropriate, sensitivity analyses were undertaken to assess the robustness of the associations observed; for example, in Chapter 5, sensitivity analyses were used to compare three models of malaria transmission intensity and their association with the outcome of interest.

This thesis makes a contribution to the limited existing literature on the burden of NCDs and co-morbidity with infectious diseases, healthcare access and intervention coverage in Namibia. The findings presented highlight the importance of reducing sociodemographic and socioeconomic inequalities in the population, which were reflected in the distribution of disease, barriers to healthcare and the coverage of health insurance in the country, and present opportunities for further research.

9.3.2 Limitations

The findings presented in this thesis must be considered in the context of data limitations. It is important to note that the data used for these analyses were collected in 2013 and thus may not fully reflect the situation in Namibia at present. As the DHS is a cross-sectional survey, it was not possible to estimate the incidence of disease nor assess the temporality of associations observed [345, 346]. Another limitation of the DHS data is that given the importance of wealth in a number of analyses, it would have been valuable to understand the effect of individual wealth on various outcomes. As this was a household-level measurement this limited the inferences that could be made at the individual-level about the effect of wealth.

The DHS sampling strategy meant that some data were collected only in women or within certain age ranges of men and women, for example blood pressure testing was only carried out in those aged 35–64 years. Additionally, by design, the Woman's Questionnaire interviewed a larger sample size than that of the Man's Questionnaire (10,018 women were surveyed compared with 4,481 men). Whilst these data are useful for understanding the prevalence and determinants of outcomes in these specific population groups, this does limit the generalisability of results to the wider population.

In addition, the DHS Program highlights the non-proportional sampling of regional populations as well as the potential for variations in the proportion of responses [120], which may limit generalisability. To account for this, additional analyses including survey sampling weights were conducted (**Appendix 2**). No material difference between weighted and unweighted prevalence estimates was observed. Additionally, the urban-rural and regional distribution of the DHS population were compared with 2011 Population and Housing Census results in Chapter 3 and were found to be broadly reflective of the census population distribution.

Although the large DHS sample size provides reasonable power to detect strong and modest associations, these data may not be powered to detect weaker associations. In a number of chapters, effect modification was assessed and these stratified analyses may not have sufficient statistical resolution to detect effect modification or interaction. Furthermore, restrictions of the data to specific subsets of the population with complete data may have reduced the statistical resolution to detect associations.

There is also the possibility for selection bias due to the restriction of analyses to subsets of the DHS population with complete data for all variables of interest in each chapter, if those included compared with those excluded differed systematically based on the outcome or other key exposures. As completion of Questionnaires was high in the DHS, most individuals had complete data and only a small number were excluded based on missing data. However, bias may have been introduced in the exclusion of individuals based on inaccurate travel time estimates in Chapter 7, for example, as these individuals were all from a similar geographical area in the Erongo region. Throughout this thesis, the populations included in the final analyses were compared with those excluded in relation to key outcomes and sociodemographic factors, where relevant. No substantial differences were observed between populations, suggesting that selection bias due to restrictions of data is likely to be minimal.

Information bias, due to systematic differences in reporting of an outcome or exposure, may also influence the associations observed. For example, if individuals answered questions related to sexual behaviours differently depending on whether they were HIV-positive or not, or whether individuals were more likely to report barriers to healthcare if they had recently sought care. Information bias may also result from the misclassification of individuals relative to outcome or exposure variables; for example, if equipment used to obtain anthropometric measurements or conduct diagnostic tests was imprecise. Given the standardisation of DHS protocols and data collection procedures as well as the provision of rigorous training and use of quality control measures [120, 125], the possibility of information bias is reduced.

Respondent error could be introduced due to a single member of the household answering questions specific to other household members as part of the Household Questionnaire, including questions relating to age, sex, education level and marital status. If misclassification due to respondent error was differential, this could result in an under- or over-estimation of prevalence or associations for sub-groups of the population [345]. Where possible, this information provided in the Household Questionnaire was replaced with data from the individual questionnaire for respondents who took part in the Man and Woman’s surveys.

A further consideration of these analyses is that the associations observed could be influenced by confounding if factors associated with the exposures and outcomes investigated, but not on the causal pathway, were not accounted for. In Chapters 4–8, potential confounders were adjusted for, including established risk factors identified in the wider literature, and stratified analyses were also conducted to control for confounding. Potential confounders explored included age, sex, education, wealth and behavioural factors. However, there may be confounding by unmeasured factors, which therefore could not be explored; for example, the lack of physical activity data, which could be associated with hypertension, hyperglycaemia or other risk factors explored. There may also be residual confounding by factors that were adjusted for but did not accurately capture the confounding measure in question. Differential or non-differential misclassification due to random error could occur. Any non-differential misclassification tends to underestimate the association between the exposure and outcome. However, the rigorous training and quality control checks implemented by the DHS Program would act to minimise the introduction of random error into the data. Additionally, the large sample size used for these analyses should reduce the effect of any random error on the results presented.

It is also possible that the associations observed throughout this thesis could be explained by chance. *P* values less than 0.05 were considered statistically significant but *p* values close to 0.05 were interpreted with caution and emphasis was placed only those notably less than 0.05. Additionally, for most associations observed the *p* value was <0.01 or <0.001 and only *p* values much smaller than 0.05 were considered as evidence for a strong association. In a number of analyses, multiple hypotheses were tested to explore the association between several exposures and the outcome of interest. The higher the number of hypotheses tested, the greater the probability that a significant association may be observed due to chance [345]. No correction was made to account for multiple hypothesis testing in this thesis. However, associations were interpreted with caution and considered statistical significance. Furthermore, the large sample size in which associations were explored should act to reduce the effect of chance.

Throughout this thesis, variables were recoded to group individuals into fewer distinct groups to reduce the number of parameters for the analyses carried out. However, by grouping individuals into broader categories, for example, in the creation of the occupation variable, some of the granularity around this variable is lost. Furthermore, individuals may have been grouped together into broader categories but the prevalence or risk of the outcomes explored may differ by the subgroups of the category. In the occupation variable, “professional” category included individuals in sales occupations. However, individuals who work in sales could work in the market without any professional training. Additionally, individuals were distinguished based on agricultural and manual occupations (skilled and unskilled). However, agricultural work is also likely to be manual labour, so these groups are potentially closely related. The broad categorisation of occupation in the DHS as well as further re-categorisation of individuals for these analyses may therefore affect prevalence and effect estimates observed as a function of occupation. The DHS could improve the collection of data on occupation by more specifically defining occupation groups throughout the survey to ensure individuals are appropriately categorised. It is not clear how participants are grouped from the answers provided by participants in the survey. More details around this classification criteria would better inform further grouping of individuals by occupation and enable better interpretation of occupation in analyses.

With consideration to the limitations outlined, these DHS data and the analyses presented in this thesis are valuable for contributing to the limited existing knowledge of disease burden and risk, intervention coverage and healthcare access in Namibia. These findings present opportunities for future research to understand the associations observed here in more detail and have the potential to inform regional and national health policy and planning in Namibia.

9.4 Further research and future directions

To date, research into population health in Namibia has been somewhat limited and has focused on specific disease outcomes or sub-populations, such as elderly or disabled populations, and national estimates have largely been presented in descriptive reports. This thesis provides an understanding of sociodemographic factors associated with disease outcomes and healthcare access at the population level, and informs directions for further research to better understand the barriers to healthcare access in the Namibian population. These findings may help to inform healthcare planning and policy, through the identification of sociodemographic groups, to which public health interventions could be targeted. Key areas for further research in Namibia are presented here.

9.4.1 Co-morbidity of infectious and non-infectious diseases

Despite being amongst the ten leading causes of death in Namibia [34], there has been limited research into cardiometabolic disease traits in the country to date. Furthermore, given the ongoing high burden of infectious diseases in Namibia, there is a need for substantive research into the double burden of infectious and NCDs in the country.

Large-scale observational studies to investigate the double burden of disease in Namibia

In Chapter 4, the co- and multi-morbidity of HIV, hyperglycaemia and hypertension was observed to be low, suggesting that in 2013 despite the notable burden of these conditions individually, these diseases did not converge in the same populations. However, given the cross-sectional nature of the data, the limited sample size and restricted age ranges in which measures for hyperglycaemia and hypertension were collected, there remains a need for more large-scale, representative data to understand the double burden of disease in Namibian populations. Longitudinal data would enable an assessment of disease incidence and would also facilitate investigation of associations between cardiometabolic risk factors and disease outcomes such as stroke and myocardial infarction. More large-scale data could also help to better understand the extent of infectious and NCD co-morbidity and associated risk factors in Namibia. Such research would be useful for informing health policy and planning. Furthermore, national-level data on additional NCD and infectious disease outcomes would help to understand the co-morbidity and multi-morbidity of a greater variety of conditions. In addition, understanding the fine-scale geographical distribution of disease conditions could help to inform resource allocation to health facilities.

Strategies to monitor, prevent and manage the double burden of disease

In addition to further research, as the burden of NCDs is likely to continue to rise in Namibia and the burden of infectious diseases remain high, it will be important to monitor disease incidence, understand the sociodemographic determinants of these conditions, evaluate health service provision and engage with the population to bring about behaviour change to prevent onset or transmission of these diseases. There are many strategies that could help to achieve these objectives. However, one such strategy could be to integrate electronic health records (EHRs) into Namibia's health system. EHRs can be used to inform regional and national healthcare planning, health resource allocation, support clinical decision making and facilitate disease surveillance [347-349]. EHRs can assist in the management of multiple chronic diseases and can help to assess the quality of care provided to patients [348]. They can also support clinical and epidemiological research, including longitudinal studies of population health and disease risk, as well as research to evaluate health services [350]. Data could also be collected using EHRs in areas that are usually under-represented in national surveys, if they are implemented on a national scale [348]. However, to implement such systems in LMICs, there may be need for improved technical infrastructure and connectivity [351].

9.4.2 Coverage and uptake of interventions

There has been a growing research focus on malaria in Namibia, as an elimination country that has experienced a rise in cases. Analyses conducted in Chapter 5 highlighted the need for monitoring and evaluation of vector control implementation programmes.

In addition to monitoring and evaluation of existing control programmes, further research could aim to understand the uptake of malaria control interventions at the population level. Even if the coverage of ITNs is high and sufficient for one net per two people, the effectiveness of these interventions depends upon their use during the transmission season. It is possible that ITNs were not used due to perceptions that malaria is not a threat as the incidence of malaria had decreased prior to recent outbreaks, because the ITN itself was old or ineffective, or that they are uncomfortable to sleep under [352-354]. ITNs may also be hung incorrectly or used for another purpose entirely [352, 355]. Longitudinal research could explore the association between non-ownership or non-use of ITNs and malaria infection, which could help to understand the impact of malaria interventions on malaria incidence in the country to inform elimination efforts.

9.4.3 Geographical accessibility of healthcare

The geographical accessibility of health facilities was assessed through self-report, travel time and distance estimates in this thesis. These methods, individually and collectively, identified that health facilities are likely to be inaccessible for some Namibian populations, particularly those in rural areas and those who are less educated and less wealthy. There are many future directions for research into the accessibility of care as well as innovative approaches to increase healthcare access for remote populations that could be implemented in Namibia.

Understanding the impact of inaccessibility on health outcomes

Further research could aim to assess the impact of living in inaccessible areas on health outcomes, which was not possible within the remit of the DHS data. Previous studies in Namibia to date have investigated treatment seeking behaviour for fever and HIV, and healthcare access for disabled or elderly populations [88, 92, 114, 118]. However, these studies also used cross-sectional data, thus provide a limited understanding of how health facility inaccessibility influences health service utilisation and, ultimately, population health outcomes. Thus, longitudinal data are required to better understand this potential pathway. For example, a prospective cohort study could enable a comparison between urban and rural individuals over time in their ability to access healthcare and obtain treatment.

Research to more accurately evaluate accessibility of healthcare

In order to better inform policy and planning for healthcare access, further research is needed to fully understand differential accessibility of healthcare within populations. First, the current research measured a single scenario of travel time to health facilities but makes a number of assumptions about modes of transport. Additional models that are about to account for different modes of transport or use of multiple transport options would help to understand accessibility in more detail. Furthermore, research which evaluates the efficacy, availability and affordability of transport options for underserved populations would be valuable to understand the role of transport in health facility accessibility. Furthermore, it has been shown that individuals do not always choose to use their closest health facility [291, 356]. Choice may be influenced by the quality of care or the specific services available at a given facility [356, 357]. Therefore, research which aims to understand the choice of health facility and how that choice impacts on the accessibility of healthcare for individuals would provide a greater understanding of healthcare access in Namibia. These data could be obtained through cross-sectional qualitative or quantitative interviews and could be applied to objective models of geographical accessibility as conducted in this thesis.

Interventions and strategies to expand the reach of health services

In addition to further research, the findings of this thesis provide a rationale to address geographical inaccessibility in rural populations. One way to address this urban-rural inequity could be to build additional health facilities closer to rural populations [60]. However, not only would this require substantial financial investment but it would increase the demand for human resources, which is unlikely to be feasible given the existing shortage of qualified medical personnel [2, 358]. It is also often harder to staff facilities in remote and poorer areas as they are less appealing to medical practitioners [60].

As such, it may be necessary to rely on outreach services, which can help to expand the reach of health services to remote populations and are currently used in Namibia [3]. However, the remit of care that can be provided by outreach services and community-based interventions is often limited, thereby not fully addressing challenges in healthcare access [60].

Another solution could be to provide more transport options, which are affordable to lower-income populations, who were found to experience the greatest accessibility challenges. Vouchers for health services, which enable patients to use specific services at selected facilities at no cost, could also be used to pay for transport to health facilities [60, 359, 360]. Additionally, community loan funds, which enable money to be borrowed at low or no interest to pay for healthcare, could also be used to cover the costs of emergency transport to health facilities [60].

In the absence of additional permanent health facilities in close proximity to remote and rural communities, mobile health (mHealth) and telemedicine technologies could be used to provide healthcare to more remote populations [361]. These technologies can enable communication between health professionals, or between the patient and the provider, to encourage treatment adherence, monitor a patient's condition and deliver remote consultations [292, 361-365]. The benefits of such technologies are that they are accessible, are generally well accepted by the user, easy to use and are affordable; but to be successful they require strong political commitment, good management and clear division of responsibilities [363, 366-368]. Whilst telemedicine initiatives have been implemented in other sub-Saharan African countries, setting a precedent for their utility in other countries in the region [369], more evidence is needed to establish whether such technologies are cost-effective in LMICs [370]. Furthermore, sustainable financing solutions and stronger technical infrastructure will be needed if these technologies are to be implemented on a large scale in Namibia. Other innovative mechanisms of improving the delivery of health services to rural populations could include the use of drone technologies [371, 372] and motorbike ambulances [373, 374].

The design of interventions to reach remote populations would benefit from a greater body of context-specific research to inform their design and strategies for implementation. Pilot studies to monitor and evaluate receptivity to a given intervention, the effectiveness of the intervention in delivering care and bridging healthcare gaps, and the cost-effectiveness and sustainability of the intervention will help to inform whether such approaches should be scaled-up in Namibia.

Furthermore, there are multiple components which influence the accessibility of health services, including health facility location, transport infrastructure and cost. Currently, these factors are managed by different government Ministries. This thesis highlights the need for a multi-sector approach to tackle the numerous facets of healthcare accessibility in Namibia. This could involve members from Ministries of Health, Transport and Education, as well as academia and the private sector.

9.4.4 Affordability of healthcare

The cost of care was one of the most commonly reported barriers to healthcare among women in this DHS population. Health insurance was protective against this barrier and was also associated with health service utilisation. However, the coverage of health insurance was unequal in this population. Further research is needed to more comprehensively understand the financial barriers to healthcare in more detail in Namibia.

Research to understand financial barriers to care

The recent "Tracking Universal Health Coverage Global Monitoring Report 2017" highlighted the lack of quality data to understand financial protection against healthcare-associated costs in Namibia [4]. More data are needed to understand the prevalence and impact of catastrophic payments in Namibia. Whilst OOP expenditure in Namibia is low, high income inequality means that there are a number of households for which user fees or other OOP expenses would be unaffordable and could be catastrophic. The extent to which this impacts on health service utilisation and health outcomes also needs to be carefully evaluated. A greater body of research on these factors would provide a basis to design appropriate risk-protection strategies. Longitudinal data would be valuable to explore the effect of differences in household wealth on health service utilisation and health outcomes, to better inform health policies for affordable healthcare in Namibia.

With the knowledge that some poorer households are likely to be unable to afford healthcare, some examples of financial interventions to improve the affordability of care could include voucher schemes, funded by governments or donors, that can be used at selected health facilities [375], which have been shown to reduce OOP payments, channel additional funds into the health system, are thought to be cost-effective based on disability-adjusted-life years and deaths averted, and increase health service utilisation [359, 360, 376, 377]. Another approach is the use of conditional cash transfers, which provide a monetary incentive for certain health behaviours, for example, collecting HIV test results, and bringing children to health examinations and vaccination appointments [378]. This approach has been shown to increase health service utilisation in a number of LMICs as well as improving certain health outcomes [378].

Increasing health insurance coverage is another strategy that could help to improve the affordability and use of healthcare. Health insurance coverage could be expanded through the extension of health insurance to poorer populations through flexible payment plans, cross-subsidies between wealthier and poorer populations [106] or government subsidisation for the poor and those less able to enrol in insurance schemes [59, 341]. However, these mechanisms to improve the affordability of healthcare need to be carefully evaluated in Namibia. For example, having numerous health insurance options can fragment the risk pool, resulting in variations in the quality and quantity of access to healthcare [307, 308]. Furthermore, many of these strategies ultimately rely upon sustained funding from government or donor bodies. Populations that come to benefit from these schemes may become reliant on this financial support for healthcare-associated costs. These funding sources are volatile and are likely to fluctuate with variations in the national or global economy, international donor interests or government priorities. As such, it is important to address the underlying causes of inability or unwillingness to pay for care. Undoubtedly, socioeconomic inequalities are at the root of this problem and strategies to promote economic growth and stability, reduce poverty and increase educational attainment and earning potential will be central to improving population health and human development.

9.4.5 Socioeconomic inequalities

Throughout this thesis, socioeconomic factors, principally education and wealth, were associated with healthcare barriers. Less wealthy and less educated individuals were more likely to suffer healthcare barriers, including inaccessibility of health facilities, and were less likely to have health insurance. Educational attainment can lead to better employment prospects and earning potential, which in turn can result in greater household wealth and ability to afford healthcare. Being able to financially access healthcare can lead to better health outcomes, which in turn, enables children and adolescents to obtain education and can enable working populations to remain in employment, contributing to overall household wealth. Greater educational attainment can facilitate the acquisition of health-related knowledge later in life [273] and also enables individuals to obtain basic needs and living standards that support health-seeking behaviour [272].

Other DHS surveys have shown that antenatal care, attended deliveries, treatment of diarrhoea, fever and acute respiratory infection, and immunisation coverage was lower in poorer households [379]. Even where improvements in the coverage of essential services are achieved, it is the wealthier households who appear to benefit from this progress [59]. This is called the 'inverse equity hypothesis' [60]. Therefore, addressing the underlying factors that perpetuate inequality is important to also improve equity in population health.

In Namibia, strategies to reduce inequalities have been outlined by the Namibian Government [1, 5]. However, longitudinal studies could enable an investigation of the association between socioeconomic factors and health outcomes and health service utilisation, and an assessment of the impact of poverty reduction and increased educational attainment in the population over time on these factors. Findings from such studies could help to incentivise and facilitate change.

9.4.6 Health service provision

This thesis has identified a number of population-level factors that may impact on healthcare access. However, the development of strategies to reduce these healthcare barriers needs to occur in parallel to ensure that health services are available and provide a good quality of care. Further research is needed to understand the availability and quality of essential services. The "Tracking Universal Health Coverage Global Monitoring Report 2017" explored the coverage of essential services at the national level, but granularity around the equity in access to these interventions at the regional and population level would help to inform resource allocation and distribution in the health sector to scale-up the coverage of these services [4]. This would require more fine-scale, national, comprehensive data on the availability of public health resources relative to demand.

Furthermore, research into the quality of healthcare in Namibia is lacking. Peters *et al.* place quality at the centre of healthcare access as it relates to other facets of access [61]. Quality of healthcare not only affects provision but also the choice of facility, the decision to seek care and the willingness to pay for care [61]. As such, future research could aim to assess the quality of healthcare from the patient perspective and the relationship with health-seeking behaviour in Namibia. Additionally, it would be interesting to understand the perceptions of health workers on the quality of care delivered by the facility and the challenges faced in delivering adequate care.

9.4.7 Indigenous populations

It was not possible to understand access to healthcare for indigenous populations in detail within the scope of this thesis. However, using language as a proxy for ethnicity indicated that ethnic groups were differentially distributed by socioeconomic factors, for example with the majority of Afrikaans-speaking populations being predominantly wealthy. Ethnicity was also associated with healthcare barriers, with the Herero population having the highest prevalence of reporting distance as a barrier to healthcare. This population also had the greatest average travel time to health facilities, suggesting that there were differences in healthcare access between ethnic groups, which may be related to SES, social factors or geographical location. Indigenous groups in Namibia make up around 8% of the population are severely disadvantaged in terms of education, wealth, employment and life expectancy in Namibia [5, 29, 380]. There is also a lack of health data on indigenous populations, but it is thought that access to health services is likely to be poor [29]. Furthermore, the factors that were associated with poor access to healthcare, specifically low levels of education and wealth, also characterise Namibia's indigenous populations [5]. It is therefore likely that indigenous groups may experience greater barriers to healthcare than the general population.

Research to better understand health outcomes and healthcare access in Namibia's indigenous populations

There is an acute need to address the shortage of health data related to indigenous populations in Namibia. The health of indigenous populations often tends to be worse than that of the general population [30], therefore it is likely that Namibia's indigenous groups suffer worse health outcomes compared with the rest of the population. Additionally, further research to explore the specific barriers to healthcare experienced by indigenous populations in Namibia will be important to inform health polices and improve healthcare coverage of these populations. For example, language barriers can prevent the delivery of appropriate care to indigenous populations and can result in misdiagnosis and treatment, as has been shown in other contexts [381, 382]. Future research could investigate perceptions of healthcare barriers, the choice of health facilities based the provision of culturally appropriate and accessible services as well as actual use of these services when ill to inform strategies to ensure equal access to healthcare for indigenous populations.

9.5 Concluding remarks

The research presented in this thesis contributes to the limited existing literature on population health and healthcare access in Namibia. Collectively, these findings suggest that disease outcomes, intervention coverage, healthcare barriers and coverage of health insurance varies by region, residence type and sociodemographic factors. This research highlights the differential distribution of HIV and cardiometabolic risk factors amongst the population and suggested that co-morbidity of these disease traits was low. Access to interventions for malaria, although targeted to high-risk populations, was below government target levels. Furthermore, women identified experiencing distance to health facilities, needing money for treatment, needing permission and not wanting to go alone to health facilities as barriers to healthcare. Objective measures of accessibility supported the notion that for some, mostly rural households, health facilities were likely to be inaccessible. Finally, health insurance was protective against cost barriers and was associated with health service utilisation but coverage of insurance was low and disproportionately covered wealthier and more educated populations. Throughout this thesis, populations who were most disadvantaged were typically rural, less wealthy and less educated. As such, these socioeconomic inequities are likely to undermine population health in the country, which points to the need to address these underlying inequalities to improve population health and human development in Namibia. These findings provide a basis for further research to better understand health and healthcare access in Namibia and could inform the design and implementation of interventions to improve healthcare access for disadvantaged populations. Healthcare access, good quality care and disease prevention strategies are essential to improving population health and human development as part of wider goals to achieve national development in Namibia.

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Appendix 1

Appendix 1: Construction of the wealth index for the 2013 Namibia DHS

The DHS wealth index is a measure of a household's living standards and is calculated using data on household assets, housing materials and household facilities. This appendix contains the results of the principal components analysis (PCA) used to construct the wealth index, which was subsequently divided into quintiles used in analyses presented throughout this thesis.

Detail on how the wealth index is constructed is described in Chapter 2 and in detail elsewhere [130].

The **common wealth score** refers to indicator variables that are thought to be associated with wealth in both urban and rural areas. This does not include variables that may differentially indicate wealth or poverty in urban and rural areas.

The **urban wealth score** refers to indicator variables that are thought to be associated with wealth in urban areas.

The **rural wealth score** refers to indicator variables that are thought to be associated with wealth in rural areas.

The **composite wealth score** is generated by regressing urban and rural wealth scores on the common wealth scores to estimate the composite wealth score.

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Appendix 2

Appendix 2: comparison of weighted and unweighted prevalence estimates for key variables in Chapters 4–8.

Weights are calculated using the DHS household sample weight for analyses relevant to Chapters 5 and 7 and are calculated using the DHS Woman's and Man's survey sample weights for analyses relevant to Chapters 4, 6 and 8.

Chapter 4

1. Weighted and unweighted prevalence estimates for overweight, obese, hyperglycaemia, hypertension, current smoker and low fruit and vegetable intake.

Weighted and unweighted prevalence of cardiometabolic risk factors

	Unweighted No. (%)	**Weighted** No. (%)
BMI class		
Overweight	724 (22.3)	671 (22.0)
Obese	655 (20.2)	568 (18.6)
Hyperglycaemia	176 (5.4)	155 (5.1)
Hypertension	1,199 (36.9)	1,134 (37.1)
Current smoker	635 (20.1)	493 (16.6)
Low fruit and vegetable intake	2,953 (91.0)	2,785 (91.2)

BMI: body mass index | weighted estimates based on household survey weights

2. Weighted and unweighted prevalence of HIV by sociodemographic and behavioural risk factors. [Corresponds to Table 4.5, Chapter 4]

Weighted and unweighted prevalence of HIV by sociodemographic factors		
Sociodemographic Characteristics	**Unweighted HIV prevalence** No. (%)	**Weighted HIV prevalence** No. (%)
Sex		
Men	403 (10.6)	413 (11.1)
Women	765 (16.6)	676 (17.1)
Age group		
15 – 19	46 (2.8)	38 (2.3)
20 – 24	76 (5.5)	75 (5.1)
25 – 29	156 (13.3)	156 (13.2)
30 – 34	212 (21.7)	227 (23.4)
35 – 39	230 (25.8)	243 (28.0)
40 – 44	160 (22.7)	162 (25.3)
45 – 49	124 (22.2)	127 (25.2)
50+	161 (15.3)	62 (16.0)
Education level		
No education	136 (17.5)	110 (20.5)
Primary	394 (18.0)	347 (19.5)
Secondary	605 (12.3)	596 (12.6)
Higher	33 (6.2)	36 (5.9)
Wealth quintile		
Lowest	243 (18.1)	225 (18.3)
Second	289 (17.8)	297 (19.9)
Middle	288 (15.6)	275 (16.9)
Fourth	265 (13.1)	225 (12.6)
Highest	83 (5.3)	67 (4.4)
Occupation		
Professional	464 (16.8)	444 (16.9)
Agricultural	69 (14.7)	46 (16.5)
Manual	156 (14.5)	175 (16.4)
Unemployed	479 (11.7)	424 (11.5)
Residence type		
Urban	540 (13.2)	537 (13.2)
Rural	628 (14.5)	552 (15.3)
Marital status		
Never married	508 (10.7)	496 (10.4)
Currently married	215 (12.8)	194 (14.7)
Living with partner	277 (20.3)	267 (22.6)
Formerly/ever married	168 (27.6)	132 (34.1)
Lifetime sexual partners		
None	21 (2.0)	20 (1.8)
1	114 (7.5)	113 (7.8)
>1	971 (17.4)	895 (18.3)
Don't know	62 (24.0)	62 (23.4)
Age at first sex		
Never had sex	21 (2.0)	20 (1.8)
<15 years	65 (10.7)	55 (9.9)
15 – 19 years	756 (15.6)	708 (16.2)
20+ years	326 (17.2)	305 (18.3)
Total	1,168 (13.9)	1,088 (14.2)

Weighted estimates based on individual survey weights

Chapter 5

1. Weighted and unweighted distribution of households by background characteristics including measures of malaria transmission intensity and levels of vector control coverage [Corresponds to Table 5.1, Chapter 5]

Weighted and unweighted distribution of households by background characteristics

Background characteristics	Unweighted distribution of households No. (%)	Weighted distribution of households No. (%)
Residence type		
Urban	4,763 (48.4)	5,118 (52.0)
Rural	5,083 (51.6)	4,728 (48.0)
Wealth quintile		
Lowest	1,696 (17.2)	1,737 (17.6)
Second	1,945 (19.8)	1,910 (19.4)
Middle	2,012 (20.4)	1,954 (19.9)
Fourth	2,178 (22.1)	2,133 (21.7)
Highest	2,015 (20.5)	2,110 (21.4)
Regional *Pf*PR$_{2\text{-}10}$		
<1%	3,467 (35.2)	3,730 (37.9)
1-<5%	1,432 (14.5)	875 (8.9)
≥5%	4,947 (50.2)	5,241 (53.2)
EA *Pf*PR$_{2\text{-}10}$		
<1%	4,184 (42.5)	4,126 (41.9)
1-<5%	1,082 (11.0)	903 (9.2)
≥5%	4,580 (46.5)	4,816 (48.9)
MSP zone		
3	3,588 (36.4)	3,838 (39.0)
2	2,033 (20.7)	1,306 (13.3)
1	4,225 (42.9)	4,702 (47.8)
IRS coverage*		
No IRS	7,921 (80.5)	7,898 (80.2)
IRS	1,676 (17.0)	1,670 (17.0)
Don't know	245 (2.5)	275 (2.8)
ITN coverage		
No net	6,533 (66.4)	6,433 (65.3)
untreated net	940 (9.6)	1,011 (10.3)
ITN	2,373 (24.1)	2,401 (24.4)
Number of ITNs in household		
0	7,473 (75.9)	7,444 (75.6)
1	1,142 (11.6)	1,129 (11.5)
>1	1,231 (12.5)	1,272 (12.9)
ITN per two people		
<1 ITN per two people	8,724 (88.6)	8,707 (88.4)
≥1 ITN per two people	1,122 (11.4)	1,138 (11.6)
Total	9,846 (100.0)	9,846 (100.0)

*Pf*PR$_{2\text{-}10}$: *Plasmodium falciparum* Parasite Rate in ages 2 to 10 years | EA: enumeration area | MSP: Malaria Strategic Plan | IRS: Indoor Residual Spraying | ITN: Insecticide-treated net|*n=9,842 | weighted estimates based on household survey weights

Chapter 6

1. Weighted and unweighted prevalence estimates of reported barriers to healthcare. [Corresponds to Table 6.3, Chapter 6]

Weighted and unweighted prevalence of barriers to healthcare

Barrier to access to healthcare for self	Considered a big problem	
	Unweighted No. (%)	**Weighted** No. (%)
Getting money for treatment	2,960 (29.7)	2,518 (27.6)
Distance to health facility	3,286 (32.9)	2,786(30.5)
Getting permission	640 (6.4)	572 (6.3)
Not wanting to go alone	1,454 (14.6)	1,338 (14.7)

Weighted estimates based on individual survey weights

2. Weighted and unweighted prevalence of reporting distance as a healthcare barriers amongst women by sociodemographic characteristics. [Corresponds to Table 6.6, Chapter 6]

Weighted and unweighted prevalence of distance as a barrier to healthcare by sociodemographic characteristics

Sociodemographic Characteristics	Distance is a problem when seeking medical help for self	
	Unweighted No. (%)	**Weighted** No. (%)
Age group		
15 – 19	559 (30.2)	558(29.3)
20 – 24	541 (31.5)	511 (28.7)
25 – 29	481 (32.3)	441 (29.8)
30 – 34	387 (30.8)	371(29.6)
35 – 39	393 (34.5)	369 (33.5)
40 – 44	313 (33.3)	287 (31.4)
45 – 49	272 (36.4)	249 (35.5)
50+	340 (40.5)	N/A
Education level		
No education	439 (60.8)	242 (58.4)
Primary	1,087 (47.3)	864 (48.2)
Secondary	1,667 (26.8)	1,566 (26.1)
Higher	93 (12.5)	114 (12.3)
Residence type		
Urban	977 (19.0)	962 (18.6)
Rural	2,309 (47.7)	1,824 (45.9)
Wealth quintile		
Lowest	1,010 (61.9)	876 (61.7)
Second	851 (46.9)	718 (44.4)
Middle	705 (34.5)	573 (32.0)
Fourth	502 (21.4)	414 (19.6)
Highest	218 (10.2)	205 (9.3)
Marital status		
Never married	1,612 (30.3)	1,563 (28.7)
Currently married	647 (30.5)	433 (26.4)
Living with partner	672 (40.3)	564 (38.5)
Formerly/ ever married	355 (40.4)	226 (38.1)
Occupation		
Professional	948 (24.8)	869 (23.4)
Agricultural	93 (46.0)	60 (44.6)
Manual	94 (25.3)	78 (25.3)
Unemployed	2,151 (38.5)	1,779 (35.7)
Health insurance		
No	3,084 (36.9)	2,618 (34.8)
Yes	202 (12.5)	167 (10.4)
Total	3,286 (100.0)	2,786 (100.0)

Weighted estimates based on individual survey weights

Chapter 7

1. Weighted and unweighted distribution of the population by categories of travel time and distance to health facilities. [Corresponds to Table 7.6, Chapter 7]

Unweighted and weighted population distribution by travel time and distance categories

Accessibility measure	Unweighted			Weighted		
	All No. (%)	Urban No. (%)	Rural No. (%)	All No. (%)	Urban No. (%)	Rural No. (%)
Travel time categories						
<15 minutes	14,497 (35.4)	13,321 (72.9)	1,176 (5.2)	14,930(35.4)	13,666 (69.7)	1,265 (5.6)
15 – <30 minutes	7,943 (19.4)	3,812 (20.9)	4,131 (18.2)	9,049 (21.5)	4,731 (24.1)	4,318 (19.2)
30 – <45 minutes	4,722 (11.5)	660 (3.6)	4,062 (17.9)	4,820 (11.4)	572 (2.9)	4,248 (18.9)
45 – <60 minutes	4,247 (10.4)	428 (2.3)	3,819 (16.8)	4,719 (11.2)	429 (2.2)	4,290 (19.0)
1 – <2 hours	4,860 (11.9)	57 (0.3)	4,803 (21.2)	5,234 (12.4)	214 (1.1)	5,021 (22.3)
2 – <4 hours	3,685 (9.0)	0 (0.0)	3,685 (16.2)	2,819 (6.7)	0 (0.0)	2,819 (12.5)
≥4 hours	1,046 (2.6)	0 (0.0)	1,046 (4.6)	573 (1.4)	0 (0.0)	573 (2.5)
Distance categories						
<5 Km	25,147 (61.3)	17,828 (97.5)	7,319 (32.2)	26,575 (63.1)	19,004 (96.9)	7,571 (33.6)
5 - <10 Km	7,763 (18.9)	409 (2.2)	7,354 (32.4)	8,947 (21.2)	591 (3.0)	8,356 (37.1)
10 - <15 Km	2,544 (6.2)	41 (0.2)	2,503 (11.0)	2,587 (6.1)	16 (0.1)	2,571 (11.4)
15 - <20 Km	1,438 (3.5)	0 (0.0)	1,438 (6.3)	1,401 (3.3)	0 (0.0)	1,401 (6.2)
≥20 Km	4,108 (10.0)	0 (0.0)	4,108 (18.1)	2,633 (6.3)	0 (0.0)	2,633 (11.7)
Total	41,000 (100.0)	18,278 (100.0)	22,722 (100.0)	42,143 (100.0)	19,611 (100.0)	22,532 (100.0)

Weighted estimates based on household survey weights

Chapter 8

1. Weighted and unweighted prevalence of health insurance coverage by sociodemographic characteristics. [Corresponds to Table 8.3, Chapter 8]

Weighted and unweighted coverage of health insurance coverage by sociodemographic characteristics

Sociodemographic Characteristics	Health Insurance Coverage	
	Unweighted No. (%)	**Weighted** No. (%)
Sex		
Men	902 (20.3)	952 (21.3)
Women	1,620 (16.2)	1,610 (17.6)
Age group		
15 – 19	272 (10.0)	337 (11.9)
20 – 24	265 (10.7)	331 (12.8)
25 – 29	290 (13.8)	329 (15.4)
30 – 34	348 (19.7)	374 (21.1)
35 – 39	335 (21.1)	340 (28.2)
40 – 44	353 (26.3)	363 (21.9)
45 – 49	325 (30.8)	329 (33.2)
50+	334 (24.4)	160 (35.0)
Education level		
No education	48 (4.0)	39.5 (4.9)
Primary	213 (6.1)	146.7 (5.1)
Secondary	1,548 (17.8)	1,551 (18.1)
Higher	713 (66.5)	825 (61.9)
Wealth quintile		
Lowest	36 (1.6)	33 (1.6)
Second	119 (4.4)	103 (4.2)
Middle	281 (9.2)	288 (10.4)
Fourth	632 (18.7)	620 (19.8)
Highest	1,454 (47.9)	1,518 (47.9)
Residence type		
Urban	1,888 (25.7)	2,062 (27.0)
Rural	634 (8.9)	500 (8.4)
Marital status		
Never married	959 (12.1)	1,118 (13.6)
Currently married	1,137 (36.8)	1,048 (41.4)
Living with partner	263 (11.2)	259 (12.4)
Formerly/ever married	163 (15.4)	137 (18.1)
Occupation		
Professional	1,569 (30.8)	1,603 (31.6)
Agricultural	107 (16.6)	64 (15.9)
Manual	312 (21.7)	308 (21.7)
Unemployed	534 (7.3)	587 (8.8)
Total	2,522 (17.5)	2,562 (18.8)

Weighted estimates based on individual survey weights

Appendix 3

Appendix 3: additional analyses exploring language as a proxy for ethnicity in relation to key outcomes presented in Chapters 4, 6, 7 and 8.

Table 1: Prevalence of HIV, hyperglycaemia and hypertension by ethnicity

	HIV			Hyperglycaemia			Hypertension		
	HIV negative	**HIV positive**	***p***	**No**	**Yes**	***p***	**No**	**Yes**	***p***
	No. (%)	No. (%)		No. (%)	No. (%)		No. (%)	No. (%)	
Ethnicity									
Afrikaans	821 (94.9)	44 (5.1)	<0.001	385 (88.7)	49 (11.3)	<0.001	258 (59.9)	173 (40.1)	0.095
Damara/Nama	1,237 (90.4)	132 (9.6)		504 (91.5)	47 (8.5)		328 (59.6)	222 (40.4)	
Herero	703 (93.1)	52 (6.9)		324 (95.3)	16 (4.7)		212 (62.5)	127 (37.5)	
Oshiwambo	3,060 (82.4)	653 (17.6)		1,186 (96.4)	44 (3.6)		791 (64.3)	440 (35.7)	
Other	1,415 (83.2)	286 (16.8)		546 (96.3)	21 (3.7)		373 (66.3)	190 (33.8)	
Total	7,236 (86.1)	1,167 (13.9)		2,945 (94.3)	177 (5.7)		1,962 (63.0)	1,152 (37.0)	

p value corresponds to a chi squared test.

Table 2: Association between HIV and sociodemographic and behavioural factors (n=8,406)						
Sociodemographic and behavioural characteristics	Model 1		Model 2		Model 3*	
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*
Sex						
Men	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Women	1.56 (1.38 - 1.76)	<0.001	1.53 (1.35 - 1.74)	<0.001	1.60 (1.39 - 1.86)	<0.001
Age group						
15 – 19	1.00 (reference)		1.00 (reference)		1.00 (reference)	
20 – 24	1.94 (1.35 - 2.79)	<0.001	2.05 (1.45 - 2.88)	<0.001	1.22 (0.81 - 1.86)	0.344
25 – 29	4.69 (3.38 - 6.52)	<0.001	5.03 (3.00 - 8.44)	<0.001	2.55 (1.50 - 4.34)	0.001
30 – 34	7.65 (5.56 - 10.53)	<0.001	8.27 (4.57 - 14.98)	<0.001	4.11 (2.36 - 7.16)	<0.001
35 – 39	9.09 (6.62 - 12.47)	<0.001	9.84 (5.53 - 17.51)	<0.001	4.73 (2.75 - 8.13)	<0.001
40 – 44	7.98 (5.75 - 11.07)	<0.001	8.87 (4.70 - 16.75)	<0.001	4.67 (2.59 - 8.44)	<0.001
45 – 49	7.82 (5.58 - 10.97)	<0.001	9.02 (5.08 - 16.03)	<0.001	4.66 (2.80 - 7.74)	<0.001
50+	5.38 (3.88 - 7.47)	<0.001	6.10 (3.45 - 10.76)	<0.001	3.33 (2.00 - 5.54)	<0.001
Education level						
No education	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Primary	1.03 (0.85 - 1.25)	0.766	0.90 (0.76 - 1.07)	0.226	1.06 (0.91 - 1.23)	0.469
Secondary	0.71 (0.59 - 0.85)	<0.001	9.60 (0.47 - 0.78)	<0.001	0.90 (0.74 - 1.09)	0.277
Higher	0.56 (0.24 - 0.52)	<0.001	0.31 (0.17 - 0.56)	<0.001	0.58 (0.37 - 0.92)	0.020
Wealth quintile						
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Second	0.98 (0.83 - 1.17)	0.851	1.01 (0.85 - 1.20)	0.912	1.06 (0.94 - 1.18)	0.360
Middle	0.86 (0.73 - 1.03)	0.095	0.89 (0.68 - 1.15)	0.367	0.94 (077 - 1.38)	0.511
Fourth	0.72 (0.61 - 0.86)	<0.001	0.75 (0.55 - 1.03)	0.071	0.86 (0.69 - 1.08)	0.193
Highest	0.29 (0.23 - 0.38)	<0.001	0.30 (0.19 - 0.46)	<0.001	0.44 (0.34 - 0.58)	<0.001
Occupation						
Professional	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Agricultural	0.88 (0.68 - 1.13)	0.301	1.05 (0.81 - 1.36)	0.714	1.10 (0.80 - 1.49)	0.564
Manual	0.86 (0.72 - 1.03)	0.105	0.89 (0.73 - 1.08)	0.242	0.96 (0.80 - 1.16)	0.673
Unemployed	0.70 (0.61 - 0.79)	<0.001	0.64 (0.56 - 0.73)	<0.001	0.92 (0.81 - 1.05)	0.209
Residence type						
Urban	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Rural	1.10 (0.98 - 1.23)	0.110	0.91 (0.72 - 1.15)	0.446	0.77 (0.65 - 0.93)	0.006
Marital status						
Never married	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Currently married	1.20 (1.02 - 1.41)	0.026	1.27 (1.02 - 1.59)	0.035	0.75 (0.63 - 0.90)	0.002
Living with partner	1.90 (1.64 - 2.20)	<0.001	2.28 (1.92 - 2.72)	<0.001	1.20 (1.04 - 1.39)	0.013
Formerly/ever married	2.58 (2.17 - 3.07)	<0.001	2.66 (2.16 - 3.27)	<0.001	1.25 (1.03 - 1.53)	0.026
Lifetime sexual partners						
None	1.00 (reference)		1.00 (reference)		1.00 (reference)	
1	3.78 (2.37 - 6.02)	<0.001	3.93 (2.46 - 6.29)	<0.001	0.38 (0.27 - 0.53)	<0.001
>1	8.76 (5.68 - 13.50)	<0.001	9.76 (6.23 - 15.30)	<0.001	0.72 (0.57 - 0.92)	0.009

Table 2: Association between HIV and sociodemographic and behavioural factors (n=8,406)						
Sociodemographic and behavioural characteristics	**Model 1**		**Model 2**		**Model 3***	
	RR (95% CI)	***p***	**RR (95% CI)**	***p***	**RR (95% CI)**	***p***
Don't know	12.08 (7.37 - 19.82)	<0.001	13.27 (7.76 - 22.72)	<0.001	—	—
Age at first sex						
Never had sex	1.00 (reference)		1.00 (reference)		1.00 (reference)	
<15 years	5.36 (3.28 - 8.76)	<0.001	5.72 (4.13 - 7.93)	<0.001	3.59 (2.10 - 6.11)	<0.001
15 – 19 years	7.85 (5.09 - 12.11)	<0.001	8.53 (5.45 - 13.33)	<0.001	4.28 (2.59 - 7.08)	<0.001
20+ years	8.64 (5.56 - 13.44)	<0.001	9.16 (5.66 - 14.84)	<0.001	3.89 (2.27 - 6.66)	<0.001
Ethnicity*						
Afrikaans	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Damara/Nama	1.90 (1.35 - 2.67)	<0.001	1.92 (1.48 - 2.50)	<0.001	1.24 (0.96 - 1.59)	0.103
Herero	1.35 (0.91 - 2.02)	0.139	1.42 (1.02 - 1.97)	0.036	0.96 (0.68 - 1.37)	0.834
Oshiwambo	3.46 (2.55 - 4.69)	<0.001	3.47 (2.49 - 4.83)	<0.001	2.42 (1.76 - 3.31)	<0.001
Other	3.31 (2.41 - 4.54)	<0.001	2.85 (1.89 - 4.28)	<0.001	2.19 (1.51 - 3.19)	<0.001

*n=8,403 with data on ethnicity | Model 1: univariable Poisson regression for association between exposure and HIV | Model 2: mixed effects Poisson regression between each exposure and HIV adjusted for regional, EA and household clustering | Model 3: multivariable mixed effects Poisson regression, additionally adjusted for all other exposures in the table | RR: Risk Ratio | 95% CI: 95% Confidence Interval

Table 3: Association between hyperglycaemia and sociodemographic, biophysical and behavioural risk factors

Potential risk factors	Model 1 (n=3,255)		Model 2 (n=3,255)		Model 3 (n=3,105)	
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*
Sex						
Men	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Women	0.95 (0.71 - 1.26)	0.704	0.97 (0.71 - 1.31)	0.824	0.86 (0.61 - 1.21)	0.384
Age group						
34 – 39	1.00 (reference)		1.00 (reference)		1.00 (reference)	
40 – 44	1.05 (0.65 - 1.69)	0.860	1.04 (0.67 - 1.60)	0.877	0.97 (0.62 - 1.52)	0.894
45 – 49	1.12 (0.68 - 1.84)	0.651	1.06 (0.62 - 1.80)	0.840	0.93 (0.55 - 1.56)	0.775
50 – 54	1.63 (1.03 - 2.58)	0.039	1.62 (1.08 - 2.41)	0.019	1.42 (0.94 - 2.15)	0.094
55 – 59	1.63 (0.98 - 2.73)	0.061	1.59 (1.04 - 2.43)	0.033	1.45 (0.96 - 2.20)	0.081
60 – 64	2.16 (1.33 - 3.50)	0.002	2.16 (1.61 - 2.88)	<0.001	2.00 (1.42 - 2.81)	<0.001
Education level						
No education	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Primary	1.39 (0.84 - 2.30)	0.205	1.26 (0.74 - 2.12)	0.393	1.30 (0.74 - 2.27)	0.359
Secondary	1.51 (0.93 - 2.47)	0.096	1.38 (0.92 - 2.06)	0.120	1.16 (0.74 - 1.81)	0.523
Higher	2.51 (1.39 - 4.54)	0.002	2.39 (1.23 - 4.66)	0.010	1.53 (0.80 - 2.95)	0.201
Wealth quintile						
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Second	1.30 (0.69 - 2.48)	0.420	1.25 (0.74 - 2.10)	0.408	1.13 (0.65 - 1.96)	0.662
Middle	1.37 (0.73 - 2.57)	0.322	1.33 (0.72 - 2.46)	0.358	0.98 (0.45 - 2.14)	0.957
Fourth	2.64 (1.51 - 4.59)	0.001	2.56 (1.54 - 4.27)	<0.001	1.45 (0.84 - 2.50)	0.182
Highest	3.41 (1.98 - 5.89)	<0.001	3.38 (1.92 - 5.93)	<0.001	1.72 (0.76 - 3.91)	0.193
Residence type						
Urban	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Rural	0.57 (0.43 - 0.77)	<0.001	0.58 (0.42 - 0.81)	0.001	0.89 (0.64 - 1.24)	0.490
Obesity level						
Normal or underweight	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Overweight	2.04 (1.43 - 2.91)	<0.001	1.93 (1.41 - 2.64)	<0.001	1.65 (1.16 - 2.34)	0.006
Obese	2.72 (1.93 - 3.82)	<0.001	2.50 (1.53 - 4.09)	<0.001	2.05 (1.21 - 3.45)	0.007
Hypertension						
Not hypertensive	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Hypertensive	1.45 (1.09 - 1.94)	0.011	1.41 (0.94 - 2.11)	0.097	1.23 (0.80 -1.88)	0.349
Low fruit and vegetable intake						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	0.68 (0.44 - 1.04)	0.074	0.70 (0.49 - 1.00)	0.047	0.93 (0.66 - 1.29)	0.349
Current smoker*						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	1.21 (0.86 - 1.71)	0.284	0.96 (0.74 - 1.25)	0.757	1.11 (0.86 - 1.43)	0.650
Ethnicity**						
Afrikaans	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Damara/Nama	0.76 (0.51 - 1.13)	0.170	0.80 (0.43 - 1.47)	0.466	1.11 (0.62 - 1.98)	0.727
Herero	0.42 (0.24 - 0.73)	0.002	0.48 (0.30 - 0.75)	0.002	0.74 (0.43 - 1.29)	0.293
Oshiwambo	0.32 (0.21 - 0.48)	<0.001	0.35 (0.25 - 0.50)	<0.001	0.66 (0.44 - 1.02)	0.059
Other	0.33 (0.20 - 0.55)	<0.001	0.38 (0.21 - 0.70)	0.002	0.72 (0.45 - 1.15)	0.167

*n=3,157 due to 90 with missing data on smoking | **n=3,122 individuals with data on ethnicity | Model 1: univariable Poisson regression | Model 2: Univariable mixed effects analyses adjusted for regional, EA and household clustering | Model 3: fully-adjusted multivariable mixed effects analysis, adjusted for clustering and all other exposures in the table | RR: Risk Ratio | 95% CI: 95% Confidence Interval

Table 4: Association between hypertension and sociodemographic, biophysical and behavioural risk factors						
Potential risk factors	**Model 1 (n=3,247)**		**Model 2 (n=3,247)**		**Model 3 (n=3,097)**	
	RR (95% CI)	***p***	**RR (95% CI)**	***p***	**RR (95% CI)**	***p***
Sex						
Men	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Women	0.95 (0.84 - 1.06)	0.331	0.95 (0.85 - 1.06)	0.334	0.87 (0.79 - 0.95)	0.002
Age group						
34 – 39	1.00 (reference)		1.00 (reference)		1.00 (reference)	
40 – 44	1.28 (1.06 - 1.55)	0.009	1.28 (1.14 - 1.44)	<0.001	1.22 (1.09 - 1.38)	0.001
45 – 49	1.51 (1.25 - 1.82)	<0.001	1.51 (1.29 - 1.76	<0.001	1.42 (1.21 - 1.67)	<0.001
50 – 54	1.66 (1.38 - 2.00)	<0.001	1.66 (1.37 - 2.01)	<0.001	1.57 (1.33 - 1.87)	<0.001
55 – 59	1.86 (1.52 - 2.28)	<0.001	1.86 (1.60 - 2.17)	<0.001	1.80 (1.57 - 2.07)	<0.001
60 – 64	1.59 (1.29 - 1.97)	<0.001	1.60 (1.35 - 1.89)	<0.001	1.51 (1.25 - 1.84)	<0.001
Education level						
No education	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Primary	0.90 (0.76 - 1.06)	0.219	0.89 (0.82 - 0.97)	0.007	0.86 (0.79 - 0.94)	<0.001
Secondary	0.84 (0.72 - 0.99)	0.039	0.83 (0.74 - 0.93)	0.001	0.82 (0.70 - 0.95)	0.008
Higher	0.90 (0.70 - 1.15)	0.393	0.88 (0.71 - 1.09)	0.250	0.76 (0.58 - 1.00)	0.048
Wealth quintile						
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Second	1.25 (1.02 - 1.53)	0.033	1.25 (1.06 - 1.47)	0.007	1.19 (1.02 - 1.38)	0.023
Middle	1.31 (1.07 - 1.59)	0.008	1.31 (1.19 - 1.43)	<0.001	1.21 (1.09 - 1.34)	0.001
Fourth	1.41 (1.17 - 1.70)	<0.001	1.41 (1.25 - 1.59)	<0.001	1.12 (0.95 - 1.32)	0.186
Highest	1.33 (1.10 - 1.62)	0.004	1.33 (1.18 - 1.51)	<0.001	1.00 (0.87 - 1.15)	0.973
Residence type						
Urban	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Rural	0.81 (0.72 - 0.91)	<0.001	0.81 (0.73 - 0.90)	<0.001	0.79 (0.71 - 0.88)	<0.001
Obesity level						
Normal or underweight	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Overweight	1.26 (1.09 - 1.45)	0.002	1.26 (1.17 - 1.35)	<0.001	1.28 (1.18 - 1.39)	<0.001
Obese	1.52 (1.32 - 1.74)	<0.001	1.52 (1.38 - 1.67)	<0.001	1.58 (1.41 - 1.76)	<0.001
Hyperglycaemia						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	1.26 (1.01 - 1.58)	0.042	1.26 (0.99 - 1.60)	0.056	1.14 (0.90 - 1.44)	0.294
Low fruit and vegetable intake						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	0.97 (0.80 - 1.17)	0.729	0.97 (0.84 - 1.12)	0.655	1.14 (0.90 - 1.44)	0.512
Current smoker*						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	1.04 (0.90 - 1.20)	0.585	1.04 (0.92 - 1.18)	0.552	1.05 (0.93 - 1.20)	0.432
Ethnicity**						
Afrikaans	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Damara/Nama	1.01 (0.82 - 1.23)	0.956	1.01 (0.79 - 1.28)	0.965	1.00 (0.77 - 1.28)	0.973
Herero	0.93 (0.74 - 1.17)	0.555	0.93 (0.78 - 1.11)	0.445	1.00 (0.84 - 1.18)	0.956
Oshiwambo	0.89 (0.75 - 1.06)	0.196	0.89 (0.81 - 0.98)	0.012	1.09 (0.99 - 1.21)	0.094
Other	0.84 (0.68 - 1.03)	0.099	0.84 (0.69 - 1.02)	0.084	1.03 (0.88 - 1.21)	0.683

*n=3,157 due to 90 with missing data on smoking| **n=3,114 individuals with data on ethnicity | Model 1: univariable Poisson regression | Model 2: Univariable mixed effects analyses adjusted for regional, EA and household clustering | Model 3: fully-adjusted multivariable mixed effects analysis, adjusted for clustering and all other exposures in the table | RR: Risk Ratio | 95% CI: 95% Confidence Interval

Table 5: Factors that may contribute to reporting of distance being a problem when seeking medical help for self (n=9,975)

Sociodemographic characteristics	Distance is a problem when seeking medical help for self		
	No	Yes	*p*
	No. (%)	No. (%)	
Ethnicity			
Afrikaans	925 (87.9)	127 (12.1)	<0.001
Damara/Nama	1,040 (67.4)	502 (32.6)	
Herero	567 (60.4)	372 (39.6)	
Oshiwambo	2,997 (68.7)	1,363 (31.3)	
Other	1,164 (55.9)	918 (44.1)	

p value corresponds to a chi squared test

Table 6: Association between reporting of distance as a barrier and exposures of interest (n=9,981)

Sociodemographic characteristics	Model 1		Model 2		Model 3*	
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*
Age group						
15 – 19	1.00 (reference)		1.00 (reference)		1.00 (reference)	
20 – 24	1.05 (0.93 – 1.18)	0.459	1.11 (0.97 – 1.26)	0.135	1.18 (1.04 - 1.34)	0.011
25 – 29	1.07 (0.95 – 1.21)	0.268	1.13 (1.00 – 1.29)	0.058	1.19 (1.05 - 1.36)	0.008
30 – 34	1.02 (0.90 – 1.16)	0.743	1.09 (0.92 – 1.28)	0.325	1.17 (1.00 - 1.36)	0.045
35 – 39	1.15 (1.01 – 1.30)	0.039	1.18 (1.05 – 1.33)	0.005	1.24 (1.12 - 1.37)	<0.001
40 – 44	1.10 (0.96 – 1.27)	0.160	1.16 (1.01 – 1.32)	0.038	1.24 (1.07 - 1.43)	0.003
45 – 49	1.21 (1.04 – 1.39)	0.011	1.23 (1.06 – 1.42)	0.006	1.33 (1.15 - 1.53)	<0.001
50 – 64	1.34 (1.17 – 1.54)	<0.001	1.29 (1.14 – 1.47)	<0.001	1.25 (1.11 - 1.40)	<0.001
Education level						
No education	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Primary	0.78 (0.70 – 0.87)	<0.001	0.86 (0.78 – 0.95)	0.004	0.94 (0.86 - 1.02)	0.129
Secondary	0.44 (0.40 – 0.49)	<0.001	0.63 (0.56 – 0.70)	<0.001	0.80 (0.73 - 0.87)	<0.001
Highest	0.21 (0.17 – 0.26)	<0.001	0.38 (0.32 – 0.45)	<0.001	0.74 (0.61 - 0.90)	0.002
Wealth quintile						
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Second	0.76 (0.69 – 0.83)	<0.001	0.81 (0.74 – 0.88)	<0.001	0.89 (0.80 - 0.98)	0.016
Middle	0.56 (0.51 – 0.61)	<0.001	0.63 (0.55 – 0.72)	<0.001	0.75 (0.65 - 0.87)	<0.001
Fourth	0.35 (0.31 – 0.39)	<0.001	0.40 (0.34 – 0.47)	<0.001	0.56 (0.47 - 0.67)	<0.001
Highest	0.16 (0.14 – 0.19)	<0.001	0.20 (0.16 – 0.25)	<0.001	0.38 (0.28 - 0.50)	<0.001
Residence type						
Urban	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Rural	2.51 (2.33 – 2.70)	<0.001	2.62 (2.09 – 3.28)	<0.001	1.66 (1.35 - 2.05)	<0.001

Table 6: Association between reporting of distance as a barrier and exposures of interest (n=9,981)						
Sociodemographic Characteristics	**Model 1**		**Model 2**		**Model 3***	
	RR (95% CI)	***p***	**RR (95% CI)**	***p***	**RR (95% CI)**	***p***
Marital status						
Never married	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Currently married	1.01 (0.92 – 1.10)	0.879	0.96 (0.87 – 1.07)	0.495	0.91 (0.85 - 0.98)	0.012
Living with partner	1.33 (1.22 – 1.46)	<0.001	1.10 (1.04 – 1.17)	0.002	0.95 (0.89 - 1.00)	0.057
Formerly/ ever married	1.33 (1.19 – 1.50)	<0.001	1.20 (1.09 – 1.32)	<0.001	1.02 (0.902 - 1.12)	0.731
Occupation						
Professional	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Agricultural	1.86 (1.50 – 2.30)	<0.001	1.41 (1.16 – 1.70)	<0.001	1.14 (0.95 - 1.38)	0.163
Manual	1.02 (0.82 – 1.26)	0.862	1.06 (0.86 – 1.31)	0.567	0.98 (0.78 - 1.22)	0.825
Unemployed	1.55 (1.44 – 1.68)	<0.001	1.21 (1.13 – 1.29)	<0.001	1.06 (1.01 - 1.11)	0.011
Health insurance						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	0.34 (0.29 – 0.39)	<0.001	0.49 (0.41 – 0.60)	<0.001	0.70 (0.56 - 0.86)	0.001
Ethnicity*						
Afrikaans	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Damara/Nama	2.70 (2.22 - 3.28)	<0.001	2.15 (1.96 - 2.35)	<0.001	1.53 (1.35 - 1.73)	<0.001
Herero	3.28 (2.68 - 4.01)	<0.001	2.45 (2.08 - 2.88)	<0.001	1.67 (1.51 - 1.84)	<0.001
Oshiwambo	2.59 (2.16 - 3.11)	<0.001	1.83 (1.57 - 2.13)	<0.001	1.30 (1.09 - 1.54)	0.003
Other	3.65 (3.03 - 4.40)	<0.001	2.45 (2.10 - 2.87)	<0.001	1.64 (1.45 - 1.86)	<0.001

*n=9,975 with data on ethnicity | Model 1: Univariable model | Model 2: Adjusted for enumeration area and household clustering | Model 3: Adjusted for all other exposures in the table and adjusted for regional, enumeration area and household clustering | RR: risk ratio | 95% CI: 95% confidence interval

Table 7: Average time (minutes) to health facilities by sociodemographic factors (n=14,374)

Sociodemographic Characteristics	Minutes to any HF	*p*	Minutes to clinic	*p*	Minutes to HC	*p*	Minutes to Hospitals	*p*
	Median (IQR)		Median (IQR)		Median (IQR)		Median (IQR)	
Ethnicity*								
Afrikaans	12.3 (16.8)	<0.001	20.2 (28.4)	<0.001	109.9 (129.9)	<0.001	21.0 (67.4)	<0.001
Damara/Nama	16.2 (48.7)		23.7 (65.3)		128.1 (115.8)		36.4 (109.0)	
Herero	27.9 (114.6)		43.1 (112.7)		158.1 (184.1)		123.2 (216.2)	
Oshiwambo	26.9 (36.3)		29.0 (34.5)		65.8 (101.6)		43.7 (95.3)	
Other	19.7 (41.1)		23.0 (46.7)		58.4 (76.4)		35.2 (92.5)	

p value corresponds to Wilcoxon rank-sum (Mann-Whitney U) test for binary sociodemographic factors (sex and residence type) and corresponds to a Kruskal Wallis test for sociodemographic factors with multiple categories (all other variables) | HC: health centre

Table 8: Predicted travel time in minutes by ethnicity (n=14,374)

	Model 1		Model 2		Model 3	
	Predicted travel time in minutes (95% CI)	***p***	**Predicted travel time in minutes (95% CI)**	***p***	**Predicted travel time in minutes (95% CI)**	***p***
Ethnicity						
Afrikaans	28.70 (24.28 - 33.92)	<0.001	21.59 (16.94 - 27.51)	<0.001	28.70 (24.28 - 33.92)	<0.001
Damara/Nama	26.01 (22.04 - 30.69)	<0.001	25.51 (20.07 - 32.44)	<0.001	26.01 (22.04 - 30.69)	<0.001
Herero	21.97 (18.58 - 25.98)	<0.001	31.50 (24.69 - 40.19)	<0.001	21.97 (18.58 - 25.98)	<0.001
Oshiwambo	21.75 (18.46 - 25.62)	<0.001	21.75 (17.15 - 27.57)	<0.001	21.75 (18.46 - 25.62)	<0.001
Other	22.23 (18.82 - 26.24)	<0.001	27.14 (21.33 - 34.54)	<0.001	22.23 (18.82 - 26.24)	<0.001

95% CI: 95% Confidence Interval | Model 1: Univariable model of association between ethnicity and travel time to health facilities | Model 2: Mixed effects model accounting for clustering at the regional level | Model 3: fully-adjusted multivariable mixed effects model, adjusted for age, sex, education, wealth and residence type and accounting for regional clustering

Table 9: Prevalence of health insurance, outpatient care, inpatient care and reporting cost as a healthcare barrier by ethnicity

	n=14,436			n=14,436			n=14,436			n=9,978		
	No health insurance	**Health insurance**	***p***	**No outpatient care**	**Outpatient care**	***p***	**No inpatient care**	**Inpatient care**	***p***	**No affordability barrier**	**Affordability barrier**	***p***
	No. (%)	No. (%)		No. (%)	No. (%)		No. (%)	No. (%)		No. (%)	No. (%)	
Ethnicity*												
Afrikaans	899 (57.4)	668 (42.6)	<0.001	1,369 (87.4)	198 (12.6)	<0.001	1,496 (95.5)	71 (4.5)	0.004	936 (88.9)	117 (11.1)	<0.001
Damara/Nama	1,919 (87.1)	285 (12.9)		2,032 (92.2)	172 (7.8)		2,081 (94.4)	123 (5.6)		1,092 (70.8)	450 (29.2)	
Herero	1,103 (83.3)	222 (16.8)		1,190 (89.8)	135 (10.2)		1,258 (94.9)	67 (5.1)		665 (70.7)	275 (29.3)	
Oshiwambo	5,369 (85.6)	905 (14.4)		5,694 (90.8)	580 (9.2)		6,038 (96.2)	236 (3.8)		3,314 (76.0)	1,047 (24.0)	
Other	2,624 (85.6)	442 (14.4)		2,797 (91.2)	269 (8.8)		2,939 (95.9)	127 (4.1)		1,013 (48.7)	1,069 (51.3)	
Total	11,914 (82.5)	2,522 (17.5)		13,082 (90.6)	1,354 (9.4)		13,812 (95.7)	624 (4.3)		7,020 (70.4)	2,958 (29.7)	

p value corresponds to a chi squared test

Table 10: Association between sociodemographic factors and health insurance coverage (n=14,443)						
Sociodemographic Characteristics	**Model 1**		**Model 2**		**Model 3***	
	RR (95% CI)	***p***	**RR (95% CI)**	***p***	**RR (95% CI)**	***p***
Sex						
Men	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Women	0.80 (0.74 – 0.87)	<0.001	0.79 (0.71 – 0.88)	<0.001	0.84 (0.74 - 0.94)	0.004
Age group						
15 – 19	1.00 (reference)		1.00 (reference)		1.00 (reference)	
20 – 24	1.07 (0.91 – 1.27)	0.421	0.99 (0.80 – 1.23)	0.951	0.64 (0.54 - 0.75)	<0.001
25 – 29	1.39 (1.18 – 1.64)	<0.001	1.30 (1.00 – 1.68)	0.049	0.70 (0.61 - 0.82)	<0.001
30 – 34	1.98 (1.69 – 2.32)	<0.001	1.80 (1.40 – 2.32)	<0.001	0.83 (0.72 - 0.96)	0.012
35 – 39	2.12 (1.81 – 2.49)	<0.001	1.97 (1.45 – 2.68)	<0.001	0.89 (0.75 - 1.06)	0.185
40 – 44	2.65 (2.26 – 3.10)	<0.001	2.28 (1.67 – 3.10)	<0.001	0.97 (0.81 - 1.36)	0.699
45 – 49	3.09 (2.63 – 3.63)	<0.001	2.66 (1.98 – 3.57)	<0.001	1.13 (0.93 - 1.36)	0.223
50 – 64	2.45 (2.09 – 2.88)	<0.001	2.35 (1.80 – 3.07)	<0.001	1.07 (0.86 - 1.32)	0.542
Education level						
No education	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Primary	1.55 (1.13 – 2.12)	0.006	1.53 (1.13 – 2.07)	0.006	1.27 (0.97 - 1.65)	0.078
Secondary	4.50 (3.38 – 6.00)	<0.001	3.44 (2.73 – 4.34)	<0.001	2.29 (1.85 - 2.83)	<0.001
Higher	16.81 (12.55 – 22.51)	<0.001	9.42 (6.14 – 14.47)	<0.001	3.86 (3.00 - 4.97)	<0.001
Wealth quintile						
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Second	2.84 (1.96 – 4.12)	<0.001	2.89 (1.76 – 4.75)	<0.001	2.54 (1.56 - 4.15)	<0.001
Middle	5.89 (4.17 – 8.34)	<0.001	6.03 (4.07 – 8.95)	<0.001	4.51 (2.97 - 6.84)	<0.001
Fourth	11.95 (8.54 – 16.72)	<0.001	12.86 (8.97 – 18.43)	<0.001	7.67 (5.19 - 11.33)	<0.001
Highest	30.62 (22.00 – 42.62)	<0.001	30.86 (21.84 – 43.60)	<0.001	13.28 (9.05 - 19.49)	<0.001
Residence type						
Urban	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Rural	0.35 (0.32 – 0.38)	<0.001	0.42 (0.35 – 0.50)	<0.001	1.02 (0.90 - 1.16)	0.750
Marital status						
Never married	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Currently married	3.05 (2.80 – 3.32)	<0.001	2.67 (2.19 – 3.24)	<0.001	1.67 (1.45 - 1.93)	<0.001
Living with partner	0.93 (0.81 – 1.06)	0.287	1.06 (0.89 – 1.26)	0.522	1.07 (0.93 - 1.23)	0.329
Formerly/ever married	1.28 (1.08 – 1.51)	0.004	1.40 (1.24 – 1.58)	<0.001	1.14 (1.03 - 1.25)	0.009
Occupation						
Professional	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Agricultural	0.54 (0.44 – 0.66)	<0.001	0.79 (0.69 – 0.91)	0.001	0.89 (0.76 - 1.04)	0.137
Manual	0.71 (0.63 – 0.80)	<0.001	0.79 (0.70 – 0.90)	<0.001	0.86 (0.77 - 0.96)	0.009
Unemployed	0.24 (0.21 – 0.26)	<0.001	0.32 (0.23 – 0.44)	<0.001	0.44 (0.35 - 0.56)	<0.001
Ethnicity*						
Afrikaans	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Damara/Nama	0.30 (0.26 - 0.35)	<0.001	0.50 (0.41 - 0.60)	<0.001	0.79 (0.67 - 0.93)	0.005
Herero	0.39 (0.34 - 0.46)	<0.001	0.61 (0.48 - 0.79)	<0.001	0.97 (0.82 - 1.14)	0.674
Oshiwambo	0.34 (0.31 - 0.38)	<0.001	0.63 (0.55 - 0.73)	<0.001	0.95 (0.78 - 1.15)	0.580
Other	0.34 (0.30 - 0.38)	<0.001	0.70 (0.56 - 0.87)	0.002	0.93 (0.81 - 1.06)	0.267

*n=14.436 | RR: risk ratio derived from Poisson regression analyses | 95% CI: 95% confidence intervals | Model 1: univariable association between exposure and having health insurance | Model 2: same as model one with region, enumeration area and household included as random effects (mixed effects Poisson regression) | Model 3: additionally adjusted for all covariates included in the table (multivariable mixed effects Poisson regression)

Table 11: Association between exposures of interest and seeking outpatient care in the four weeks prior to the survey (n=14,443)

Exposures of interest	Model 1		Model 3*	
	RR (95% CI)	*p*	RR (95% CI)	*p*
Health Insurance				
No	1.00 (reference)		1.00 (reference)	
Yes	1.65 (1.46 – 1.86)	<0.001	1.27 (1.07 - 1.50)	0.007
Sex				
Men	1.00 (reference)		1.00 (reference)	
Women	1.33 (1.18 – 1.51)	<0.001	1.30 (1.13 - 1.50)	<0.001
Age group				
15 – 19	1.00 (reference)		1.00 (reference)	
20 – 24	1.37 (1.08 – 1.75)	0.011	1.29 (1.00 - 1.67)	0.049
25 – 29	2.06 (1.64 – 2.60)	<0.001	1.89 (1.37 - 2.52)	<0.001
30 – 34	2.49 (1.98 – 3.13)	<0.001	2.11 (1.73 - 2.57)	<0.001
35 – 39	2.41 (1.90 – 3.05)	<0.001	1.97 (1.53 - 2.53)	<0.001
40 – 44	2.82 (2.22 - 3.57)	<0.001	2.20 (1.64 - 2.96)	<0.001
45 – 49	3.47 (2.73 – 4.40)	<0.001	2.64 (2.06 - 3.39)	<0.001
50 – 64	3.84 (3.08 – 4.80)	<0.001	3.08 (2.32 - 4.09)	<0.001
Education level				
No education	1.00 (reference)		1.00 (reference)	
Primary	1.16 (093 – 1.44)	0.202	1.28 (1.08 - 1.51)	0.004
Secondary	1.06 (0.86 – 1.30)	0.601	1.31 (1.10 - 1.55)	0.002
Higher	1.60 (1.24 – 2.06)	<0.001	1.47 (1.11 - 1.96)	0.008
Wealth quintile				
Lowest	1.00 (reference)		1.00 (reference)	
Second	0.93 (0.77 – 1.12)	0.424	0.94 (0.75 - 1.16)	0.558
Middle	0.89 (0.74 – 1.07)	0.202	0.87 (0.72 - 1.05)	0.144
Fourth	0.97 (0.82 – 1.16)	0.748	0.89 (0.712 - 1.12)	0.316
Highest	1.23 (1.04 – 1.45)	0.018	0.94 (0.72 - 1.22)	0.640
Residence type				
Urban	1.00 (reference)		1.00 (reference)	
Rural	0.95 (0.85 – 1.05)	0.319	0.98 (0.80 - 1.20)	0.847
Marital status				
Never married	1.00 (reference)		1.00 (reference)	
Currently married	1.96 (1.72 – 2.22)	<0.001	1.19 (0.98 - 1.43)	0.079
Living with partner	1.36 (1.17 – 1.60)	<0.001	1.15 (0.96 - 1.38)	0.120
Formerly/ ever married	2.56 (2.17 – 3.03)	<0.001	1.62 (1.31 - 2.01)	<0.001
Occupation				
Professional	1.00 (reference)		1.00 (reference)	
Agricultural	0.86 (0.66 – 1.11)	0.233	1.00 (0.85 - 1.19)	0.960
Manual	0.73 (0.60 – 0.89)	0.002	0.88 (0.77 - 1.01)	0.068
Unemployed	0.68 (0.61 – 0.77)	<0.001	0.92 (0.84 - 1.01)	0.086
Ethnicity*				
Afrikaans	1.00 (reference)		1.00 (reference)	
Damara/Nama	0.62 (0.50 - 0.76)	<0.001	0.78 (0.58 - 1.06)	0.111
Herero	0.81 (0.65 - 1.00)	0.054	1.01 (0.72 - 1.44)	0.937
Oshiwambo	0.73 (0.62 - 0.86)	<0.001	0.94 (0.76 - 1.17)	0.569
Other	0.69 (0.58 - 0.83)	<0.001	0.82 (0.65 - 1.03)	0.090

*n=14,436 | RR: risk ratio | 95% CI: 95% confidence interval | Model 1: Univariable model | Model 3: Adjusted for regional, enumeration area and household clustering and all other covariates in the table | Model 2 as described in methods not shown

Table 12: Association between exposures of interest and inpatient care in the six months prior to the survey (n=14,443)				
Exposures of interest	**Model 1**		**Model 3***	
	RR (95% CI)	***p***	**RR (95% CI)**	***p***
Health Insurance				
No	1.00 (reference)		1.00 (reference)	
Yes	1.42 (1.18 – 1.71)	<0.001	1.52 (1.26 - 1.84)	<0.001
Sex				
Men	1.00 (reference)		1.00 (reference)	
Women	1.98 (1.62 – 2.42)	<0.001	1.95 (1.55 - 2.46)	<0.001
Age group				
15 – 19	1.00 (reference)		1.00 (reference)	
20 – 24	1.58 (1.15 – 2.18)	0.005	1.51 (1.08 - 2.11)	0.017
25 – 29	2.34 (1.72 – 3.18)	<0.001	2.10 (1.55 - 2.85)	<0.001
30 – 34	2.51 (1.84 – 3.43)	<0.001	2.22 (1.41 - 3.48)	0.001
35 – 39	2.12 (1.53 – 2.95)	<0.001	1.84 (1.13 - 2.48)	0.015
40 – 44	2.04 (1.44 – 2.88)	<0.001	1.79 (1.30 -2.48)	<0.001
45 – 49	1.82 (1.24 – 2.67)	0.002	1.60 (1.13 - 2.26)	0.008
50 – 64	1.94 (1.36 – 2.74)	<0.001	1.88 (1.26 - 2.82)	0.002
Education level				
No education	1.00 (reference)		1.00 (reference)	
Primary	1.56 (1.07 – 2.27)	0.022	1.78 (1.12 - 2.84)	0.016
Secondary	1.64 (1.15 – 2.34)	0.006	1.95 (1.22 - 3.11)	0.005
Higher	1.95 (1.27 – 3.00)	0.002	2.24 (1.31 - 3.84)	0.003
Wealth quintile				
Lowest	1.00 (reference)		1.00 (reference)	
Second	1.11 (0.85 – 1.45)	0.464	1.01 (0.83 - 1.23)	0.909
Middle	1.04 (0.79 – 1.35)	0.794	0.86 (0.64 - 1.16)	0.323
Fourth	1.12 (0.86 – 1.44)	0.406	0.79 (0.62 - 1.01)	0.061
Highest	1.02 (0.79 – 1.34)	0.860	0.60 (0.45 - 0.81)	0.001
Residence type				
Urban	1.00 (reference)		1.00 (reference)	
Rural	0.87 (0.75 – 1.02)	0.095	0.89 (0.71 - 1.11)	0.301
Marital status				
Never married	1.00 (reference)		1.00 (reference)	
Currently married	1.51 (1.25 – 1.84)	<0.001	1.18 (0.99 - 1.41)	0.060
Living with partner	1.68 (1.36 – 2.06)	<0.001	1.32 (1.05 - 1.66)	0.015
Formerly/ ever married	1.42 (1.06 – 1.91)	0.020	1.11 (0.82 - 1.51)	0.511
Occupation				
Professional	1.00 (reference)		1.00 (reference)	
Agricultural	0.69 (0.45 – 1.07)	0.099	0.99 (0.58 - 1.68)	0.956
Manual	0.75 (0.56 – 1.01)	0.056	1.09 (0.82 - 1.44)	0.557
Unemployed	0.83 (0.71 – 0.99)	0.034	1.10 (0.95 - 1.28)	0.218
Ethnicity*				
Afrikaans	1.00 (reference)		1.00 (reference)	
Damara/Nama	1.23 (0.92 - 1.65)	0.162	1.26 (0.92 - 1.71)	0.148
Herero	1.12 (0.80 - 1.56)	0.519	1.17 (0.79 - 1.72)	0.436
Oshiwambo	0.83 (0.64 - 1.08)	0.169	0.84 (0.65 - 1.08)	0.166
Other	0.91 (0.68 - 1.22)	0.545	0.87 (0.72 - 1.06)	0.172

*n=14,436 | RR: risk ratio | 95% CI: 95% confidence interval | Model 1: Univariable model | Model 3: Adjusted for regional, enumeration area and household clustering and all other covariates in the table | Model 2 as described in methods not shown

Appendix 4

Appendix 4: additional analyses for Chapter 4 with the definition of the hyperglycaemia variable including self-reported diagnosis.

Table 1: The prevalence and distribution of hyperglycaemia by sociodemographic risk factors (n=3,255)

Sociodemographic factors	No hyperglycaemia No. (%)	Hyperglycaemia No. (%)	*p*
Sex			
Men	1,268 (94.1)	80 (5.9)	0.696
Women	1,800 (94.4)	107 (5.6)	
Age group			
34 – 39	767 (95.4)	35 (4.4)	0.005
40 – 44	649 (95.4)	31 (4.6)	
45 – 49	544 (95.1)	28 (4.9)	
50 – 54	484 (92.9)	37 (7.1)	
55 – 59	326 (92.9)	25 (7.1)	
60 – 64	298 (90.6)	31 (9.4)	
Education level			
No education	490 (96.1)	20 (3.9)	0.012
Primary	1,043 (94.6)	60 (5.4)	
Secondary	1,315 (94.1)	83 (5.9)	
Higher	220 (90.2)	24 (9.8)	
Wealth quintile			
Lowest	548 (97.2)	16 (2.8)	<0.001
Second	573 (96.3)	22 (3.7)	
Middle	617 (96.1)	25 (3.9)	
Fourth	705 (92.5)	57 (7.5)	
Highest	625 (90.3)	67 (9.7)	
Residence type			
Urban	1,406 (92.6)	113 (7.4)	<0.001
Rural	1,662 (95.7)	74 (4.3)	
Total	3,068 (94.3)	187 (5.8)	

p value corresponds to chi-squared test

Table 2: Distribution of hyperglycaemia by behavioural and biophysical risk factors (n=3,255)

Potential risk factors	No hyperglycaemia No. (%)	Hyperglycaemia No. (%)	*p*	Total No. (%)
Levels of obesity				
Not overweight/obese	1,801 (96.4)	68 (3.6)	<0.001	1,869 (100.0)
Overweight	674 (92.6)	54 (7.4)		728 (100.0)
Obese	593 (90.1)	65 (9.9)		658 (100.0)
Smoking*				
Non-smoking	2,390 (94.5)	138 (5.5)	0.269	2,528 (100.0)
Current smoker	595 (93.4)	42 (6.6)		637 (100.0)
Fruit and vegetable intake				
Adequate intake	271 (92.9)	24 (8.1)	0.064	295 (100.0)
Low intake	2,797 (94.5)	163 (5.5)		2,960 (100.0)
Hypertension				
Non-hypertensive	1,951 (95.1)	101 (4.9)	0.008	2,052 (100.0)
Hypertensive	1,117 (92.9)	86 (7.2)		1,203 (100.0)
Clustering of risk factors*				
0	102 (93.7)	8 (7.3)	<0.001	110 (100.0)
1	1,255 (95.8)	55 (4.2)		1,310 (100.0)
2	1,192 (94.9)	64 (5.1)		1,256 (100.0)
3	404 (89.4)	48 (10.6)		452 (100.0)
4	32 (86.5)	5 (13.5)		37 (100.0)

*N=3,165 with complete data on fasting plasma glucose, body mass index, diet and smoking | *p* value corresponds to chi-squared test

Table 3: Association between hyperglycaemia and sociodemographic, biophysical and behavioural risk factors

Potential risk factors	Model 1 (n=3,255)		Model 2 (n=3,255)		Model 3 (n=3,165)	
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*
Sex						
Men	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Women	0.95 (0.71 - 1.26)	0.704	0.97 (0.71 - 1.31)	0.824	0.86 (0.62 - 1.19)	0.369
Age group						
34 – 39	1.00 (reference)		1.00 (reference)		1.00 (reference)	
40 – 44	1.05 (0.65 - 1.69)	0.860	1.04 (0.67 - 1.60)	0.877	0.93 (0.61 - 1.42)	0.734
45 – 49	1.12 (0.68 - 1.84)	0.651	1.06 (0.62 - 1.80)	0.840	0.92 (0.61 - 1.42)	0.745
50 – 54	1.63 (1.03 - 2.58)	0.039	1.62 (1.08 - 2.41)	0.019	1.42 (0.93 - 2.19)	0.108
55 – 59	1.63 (0.98 - 2.73)	0.061	1.59 (1.04 - 2.43)	0.033	1.44 (0.97 - 2.15)	0.070
60 – 64	2.16 (1.33 - 3.50)	0.002	2.16 (1.61 - 2.88)	<0.001	2.02 (1.49 - 2.74)	<0.001
Education level						
No education	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Primary	1.39 (0.84 - 2.30)	0.205	1.26 (0.74 - 2.12)	0.393	1.29 (0.73 - 2.29)	0.375
Secondary	1.51 (0.93 - 2.47)	0.096	1.38 (0.92 - 2.06)	0.120	1.15 (0.75 - 1.78)	0.527
Higher	2.51 (1.39 - 4.54)	0.002	2.39 (1.23 - 4.66)	0.010	1.47 (0.78 - 2.76)	0.232
Wealth quintile						
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Second	1.30 (0.69 - 2.48)	0.420	1.25 (0.74 - 2.10)	0.408	1.17 (0.66 - 2.10)	0.591
Middle	1.37 (0.73 - 2.57)	0.322	1.33 (0.72 - 2.46)	0.358	1.06 (0.50 - 2.25)	0.889
Fourth	2.64 (1.51 - 4.59)	0.001	2.56 (1.54 - 4.27)	<0.001	1.63 (0.94 - 2.83)	0.083
Highest	3.41 (1.98 - 5.89)	<0.001	3.38 (1.92 - 5.93)	<0.001	1.95 (0.85 - 4.45)	0.115
Residence type						
Urban	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Rural	0.57 (0.43 - 0.77)	<0.001	0.58 (0.42 - 0.81)	0.001	0.81 (0.60 - 1.08)	0.149
Obesity level						
Normal or underweight	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Overweight	2.04 (1.43 - 2.91)	<0.001	1.93 (1.41 - 2.64)	<0.001	1.67 (1.23 - 2.27)	0.001
Obese	2.72 (1.93 - 3.82)	<0.001	2.50 (1.53 - 4.09)	<0.001	2.09 (1.31 - 3.33)	0.002
Hypertension						
Not hypertensive	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Hypertensive	1.45 (1.09 - 1.94)	0.011	1.41 (0.94 - 2.11)	0.097	1.22 (0.81 - 1.89)	0.346
Low fruit and vegetable intake						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	0.68 (0.44 - 1.04)	0.074	0.70 (0.49 - 1.00)	0.047	0.92 (0.66 - 1.27)	0.596
Current smoker*						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	1.21 (0.86 - 1.71)	0.284	0.96 (0.74 - 1.25)	0.757	1.16 (0.90 - 1.49)	0.254

*n=3,165 due to 90 with missing data on smoking | Model 1: univariable Poisson regression | Model 2: Univariable mixed effects analyses adjusted for regional, EA and household clustering | Model 3: fully-adjusted multivariable mixed effects analysis, adjusted for clustering and all other exposures in the table | RR: Risk Ratio | 95% CI: 95% Confidence Interval

Table 4: Co-morbidity and multimorbidity of HIV, hypertension and hyperglycaemia (n=3,179)				
Co- and multi-morbidity scenarios	**Neither condition** No. (%)	**One condition** No. (%)	**Two conditions** No. (%)	**Three conditions** No. (%)
Co-morbidity of hyperglycaemia and hypertension	1,902 (59.8)	1,195 (37.6)	82 (2.6)	—
Co-morbidity of HIV and hypertension	1,564 (49.2)	1,423 (44.8)	192 (6.0)	—
Co-morbidity of HIV and hyperglycaemia	2,399 (75.5)	752 (23.7)	28 (0.9)	—
Multi-morbidity of HIV, hypertension and hyperglycaemia	1,488 (46.8)	1,401 (44.1)	284 (8.9)	6 (0.2)

HIV: human immunodeficiency virus | prevalence estimates refer to those aged 35–64 years with complete information on sex, education, fasting plasma glucose measurement, blood pressure measurement and a HIV test result

Appendix 5

Appendix 5: Additional tables for Chapter 5.

Table 1: Multivariable association between IRS and exposures of interest (n=9,597)						
Exposures of interest	Model 1		Model 2		Model 3	
	RR (95%CI)	*p*	RR (95%CI)	*p*	RR (95%CI)	*p*
Residence type						
Urban	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Rural	6.41 (5.56 - 7.40)	<0.001	4.53 (1.94 – 10.54)	<0.001	5.02 (2.36 – 10.70)	<0.001
Wealth quintile						
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Second	0.71 (0.63 - 0.80)	<0.001	1.12 (1.00 - 1.25)	0.044	1.16 (1.04 - 1.29)	0.007
Middle	0.50 (0.43 - 0.57)	<0.001	1.11 (0.97 - 1.27)	0.119	1.20 (1.05 - 1.37)	0.009
Fourth	0.32 (0.28 - 0.37)	<0.001	1.02 (0.75 - 1.41)	0.884	1.25 (0.95 - 1.65)	0.111
Highest	0.16 (0.13 - 0.20)	<0.001	1.11 (0.69 - 1.79)	0.658	1.63 (1.16 - 2.28)	0.004
Regional *Pf*PR$_{2\text{-}10}$						
<1%	1.00 (reference)		1.00 (reference)		1.00 (reference)	
1-<5%	15.83 (11.40 - 22.00)	<0.001	11.00 (1.80 – 67.34)	0.010	5.82 (1.00 – 34.05)	0.051
≥5%	23.42 (17.16 - 31.95)	<0.001	27.12 (12.98 – 56.67)	<0.001	14.54 (5.50 - 38.41)	<0.001

Model 1: univariable association between exposures of interest and IRS coverage | Model 2: Adjusted for regional and EA clustering | Model 3: Additionally adjusted for all other exposures of interest in the table | RR: risk ratio | 95% CI: 95% confidence interval | 95% confidence intervals generated using robust standard errors | EA: enumeration area | *Pf*PR$_{2\text{-}10}$: Plasmodium falciparum parasite rate in those aged 2 to 10 years | IRS: Indoor residual spraying

Table 2: Association of *Pf*PR$_{2-10}$ and wealth quintile with IRS, stratified by residence type

Exposures of interest	Urban				Rural			
	Model 1		Model 2		Model 1		Model 2	
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*
Wealth quintile								
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)	
Second	0.79 (0.27 - 2.28)	0.660	1.23 (0.76 – 1.98)	0.402	0.92 (0.81 - 1.04)	0.169	1.18 (1.06 - 1.31)	0.003
Middle	1.21 (0.44 - 3.36)	0.709	1.91 (1.17 – 3.12)	0.009	0.70 (0.61 - 0.81)	<0.001	1.16 (1.02 - 1.33)	0.029
Fourth	0.91 (0.33 - 2.51)	0.860	1.76 (0.91 – 3.38)	0.092	0.68 (0.57 - 0.81)	<0.001	1.25 (0.95 - 1.64)	0.107
Highest	0.79 (0.29 - 2.17)	0.652	2.44 (1.22 – 4.90)	0.012	0.48 (0.35 - 0.66)	<0.001	1.47 (1.02 - 2.10)	0.037
***Pf*PR$_{2-10}$**								
<1%	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)	
1-<5%	1.23 (0.51 - 2.97)	0.649	1.57 (0.62 – 3.99)	0.344	14.36 (8.39 - 24.58)	<0.001	9.86 (1.32 – 73.65)	0.026
≥5%	12.12 (8.09 - 18.16)	<0.001	11.69 (3.72 - 36.79)	<0.001	17.85 (10.54 - 30.23)	<0.001	22.14 (11.40 – 42.99)	<0.001

Model 1: Univariable | Model 2: Adjusted for EA and regional clustering and adjusted for other exposures of interest in the table | RR: risk ratio | 95% CI: 95% confidence interval | EA: enumeration area | IRS: Indoor residual spraying | *Pf*PR$_{2-10}$: Plasmodium falciparum parasite rate in those aged 2 to 10 years | 95% confidence intervals generated using robust standard errors

Table 3: Multivariable association between ITN ownership and exposures of interest (n=9,842)

Exposures of Interest	Model 1		Model 2		Model 3	
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*
Residence						
Urban	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Rural	2.04 (1.87 - 2.23)	<0.001	1.17 (0.96 - 1.42)	0.124	1.32 (1.12 - 1.57)	0.001
Wealth quintile						
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Second	0.88 (0.78 - 0.99)	0.036	1.17 (1.00 - 1.37)	0.048	1.20 (1.04 - 1.39)	0.014
Middle	0.83 (0.74 - 0.93)	0.002	1.32 (1.08 - 1.62)	0.007	1.39 (1.16 - 1.66)	<0.001
Fourth	0.64 (0.56 - 0.72)	<0.001	1.36 (1.05 - 1.76)	0.020	1.48 (1.18 - 1.86)	0.001
Highest	0.42 (0.36 - 0.48)	<0.001	1.29 (0.93 - 1.80)	0.130	1.49 (1.11 – 1.00)	0.008
Regional *Pf*PR$_{2-10}$						
<1%	1.00 (reference)		1.00 (reference)		1.00 (reference)	
1-<5%	6.39 (5.46 - 7.48)	<0.001	5.96 (2.46 - 14.47)	<0.001	5.92 (2.44 - 14.38)	<0.001
≥5%	5.26 (4.56 - 6.07)	<0.001	5.36 (3.10 - 9.27)	<0.001	5.32 (3.09 - 9.17)	<0.001

Model 1: univariable association between exposures of interest and ITN coverage | Model 2: Adjusted for regional and EA clustering | Model 3: Additionally adjusted for all other exposures of interest in the table | RR: risk ratio | 95% CI: 95% confidence interval | EA: enumeration area | *Pf*PR$_{2-10}$: Plasmodium falciparum parasite rate in those aged 2 to 10 years | ITN: Insecticide-treated net | 95% confidence intervals generated using robust standard errors

Table 4: Association of *Pf*PR$_{2-10}$ and wealth quintile with ITN ownership, stratified by residence type

Exposures of interest	Urban				Rural			
	Model 1		Model 2		Model 1		Model 2	
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*
Wealth quintile								
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)	
Second	1.35 (0.73 - 2.52)	0.342	1.60 (0.96 – 2.68)	0.074	0.98 (0.87 - 1.12)	0.807	1.18 (1.03 - 1.36)	0.018
Middle	1.51 (0.82 - 2.77)	0.186	1.86 (1.05 - 3.32)	0.034	0.95 (0.83 - 1.09)	0.457	1.35 (1.15 - 1.60)	<0.001
Fourth	1.13 (0.62 - 2.07)	0.686	1.78 (0.99 - 3.19)	0.052	0.95 (0.81 - 1.11)	0.510	1.56 (1.20 – 2.03)	0.001
Highest	0.94 (0.51 - 1.72)	0.843	1.95 (1.05 - 3.65)	0.036	0.57 (0.42 - 0.77)	<0.001	1.29 (0.91 - 1.83)	0.152
***Pf*PR$_{2-10}$**								
<1%	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)	
1-<5%	5.22 (4.15 - 6.57)	<0.001	5.63 (2.50 - 12.68)	<0.001	5.13 (3.93 - 6.68)	<0.001	5.67 (2.12 - 15.15)	0.001
≥5%	5.48 (4.55 - 6.59)	<0.001	6.19 (3.14 – 12.88)	<0.001	3.81 (2.96 - 4.92)	<0.001	4.62 (2.82 - 7.58)	<0.001

Model 1: Univariable | Model 2: Adjusted for EA and regional clustering and adjusted for other exposures of interest in the table | RR: risk ratio | 95% CI: 95% confidence interval | ITN: Insecticide treated net | EA: enumeration area | RR: risk ratio | *Pf*PR$_{2-10}$: Plasmodium falciparum parasite rate in those aged 2 to 10 years | 95% confidence intervals generated using robust standard errors

Table 5: Association of exposures of interest with coverage of IRS and/or an ITN in Namibia in 2013 (n=9,597)

Exposure of interest	Model 1		Model 2		Model 3	
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*
Residence type						
Urban	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Rural	2.56 (2.37 – 2.77)	<0.001	1.47 (1.20 – 1.81)	<0.001	1.62 (1.37 – 1.93)	<0.001
Wealth quintile						
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Second	0.80 (0.72 – 0.88)	<0.001	1.07 (0.96 – 1.19)	0.252	1.12 (1.01 – 1.23)	0.026
Middle	0.69 (0.62 – 0.76)	<0.001	1.12 (0.97 – 1.31)	0.128	1.22 (1.09 – 1.37)	0.001
Fourth	0.51 (0.46 – 0.57)	<0.001	1.10 (0.87 – 1.39)	0.429	1.29 (1.08 – 1.54)	0.005
Highest	0.33 (0.29 – 0.38)	<0.001	1.07 (0.77 – 1.48)	0.698	1.36 (1.05 – 1.77)	0.018
Regional *Pf*PR$_{2\text{-}10}$						
<1%	1.00 (reference)		1.00 (reference)		1.00 (reference)	
1-<5%	6.27 (5.41 – 7.28)	<0.001	5.72 (2.36 – 13.86)	<0.001	5.05 (2.14 – 11.91)	<0.001
≥5%	6.88 (6.03 – 7.85)	<0.001	6.96 (4.27 – 11.33)	<0.001	6.10 (3.76 – 9.91)	<0.001

Model 1: univariable association between exposures of interest and IRS and/or ITN coverage | Model 2: Adjusted for regional and EA clustering | Model 3: Additionally adjusted for all other exposures of interest in the table | RR: risk ratio | 95% CI: 95% confidence interval | *Pf*PR$_{2\text{-}10}$: Plasmodium falciparum parasite rate in those aged 2 to 10 years | ITN: Insecticide-treated net | IRS: Indoor residual spraying | 95% confidence intervals generated using robust standard errors | EA: enumeration area

Table 6: Association between vector control intervention and exposures of interest (n=9,597)						
Exposures of interest	IRS		ITN*		IRS and/or ITN	
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*
MSP Zone						
3	1.00 (reference)		1.00 (reference)		1.00 (reference)	
2	6.99 (2.52- 19.39)	<0.001	3.11 (1.59 – 6.08)	0.001	3.89 (2.20 – 6.86)	<0.001
1	11.62 (4.45 - 30.39)	<0.001	5.36 (2.95 – 9.73)	<0.001	5.62 (3.37 – 9.37)	<0.001
Wealth quintile						
Lowest	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Second	1.16 (1.05 - 1.30)	0.006	1.21 (1.04 - 1.40)	0.014	1.12 (1.01 - 1.25)	0.029
Middle	1.21 (1.05 - 1.39)	0.010	1.40 (1.16 - 1.70)	0.001	1.23 (1.09 - 1.40)	0.001
Fourth	1.27 (0.95 - 1.70)	0.114	1.51 (1.18 - 1.93)	0.001	1.31 (1.08 - 1.59)	0.007
Highest	1.66 (1.17 - 2.37)	0.005	1.52 (1.11 – 2.09)	0.010	1.39 (1.05 - 1.84)	0.023
Residence type						
Urban	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Rural	4.71 (2.23 – 9.97)	<0.001	1.27 (1.07 - 1.51)	0.006	1.57 (1.35 - 1.82)	<0.001

*N=9,846 households

MSP: Malaria Strategic Plan | IRS: Indoor residual spraying | ITN: Insecticide-treated net | EA: Enumeration Area | EA: enumeration area | RR: risk ratio | 95% CI: 95% confidence interval | 95% confidence intervals generated using robust standard errors

Table 7: Table showing the differences in intervention coverage by various models of EA *Pf*PR$_{2-10}$

	IRS				ITN			ITN and/or IRS		
	No No. (%)	**Yes** No. (%)	**don't know** No. (%)	***p***	**No ITN** No. (%)	**At least one ITN** No. (%)	***p***	**None** No. (%)	**ITN and/or IRS** No. (%)	***p***
EA *Pf*PR$_{2-10}$ Model A										
<1%	3,942 (95.1)	110 (2.7)	95 (2.3)	<0.001	3,791 (91.4)	359 (8.7)	<0.001	3,627 (89.5)	425 (10.5)	<0.001
1-<5%	776 (66.6)	355 (30.5)	34 (2.9)		607 (51.1)	558 (47.9)		457 (40.4)	674 (59.6)	
≥5%	3,203 (70.7)	1,211 (26.7)	116 (2.6)		3,075 (67.9)	1,456 (32.1)		2,286 (51.8)	2,128 (48.2)	
EA *Pf*PR$_{2-10}$ Model B										
<1%	3,810 (94.9)	109 (2.7)	95 (2.4)	<0.001	3,682 (91.7)	335 (8.3)	<0.001	3,519 (89.8)	400 (10.2)	<0.001
1-<5%	776 (66.6)	355 (30.5)	34 (2.9)		607 (52.1)	558 (47.9)		457 (40.4)	674 (59.6)	
≥5%	3,335 (71.5)	1,212 (26.0)	116 (2.5)		3,184 (68.3)	1,480 (31.7)		2,394 (52.7)	2,153 (47.4)	
EA *Pf*PR$_{2-10}$ Model C										
<1%	3,612 (95.1)	95 (2.5)	90 (2.4)	<0.001	3,499 (92.1)	301 (7.9)	<0.001	3,349 (90.3)	358 (9.7)	<0.001
1-<5%	776 (66.6)	355 (30.5)	34 (2.9)		607 (52.1)	558 (47.9)		457 (40.4)	674 (59.6)	
≥5%	3,533 (72.4)	1,226 (25.1)	121 (2.5)		3,367 (69.0)	1,514 (31.0)		2,564 (53.9)	2,195 (46.1)	
EA *Pf*PR$_{2-10}$ Model D										
<1%	3,541 (96.1)	56 (1.5)	88 (2.4)	<0.001	3,411 (92.5)	277 (7.5)	<0.001	3,288 (91.4)	309 (8.6)	<0.001
1-<5%	776 (66.6)	355 (30.5)	34 (2.9)		607 (52.1)	558 (47.9)		457 (40.4)	674 (59.6)	
≥5%	3,604 (72.2)	1,265 (25.3)	123 (2.5)		3,455 (69.2)	1,538 (30.8)		2,625 (53.9)	2,244 (46.1)	

*Pf*PR$_{2-10}$: Plasmodium falciparum parasite rate in those aged 2 to 10 years | IRS: Indoor residual spraying | ITN: Insecticide-treated net | EA: enumeration area
Model A: EA *Pf*PR where EAs outside of the *Pf*PR raster boundary were assigned a value of zero
Model B: EA *Pf*PR where EAs at a distance >5 Km from the nearest raster cell were assigned a value of zero
Model C: EA *Pf*PR where EAs at a distance >10 Km from the nearest raster cell were assigned a value of zero
Model D: EA *Pf*PR where EAs at a distance >20 Km from the nearest raster cell were assigned a value of zero

Table 8: Comparison of regional *Pf*PR_{2-10}, EA *Pf*PR_{2-10}(Model B*) and MSP Zones for predicting the likelihood of having IRS, an ITN or either intervention.

Models		IRS			ITN			IRS and/or ITN		
		RR (95% CI)	*p*	LR test *p*	RR (95% CI)	*p*	LR test *p*	RR (95% CI)	*p*	LR test *p*
Model 1:	**Regional *Pf*PR_{2-10}**	3.71 (2.29 - 6.02)	<0.001		2.20 (1.57 - 3.10)	<0.001		2.38 (1.78 - 3.19)	<0.001	
Model 2:	**Regional *Pf*PR_{2-10}**	4.29 (2.53 - 7.28)	<0.001	0.1858	2.30 (1.61 - 3.29)	<0.001	0.4534	2.50 (1.85 - 3.39)	<0.001	0.2751
	EA *Pf*PR_{2-10}*	0.85 (0.66 - 1.08)	0.183		0.95 (0.84 - 1.08)	0.452		0.95 (0.86 - 1.05)	0.273	
Model 3:	**Regional *Pf*PR_{2-10}**	2.40 (1.41 - 4.10)	0.001	0.0091	1.43 (1.04 - 1.97)	0.029	0.0001	1.71 (1.31 - 2.34)	<0.001	<0.0001
	MSP Zone	1.69 (1.15 - 2.50)	0.008		1.69 (1.31 - 2.18)	<0.001		1.50 (1.24 - 1.81)	<0.001	

* Model B: EA *Pf*PR_{2-10} model assigns EAs the raster cell value up to 5 Km away

RR: risk ratio | 95% CI: 95% confidence interval | *Pf*PR_{2-10} : Plasmodium falciparum parasite rate in those aged 2 to 10 years | ITN: Insecticide-treated net | IRS: Indoor residual spraying | LR test: Likelihood ratio test | EA: enumeration area | MSP: Malaria Strategic Plan | LR test *p* value corresponds to a likelihood ratio test where Model 1 is nested in Model 2 and Model 3, respectively .

Model 1: Association between regional *Pf*PR_{2-10} and interventions, adjusted for wealth and residence type, with region and enumeration area added as mixed effects

Model 2: Same as Model 1 but additionally adjusted for EA *Pf*PR_{2-10}

Model 3: Same as Model 1 but additionally adjusted for MSP Zones

Table 9: Comparison of regional *Pf*$PR_{2\text{-}10}$, EA *Pf*$PR_{2\text{-}10}$(Model C*) and MSP Zones for predicting the likelihood of having IRS, an ITN or either intervention.

Models		IRS			ITN			IRS and/or ITN		
		RR (95% CI)	*p*	LR test *p*	RR (95% CI)	*p*	LR test *p*	RR (95% CI)	*p*	LR test *p*
Model 1:	**Regional *Pf*$PR_{2\text{-}10}$**	3.71 (2.29 - 6.02)	<0.001		2.20 (1.57 - 3.10)	<0.001		2.38 (1.78 - 3.19)	<0.001	
Model 2:	**Regional *Pf*$PR_{2\text{-}10}$**	4.26 (2.51 - 7.25)	<0.001	0.2369	2.34 (1.63 - 3.37)	<0.001	0.3333	2.54 (1.87 - 3.44)	<0.001	0.2120
	EA *Pf*$PR_{2\text{-}10}$*	0.85 (0.66 - 1.11)	0.234		0.94 (0.82 - 1.07)	0.332		0.93 (0.84 - 1.04)	0.209	
Model 3:	**Regional *Pf*$PR_{2\text{-}10}$**	2.40 (1.41 - 4.10)	0.001	0.0091	1.43 (1.04 - 1.97)	0.029	0.0001	1.71 (1.31 - 2.34)	<0.001	<0.0001
	MSP Zone	1.69 (1.15 - 2.50)	0.008		1.69 (1.31 - 2.18)	<0.001		1.50 (1.24 - 1.81)	<0.001	

* Model C: EA Pf$PR_{2\text{-}10}$ model assigns EAs the raster cell value up to 10 Km away

RR: risk ratio | 95% CI: 95% confidence interval | *Pf*$PR_{2\text{-}10}$: Plasmodium falciparum parasite rate in those aged 2 to 10 years | ITN: Insecticide-treated net | IRS: Indoor residual spraying | LR test: Likelihood ratio test | EA: enumeration area | MSP: Malaria Strategic Plan | LR test *p* value corresponds to a likelihood ratio test where Model 1 is nested in Model 2 and Model 3, respectively.

Model 1: Association between regional *Pf*$PR_{2\text{-}10}$ and interventions, adjusted for wealth and residence type, with region and enumeration area added as mixed effects

Model 2: Same as Model 1 but additionally adjusted for EA *Pf*$PR_{2\text{-}10}$

Model 3: Same as Model 1 but additionally adjusted for MSP Zones

Table 10: Comparison of regional *Pf*PR$_{2-10}$, EA *Pf*PR$_{2-10}$ (Model D*) and MSP Zones for predicting the likelihood of having IRS, an ITN or either intervention.

Models		IRS			ITN			IRS and/or ITN		
		RR (95% CI)	*p*	LR test *p*	RR (95% CI)	*p*	LR test *p*	RR (95% CI)	*p*	LR test *p*
Model 1:	**Regional *Pf*PR$_{2-10}$**	3.71 (2.29 - 6.02)	<0.001		2.20 (1.57 - 3.10)	<0.001		2.38 (1.78 - 3.19)	<0.001	
Model 2:	**Regional *Pf*PR$_{2-10}$**	3.41 (1.97 - 5.92)	<0.001	0.5319	2.34 (1.62 - 3.38)	<0.001	0.3728	2.43 (1.78 - 3.31)	<0.001	0.7514
	EA *Pf*PR$_{2-10}$*	1.10 (0.82 - 1.47)	0.532		0.94 (0.81 - 1.08)	0.371		0.98 (0.87 - 1.10)	0.751	
Model 3:	**Regional *Pf*PR$_{2-10}$**	2.40 (1.41 - 4.10)	0.001	0.0091	1.43 (1.04 - 1.97)	0.029	0.0001	1.71 (1.31 - 2.34)	<0.001	<0.0001
	MSP Zone	1.69 (1.15 - 2.50)	0.008		1.69 (1.31 - 2.18)	<0.001		1.50 (1.24 - 1.81)	<0.001	

* Model D: EA *Pf*PR$_{2-10}$ model assigns EAs the raster cell value up to 20 Km away

RR: risk ratio | 95% CI: 95% confidence interval | *Pf*PR$_{2-10}$: Plasmodium falciparum parasite rate in those aged 2 to 10 years | ITN: Insecticide-treated net | IRS: Indoor residual spraying | LR test: Likelihood ratio test | EA: enumeration area | MSP: Malaria Strategic Plan | LR test *p* value corresponds to a likelihood ratio test where Model 1 is nested in Model 2 and Model 3, respectively.

Model 1: Association between regional *Pf*PR$_{2-10}$ and interventions, adjusted for wealth and residence type, with region and enumeration area added as mixed effects

Model 2: Same as Model 1 but additionally adjusted for EA *Pf*PR$_{2-10}$

Model 3: Same as Model 1 but additionally adjusted for MSP Zones

Table 11: Comparison of regional $PfPR_{2\text{-}10}$, EA $PfPR_{2\text{-}10}$ and MSP Zones for predicting the likelihood of having IRS, an ITN or either intervention

Models		IRS			ITN			IRS and/or ITN		
		RR (95% CI)	p	LR test p	RR (95% CI)	p	LR test p	RR (95% CI)	p	LR test p
Model 1:	**Regional $PfPR_{2\text{-}10}$**	3.81 (2.33 – 6.22)	<0.001		2.17 (1.54 – 3.07)	<0.001		2.41 (1.80 - 3.24)	<0.001	
Model 2:	**Regional $PfPR_{2\text{-}10}$**	4.24 (2.50 – 7.18)	<0.001	0.2696	2.25 (1.06 – 1.36)	<0.001	0.5441	2.53 (1.86 – 3.45)	<0.001	0.2659
	EA $PfPR_{2\text{-}10}$	0.88 (0.70 – 1.10)	0.267		0.96 (0.84 – 1.10)	0.544		0.94 (0.95 – 1.05)	0.264	
Model 3:	**Regional $PfPR_{2\text{-}10}$**	2.94 (1.65 – 5.22)	0.001	0.1638	1.25 (0.88 – 1.77)	0.207	0.0001	1.73 (1.29 – 2.32)	<0.001	0.0006
	MSP Zone	1.37 (0.88 – 2.12)	0.159		1.93 (1.41 – 2.64)	<0.001		1.50 (1.19 – 1.89)	0.001	

These analyses include a subset of households in EAs for which a mean $PfPR_{2\text{-}10}$ value was obtained (IRS N=8,511; ITN N=8,727; ITN and/or IRS N=8,511 households)

RR: risk ratio | 95% CI: 95% confidence interval | $PfPR_{2\text{-}10}$: Plasmodium falciparum parasite rate in those aged 2 to 10 years | ITN: Insecticide-treated net | IRS: Indoor residual spraying | LR test: Likelihood ratio test | EA: Enumeration area | MSP: Malaria Strategic Plan | LR test *p* value corresponds to a likelihood ratio test where Model 1 is nested in Model 2 and Model 3, respectively.

Model 1: Association between regional $PfPR_{2\text{-}10}$ and interventions, adjusted for wealth and residence type, with region and enumeration area added as mixed effects

Model 2: Same as Model 1 but additionally adjusted for EA $PfPR_{2\text{-}10}$

Model 3: Same as Model 1 but additionally adjusted for MSP Zones

Table 12: Comparison of regional *Pf*PR$_{2-10}$, mean EA *Pf*PR$_{2-10}$ and MSP Zones for predicting the likelihood of having IRS, an ITN or either intervention

	Models	IRS			ITN			IRS and/or ITN		
		RR (95% CI)	*p*	LR test *p*	RR (95% CI)	*p*	LR test *p*	RR (95% CI)	*p*	LR test *p*
Model 1:	**Regional *Pf*PR$_{2-10}$**	3.81 (2.33 – 6.22)	<0.001		2.17 (1.54 – 3.07)	<0.001		2.41 (1.80 - 3.24)	<0.001	
Model 2:	**Regional *Pf*PR$_{2-10}$**	4.05 (2.40 – 6.82)	<0.001	0.5002	2.18 (1.52 – 3.12)	<0.001	0.5441	2.46 (1.81 – 3.34)	<0.001	0.6507
	Mean EA *Pf*PR$_{2-10}$	0.93 (0.74 – 1.16)	0.499		1.00 (0.87 – 1.14)	0.953		0.98 (0.88 – 1.08)	0.650	
Model 3:	**Regional *Pf*PR$_{2-10}$**	2.94 (1.65 – 5.22)	0.001	0.1638	1.25 (0.88 – 1.77)	0.207	0.0001	1.73 (1.29 – 2.32)	<0.001	0.0006
	MSP Zone	1.37 (0.88 – 2.12)	0.159		1.93 (1.41 – 2.64)	<0.001		1.50 (1.19 – 1.89)	0.001	

These analyses include a subset of households in EAs for which a mean *Pf*PR$_{2-10}$ value was obtained (IRS N=8,511; ITN N=8,727; ITN and/or IRS N=8,511 households)
RR: risk ratio | 95% CI: 95% confidence interval | *Pf*PR$_{2-10}$: Plasmodium falciparum parasite rate in those aged 2 to 10 years | ITN: Insecticide-treated net | IRS: Indoor residual spraying | LR test: Likelihood ratio test | EA: enumeration area | MSP: Malaria Strategic Plan | LR test *p* value corresponds to a likelihood ratio test where Model 1 is nested in Model 2 and Model 3, respectively.
Model 1: Association between regional *Pf*PR$_{2-10}$ and interventions, adjusted for wealth and residence type, with region and enumeration area added as mixed effects
Model 2: Same as Model 1 but additionally adjusted for EA *Pf*PR$_{2-10}$
Model 3: Same as Model 1 but additionally adjusted for MSP Zones

Table 13: ITNs identified in the 2013 Namibia DHS and the time obtained

ITN indicator	N (%)
Total ITNs observed	4372
Nets obtained ≤1 year previous	2011 (49.0)
Nets obtained ≤2 years previous	474 (11.6)
Nets obtained ≤3 years previous	108 (2.6)
Nets obtained >3 years previous	1,507 (36.8)
Total ITNs with date obtained	4100 (100.0)

ITN: insecticide-treated net

Table 14: Intervention coverage by $PfPR_{2-10}$ categories where Zambezi is allocated to the ≥5% category

Re-categorized PfPR*	Intervention coverage No. (%)			
	At least one ITN	IRS in previous 12 months	ITN and IRS	ITN and/or IRS
<1%	213 (6.1)	41 (1.2)	8 (0.2)	241 (7.1)
1-<5%	150 (20.9)	21 (2.9)	7 (1.0)	163 (23.0)
≥5%	2,010 (35.5)	1,614 (28.5)	759 (13.8)	2,823 (51.3)

**Pf*PR_{2-10} re-categorized to include Zambezi in the *Pf*PR_{2-10} ≥5%category
PfPR_{2-10}: Plasmodium falciparum parasite rate in those aged 2 to 10 years | ITN: insecticide-treated net | IRS: indoor residual spraying