Cancer incidence by Ethnic Group in England, 2001-2007.

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This dissertation is submitted for the degree of Doctor of Medicine.

Declaration

This dissertation is the result of my own work and includes nothing which is the outcome of work done in collaboration except as declared in the Preface and specified in the text.

It is not substantially the same as any that I have submitted, or, is being concurrently submitted for a degree or diploma or other qualification at the University of Cambridge or any other University or similar institution except as declared in the Preface and specified in the text. I further state that no substantial part of my dissertation has already been submitted, or, is being concurrently submitted for any such degree, diploma or other qualification at the University of Cambridge or any other University of similar institution except as declared in the Preface and specified in the text.

It does not exceed the prescribed word limit of 60,000 words.”

Raghib Ali, February 2021

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Summary

Background

There are large unexplained variations in the incidence of many cancers globally and the incidence of cancer in migrant populations can contribute to our understanding of aetiology for cancers for which there are few established risk factors. Studying different ethnic groups in the same country overcomes the limitations of some international comparisons as similar diagnostic methods, reporting and registration procedures are used.
The primary objective of this study is to compare the incidence of all major cancers in the six main 'non-White' ethnic groups in England to each other and to Whites using self-assigned ethnicity. A secondary objective is to compare these incidences with their countries of origin.

Methods

All cancer registrations from 2001–2007 in England were analysed. Ethnicity was obtained by linkage to the Hospital Episodes Statistics database and mid-year population estimates from 2001-2007 from the Office for National Statistics. Age-standardised incidence rates were calculated for all ethnic groups and incidence rate ratios (adjusted for age, sex and income) were calculated comparing the six non-White ethnic groups (and combined 'South Asian' and 'Black' groups) to Whites and to each other.

Results

There were significant differences in the incidence of nearly all cancers between the ethnic groups. In general, incidence was lower in non-White ethnic groups, but there was considerable variation with South Asians having higher rates of head & neck, liver, gallbladder, Hodgkin lymphoma and thyroid cancer and Blacks having higher rates of stomach, liver, gallbladder, prostate, endometrium, non-Hodgkin lymphoma, myeloma, thyroid and childhood cancers. There also was strong evidence of differences in risk between Indians, Pakistanis and Bangladeshis for most cancers and between Black Africans and Black Caribbeans for many.

Conclusions

The risk of most cancers varies greatly by individual ethnic group, including within those groups that have traditionally been grouped together (South Asians and Blacks). Many of these differences are not readily explained by known risk factors and suggest that important, potentially modifiable causes of these cancers are still to be discovered.

In order to understand why these differences exist and the relative contribution of genetic and environmental factors, a large, prospective cohort study of non-White ethnic groups in the UK with individual level risk-factor information is needed.

Cancer incidence by Ethnic Group in England, 2001-2007.

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List of abbreviations used.

HES – Hospital Episodes Statistics

NCIN – National Cancer Intelligence Network

CNS – central nervous system

ICD-10 – International Classifications of Diseases, 10th Revision

ICD-O-2/3 – International Classifications of Diseases of Oncology, 2nd/3rd Revisions

IMD 2007 – Index of Multiple Deprivation 2007

ONS – Office of National Statistics

ICCC-3 – International Classification of Childhood Cancer, 3rd Edition

ASR – age-standardised rates

(I)RR – (incidence) rate ratios

(F)CI – (floating) confidence intervals

HIV – Human Immunodeficiency Virus

HPV – Human Papilloma Virus

HRT – Hormone Replacement Therapy

SNP – Single Nucleotide Polymorphism

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1. Introduction

1.1 International comparisons & migrant studies

"In the development of knowledge about the cause of a disease, the first and most difficult stage is the search for clues on which hypotheses can be based. In this search, no road can be guaranteed to lead to success, but if past experience is any guide, one of the most rewarding is likely to be that which leads to a comparison of the frequency with which the disease occurs in different communities in different areas and at different times."

Sir Richard Doll, Introduction to "Cancer Incidence in Five Continents", 1966.[2]

Since this first edition of 'Cancer in Five Continents in 1966', it has been recognised that there are large global variations (more than 3 fold) in the incidence for 'All cancers' (excluding non-melanoma skin cancer) as shown in Figure 1.1 (by country) and Figure 1.2 (by region.) [1]

Such global variation is seen for almost every cancer - for example there is a 10-fold difference in colorectal cancer between the highest and lowest incidence countries - and breast and prostate cancer are roughly twice as common in developed compared to developing countries but the reverse is true of cervical and liver cancers. [1]

However, many of these international comparisons are of limited value and reliability as the quality and coverage of cancer registration varies greatly, particularly between developed and developing countries - which often have lower rates for many cancers. [1] Therefore, rates in many developing countries (e.g. particularly in South Asia and sub-Saharan Africa) are underestimated due to the systematic biases of under-diagnosis and under-ascertainment, particularly in rural areas. [1] There are also systematic variations between health systems (e.g. government-provided versus out-of-pocket) which affect the way different populations access care. Differences in the provision of screening programs will also affect the incidence of those cancers where screening is used (e.g. Breast, Cervical, Prostate, Colorectal.) [1].

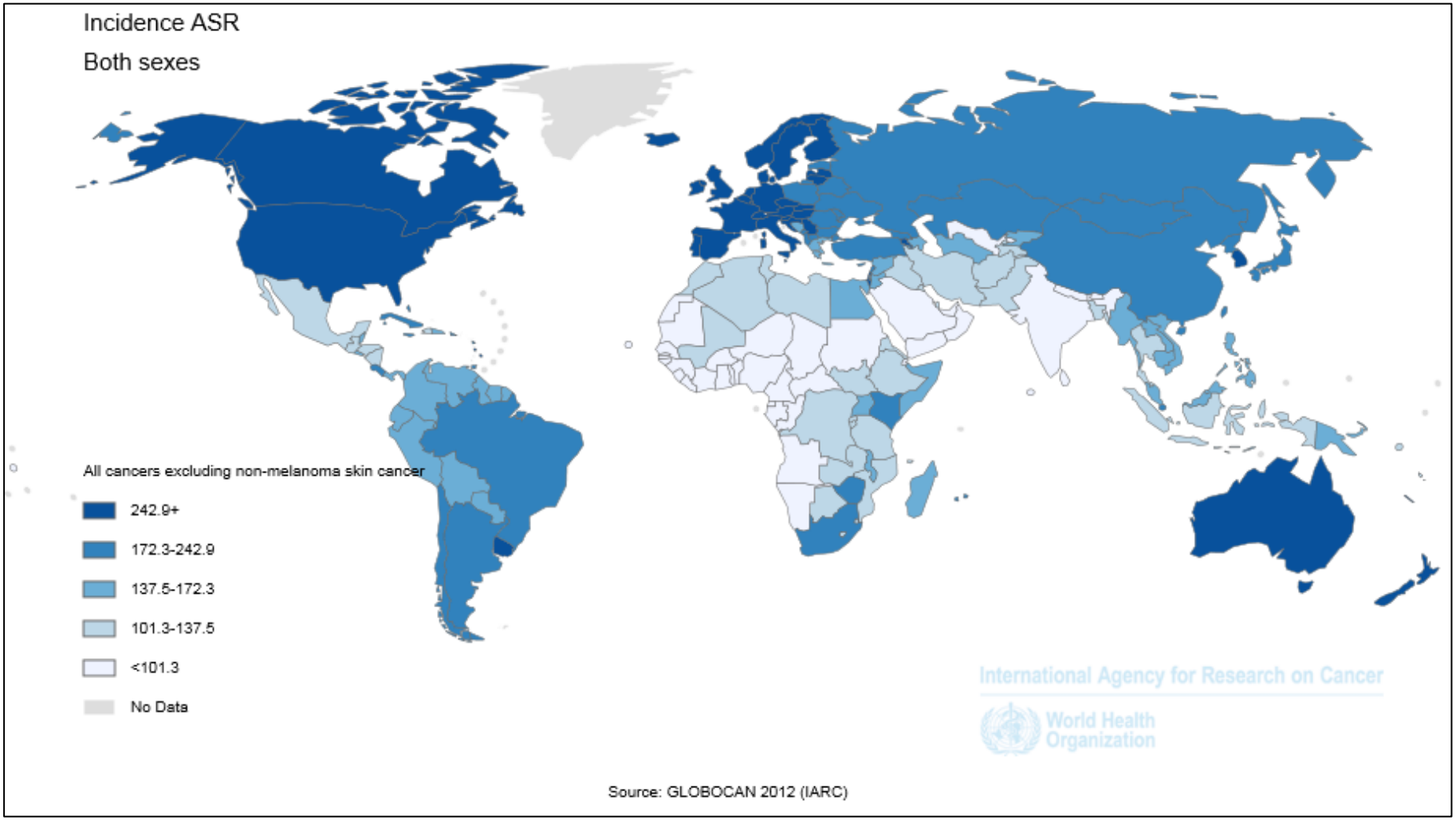

Figure 1.1
A map showing the Age-Standardised Incidence Rates per 100,000 people for 'All cancers' excluding non-melanoma skin cancer by country. [1]

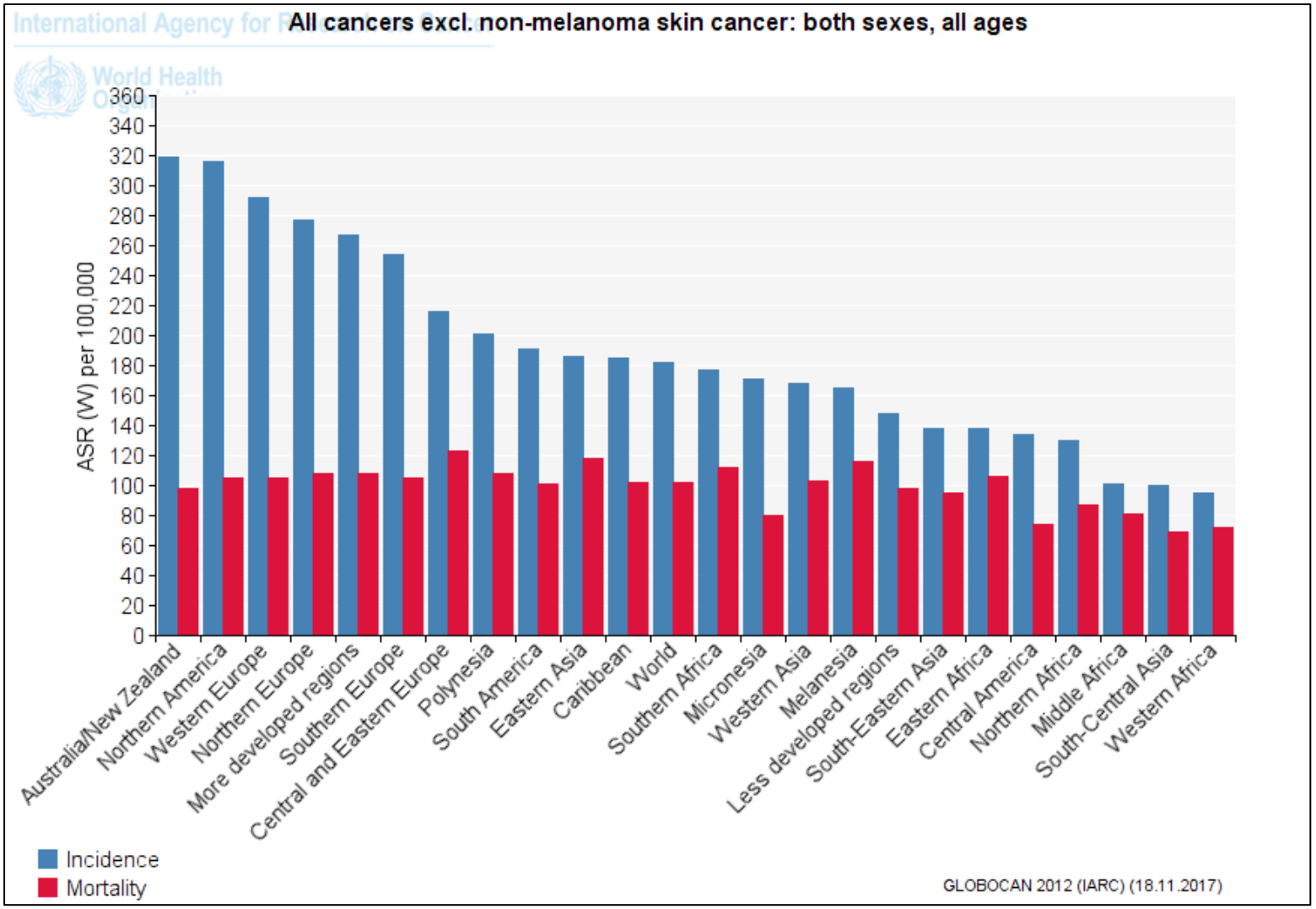

Figure 1.2
A bar chart showing the Age-Standardised Incidence Rates per 100,000 for 'All cancers' excluding non-melanoma skin cancer by region. [1]

However, even after taking this into account, when comparing data from high quality registries with similar coverage and diagnostic criteria (e.g. between the USA and Japan), much of this global variation is real but unexplained. Studies of cancer incidence in migrant populations have been used to try improve the understanding of aetiology, particularly for cancers for which there are few established risk factors (e.g. colorectal and pancreatic cancer.) [3, 4] (Such migrant studies are also useful for understanding the incidence of cancers in countries where there are no reliable cancer registries - which applies to most of the countries / regions of origin of the UK's ethnic minorities (i.e. South Asia, East and West Africa and the Caribbean. By looking at the difference in incidence rates between a migrant population (e.g. British Indians), a host population (British Whites) and people in the countries of origin (e.g. India) this gives an indication of the relative contribution of genetic and environmental factors to these differences. [4]

These 'natural experiments' have provided important insights into the aetiology of a number of cancers.[4] For example, for colorectal cancer, in the 1980s it was found that people who moved from an area of low incidence to one of high incidence (e.g. Japanese migrants to the USA and South East Asian migrants to Australia) were found to have similar rates of colon cancer to White Americans / Australians within one generation, suggesting that environmental factors were most important. [5, 6]

Today, colorectal cancer incidence rates are still much lower in South Asia than in England. Therefore, if rates in British South Asians increase and converge towards that of the host (British White) population, this would indicate that environmental / lifestyle factors are likely to be more important than genetic factors, particularly if rates were closer to British Whites in the second generation than the first generation. If, however, rates in British South Asians remain low, including in the second generation then this would suggest that genetic factors are more important - although it could also be due to them maintaining certain aspects of their South Asian environment / lifestyle (e.g. diet) that reduce the risk.

1.2 Studying different ethnic groups in the same country

Studying different ethnic groups in the same country overcomes the limitations of some international comparisons highlighted above as similar diagnostic methods, reporting and registration procedures are used, regardless of country of origin. [1, 4]

Studying the incidence of cancer by ethnic group in a country is also important to enable appropriate planning of healthcare provision among the minority ethnic groups of that country. [7]

As an increasingly multi-ethnic nation with a unified health care system, universal access free at the point of need and comprehensive cancer registration, England provides an ideal setting in which to do this. There is consistency of diagnostic methods, reporting and registration procedures across the entire health system which removes the significant biases discussed in 1.1.

Arguably it would be difficult to do such comparisons anywhere else in the world – the only other country with large numbers of minorities from the same countries is the United States but the patterns and history of migration have been very different there. The socioeconomic circumstances of some minorities are also different e.g. South Asians are generally more affluent in the US but more deprived in the UK. Decreased access to healthcare for more deprived groups in the US (especially African Americans) also makes such comparisons more challenging.

1.3 Ethnic groups in England

Over the last 60 years, England has become a multi-ethnic society, with large-scale migration from former colonies taking place in the 1950s and 60s (mainly from India, Pakistan and the Caribbean) and in the 70s and 80s from Bangladesh, sub-Saharan Africa and Hong Kong as shown in Figure 1.3.

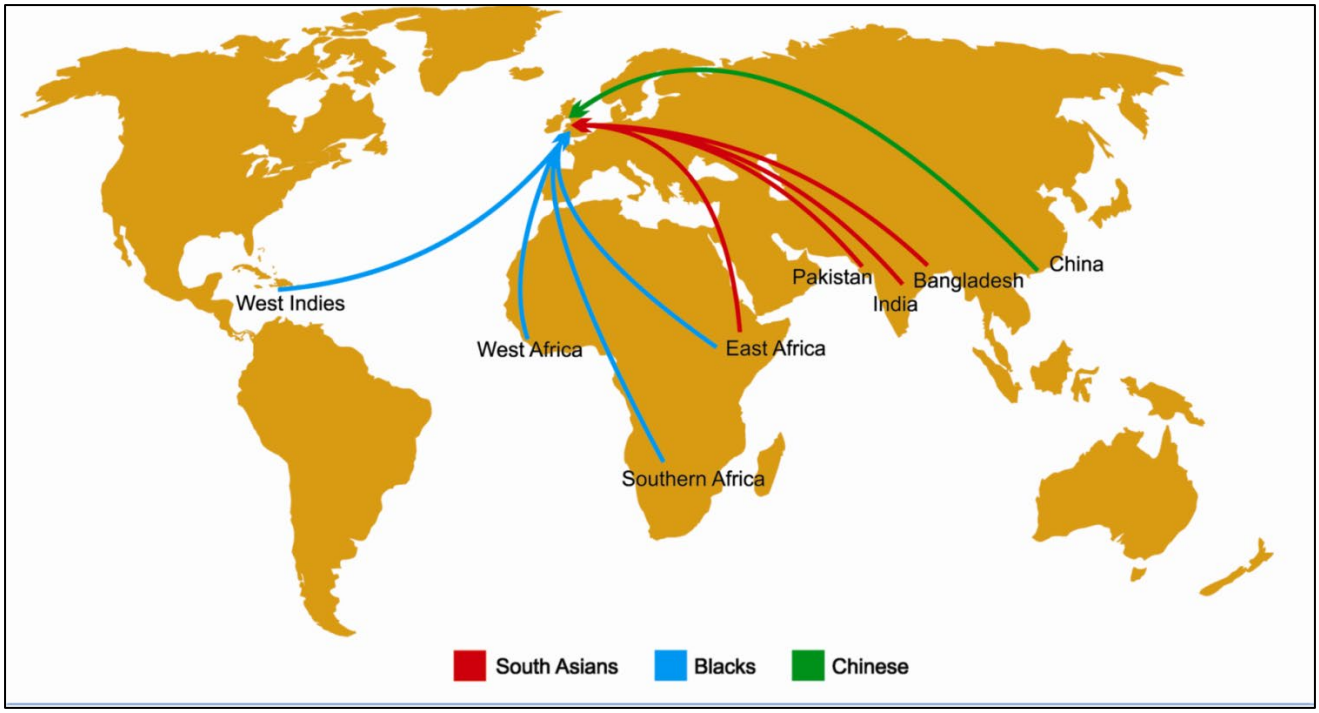

Figure 1.3 The major patterns of migration into England from former colonies in the 1950s to the 1980s.

Ethnicity has been recorded in the UK census since 1991 using the categorisations shown in Table 1.1 and the proportion of non-Whites has increased since then with the 2011 census showing that 'non-White' ethnic groups made up around 14% of England's population. British (South) Asians - Indians, Pakistanis and Bangladeshis - form the largest group of about 6%, and British Blacks - Black Africans (mainly from Nigeria, South Africa, Ghana and Somalia) and Black Caribbeans (predominantly from Jamaica) - are second at about 3%, with Chinese (mainly from Hong Kong) about 1%.[8]

1991 Census **(9 categories)**	**2001 Census** **(16 categories)**	**2011 Census** **(18 categories)**
White **Black-African** **Black-Caribbean** **Black Other** **Indian** **Pakistani** **Bangladeshi** **Chinese** **Other**	**White** **British** **Irish** **Other White** **Mixed** **White and Black Caribbean** **White and Black African** **White and Asian** **Other Mixed** **Asian or Asian British** **Indian** **Pakistani** **Bangladeshi** **Other Asian** **Black or Black British** **Caribbean** **African** **Other Black** **Chinese or Other Ethnic Group** **Chinese** **Other Ethnic Group**	**White** **English/Welsh/Scottish/Northern Irish/British** **Irish** **Gypsy or Irish Traveller** **Other White** **Mixed/Multiple Ethnic Groups** **White and Black Caribbean** **White and Black African** **White and Asian** **Other Mixed** **Asian/Asian British** **Indian** **Pakistani** **Bangladeshi** **Chinese** **Other Asian** **Black/African/Caribbean/Black British** **Caribbean** **African** **Other Black** **Other Ethnic Group** **Arab** **Any Other Ethnic Group**

Table 1.1 Ethnic group categorisation in the UK. [9]

1.3.1. Value of ethnicity as an exposure for cancer aetiology

Ethnicity is a dimension of social structure with each ethnic group having its own distinct culture, tradition and sometimes their own language or religion. Different ethnic groups have different migration histories, population sizes and age structure. They have also tended to distribute unevenly across England and are concentrated in large urban areas. There are also significant differences between ethnic groups in socioeconomic characteristics, such as economic activity, social class and housing with most ethnic groups being more deprived than Whites. [9]

Differences in cancer incidence by ethnicity could be due to differences in genetic predisposition or in exposure to environmental / lifestyle risk factors but results of previous migrant studies are consistent with environmental exposures, particularly at younger ages, being important in the aetiology of these cancers. It is therefore unlikely that ethnicity itself (or genetic factors) are responsible for most of the observed differences in incidence with ethnicity acting as a proxy for environmental / lifestyle factors (smoking, chewing tobacco, alcohol, diet, etc.).[4]

This has been shown most clearly for breast cancer where individual level risk factor data was available in a large UK prospective cohort study – the Million Women Study which showed that ethnic differences in breast cancer incidence in England were due to differences in known risk factors for the disease. [10] For example, the particularly low incidence of breast cancer among South Asians was explained by known risk factors - on average, South Asians in England have more children, are more likely to breastfeed, less likely to use HRT, much less likely to drink alcohol, and have a lower height than Whites. Indeed, at least in women over 50, rates among South Asians were actually similar to Whites once incidence rates were adjusted for known risk factors. The lower incidence rates of breast cancer among Blacks compared to Whites can also be largely explained by known risk factors, with Blacks having more children, being younger at first birth, more likely to breastfeed, less likely to use HRT and less likely to drink alcohol. And again, in women over 50, rates among Blacks were similar to Whites once incidence rates were adjusted for known risk factors.[10]

Another smaller cohort study (Predicting Risk of Cancer at Screening Study) of about 50,000 women in Manchester, which also collected individual risk factor data had similar findings. Asian women were found to have a lower risk of breast cancer than White women and this was explained by differences in known risk factors with White women being more likely to have had a younger age at menarche, be overweight or obese, taller, used hormone replacement therapy and not to have had children.[11]

1.4 Aims & Objectives

The primary objective in this study is to compare, for the first time, the incidence of all major cancers in the six main 'non-White' ethnic groups in England (Indian, Pakistani, Bangladeshi ('South Asians'), Black African, Black Caribbean ('Blacks') and Chinese) to each other and to Whites.

A secondary objective is to compare the incidence of all major cancers in the six main 'non-White' ethnic groups in England (Indian, Pakistani, Bangladeshi ('South Asians'), Black African, Black Caribbean ('Blacks') and Chinese) with their countries / regions of origin, where possible.

The results will be interpreted and discussed taking into account known risk factors and the possible contribution of genetic and environmental factors to these differences.

Although the primary exposure variable that can be measured in this type of study is ethnicity, additional analyses can be done which can show if greater exposure to the 'host environment' increases the risk of a particular cancer. For example, when comparing incidence rates by age group, if rates in younger South Asians (who are more likely to have been born in the UK and so have had greater exposure to the host environment) are closer to the rates in British Whites than in older age groups, this is indicative of environmental factors being more important than genetic. The relative convergence of incidence rates for different cancers to the White 'host' rate will also give an indication of the relative contribution of genetic and environmental / lifestyle factors to these individual cancers.

1.4.1 Organisation of the thesis

Due to the large number of cancers to be analysed - for the purposes of reviewing the previous literature, analyses, results and discussion - they will be divided up into the following categories:

1. **All cancers excluding non-melanoma of the skin**
2. **Gastrointestinal cancers**
3. **Head & Neck cancers**
4. **Trachea, Bronchus and Lung cancer**
5. **Breast and Gynaecological cancers**
6. **Urological cancers**
7. **Central Nervous System cancers**
8. **Haematological cancers**
9. **Other (Thyroid cancer and Malignant Melanoma)**
10. **Childhood cancers**

1.5 Review of the literature

1.5.1 General points:

This review focuses on previous studies done in the UK (England, Wales, Scotland and Northern Ireland) as this is the focus of the thesis and allows more valid comparisons to previous studies. (US comparisons are of limited use as the 'Asian' category is much broader than in the UK including East and South-east Asians and the history of Black migration is very different.) However, studies conducted of the relevant ethnic groups in other countries (United states, Canada, Australia, New Zealand) have been included where there was no data available from the UK and the ethnic group was comparable. (e.g. Indians and Pakistanis in the USA and Canada.)

Search strategy

The search was conducted on PubMed from Jan 1, 1950, to date for papers written in English,

The primary search was done for studies from the UK as this was the focus for this study.

The following search terms were used:

(India* OR Pakistan* OR Bangladesh* OR Asia* OR Black OR Africa* OR Caribbean OR China OR Chinese) AND (incidence OR risk OR migrant OR immigrant OR ethnic*) AND (United Kingdom OR England OR Scotland OR Wales OR "Northern Ireland') AND cancer (for both all cancers and for each group of cancers (e.g. gastrointestinal) or individual cancers (e.g. Colorectal, Oesophageal, Stomach, Liver, Gallbladder, Pancreatic) as applicable.

A secondary search was done for studies from the United States but without the term 'Asian' which has a different meaning with different populations included (e.g. in the US, Asian includes all East Asians as well as South Asians.)

Additional searches were done when looking at the prevalence of the known risk factors for each cancer by ethnic group in the UK and on the association between risk factors and each specific cancer.

Although there have been a number of studies analysing differences in the incidence or mortality of many cancers by ethnic group in the UK, these have been of limited accuracy in the past as cancer registries did not record ethnicity data and so other methods had to be used as reviewed below.

Methods of assigning ethnic group

Country of birth and death certificates

The earliest studies from the 1980's had to use country of birth as a proxy for ethnicity (as there was no recording of ethnic group in health data or in the census) and were only able to analyse mortality and not incidence as country of birth was only recorded on the death certificate, not the cancer registration. [12-16] These studies also became less useful as the proportion of ethnic minorities born in the UK increased (now more than half for South Asians) leading to misclassification.[8] (Some older Whites could also be misclassified if they had been born in Britain's former colonies e.g. India) One study, analysing data from the Office for National Statistics Longitudinal Study (1% of the UK population), was able to look at cancer incidence in South Asians and West Indians by country of birth but was limited by very small sample sizes.[17]

Name analysis

Studies in South Asians in the 1990s to 2000s assigned ethnicity on the basis of name as most South Asians have distinctive names [18-21] but this method also has significant limitations. Firstly, only South Asian ethnic groups can be analysed using this method, and not Black Africans, Black Caribbeans, Chinese, etc. Secondly, names are used to estimate the numerator but self-assigned ethnicity census data are used for the denominator, leading to possible numerator/denominator mismatch. Thirdly, name analysis also involves grouping all South Asians (Indians, Pakistani and Bangladeshis) together even though there are important differences between them (in terms of geographical origin, lifestyle habits, etc) and they also have to group all non-South Asians together (including Whites, Blacks and Chinese). A further limitation of name analysis methods is that the vast majority of Muslim names are of Arabic derivation and so it is difficult to distinguish South Asian Muslims from Northern African, Arab, Iranian, Turkish and Eastern European Muslims and up to 20% of Muslims are not of South Asian origin and so will be misclassified. [8]

Self-assigned ethnicity

The most accurate method is to use self–assigned ethnicity (as has been done in the census since 1991) which allows the same method of assigning ethnicity to be used in the numerator and denominator. Since 1995, self-assigned ethnicity has been recorded in the Hospital Episodes Statistics (HES) database (using the same classification system as used in the census) and HES records can now be linked to cancer registrations, thus providing more reliable information on ethnicity and allowing all ethnic groups to be analysed separately for the first time. [22]

Although the recording of ethnicity data in primary care is still limited [23, 24], hospital data is much better and has improved markedly in the last 20 years, with the percentage of missing ethnicity values in the HES database falling from 35% in 1998 to less than 10% by 2009. [25] A previous study also showed minimal effect of missing ethnicity data on estimates of breast cancer incidence. [26]

Single registry studies

The first studies using self-assigned ethnicity linked to HES records were published by the Thames Cancer registry which has the highest number and percentage of ethnic minorities of all UK registries (as it includes London). [22] These showed a number of important differences but were limited by much higher proportions of missing ethnicity data (35 - 41%) and a smaller number of cases as they were restricted to the Thames cancer registry which meant they could only look at a few cancers. [27-31]

A national study

In 2009, the National Cancer Intelligence Network (NCIN) published '***Cancer Incidence and Survival By Major Ethnic Group for England 2002-2006'***, [32] the first time such an analysis had been done for the whole of England using linked incidence and mortality data from cancer registries with (self-assigned) ethnicity from the Hospital Episodes Statistics (HES) database. This study showed differences in incidence in many of the different cancer types but again had some limitations which were acknowledged by the report itself and concluded that these differences needed 'investigating further and the analyses extended'.

NCIN looked at cancer incidence and survival by the four major ethnic groupings used in the census / HES (All Whites; All Blacks; All Asians; Chinese & Other.) All Asians were grouped together (including the group 'Other Asian' who may not be South Asian at all) as they had insufficient numbers of individual ethnic groups. The overall missing ethnicity was 24%.[32]

However, neither South Asians nor Blacks are a single homogenous group - there are important differences in lifestyle, religious and cultural factors and migration histories between them (as well as genetic heterogeneity) and it is therefore essential to study the individual ethnic groups (Indians, Pakistanis, Bangladeshis, Black Africans, Black Caribbeans and Chinese) which are of greater importance both from a public health and aetiological perspective.

The NCIN analysis also did not adjust for socioeconomic status which can be an important confounder in studies of health and ethnicity particularly for Pakistanis, Bangladeshis and Blacks who are in the main poorer / more deprived than British Whites and Indians. [8, 33-36]

Therefore, the risk of cancer by individual ethnic group (Indian, Pakistani and Bangladeshi; Black African, Caribbean & Chinese is unknown and all the studies reviewed below suffer from one or more of the limitations detailed above. This is the first study to look at the incidence of all the major cancers across the whole of England for the six-largest non-White ethnic groups as well adjusting for deprivation.

1.5.2 Cancers by groupings

The remainder of this review will consider cancers by the categorisation shown in 1.4.1 and summarise the results of previous studies from the UK. (Studies from the other countries were included where there was no / very limited previous data from the UK)

All cancers excluding non-melanoma of the skin

All previous studies, whether using country of birth, name analysis or self-assigned ethnicity have shown a reduced risk (incidence or mortality) of 'all cancers' in South Asians (including studies that looked individually at Indians, Pakistanis and Bangladeshis) compared to Whites. [13, 15, 17, 18, 20, 32, 35, 37, 38].

There are far fewer studies in Blacks but those that have been done showed an increased risk for Black Africans [12] and decreased risk in Black Caribbeans [15, 17] although one study found the opposite pattern for the time period 1999 - 2003. [15] Using the combined "All Blacks' category in the NCIN report, incidence rates were almost the same as in Whites.[32]

The NCIN study is also the only one to date to analyse the risk in Chinese and found a significantly reduced incidence.[32]

Gastrointestinal cancers

Gastrointestinal cancers cause more than a third of all deaths from cancer worldwide.[1] There are large unexplained variations in incidence internationally of gastrointestinal cancers with, for example, South Asian countries having some of the lowest rates of colorectal cancer and highest rates of gallbladder cancer globally.[1]

Previous studies have shown South Asians in England to have lower rates of colorectal, oesophageal, gastric and pancreatic cancer and higher rates of liver cancer than British Whites [16, 20, 32, 37, 39, 40] but the risk of gastrointestinal cancers by their individual ethnic group (Indians, Pakistanis and Bangladeshis) is unknown. Similarly, British Blacks have been shown to have lower rates of colorectal and oesophageal cancer, but higher rates of gastric and liver cancer than British Whites, [32] but again the risk by their individual ethnic group (Black African and Caribbean) is unknown.

Head & Neck

South Asian females in the UK have generally been shown to have higher rates of oral cancer than other ethnic groups [17, 28, 32, 41, 42]. Chinese in the UK are also known to have very high rates of Nasopharyngeal cancer. [28, 42, 43]

Trachea, Bronchus and Lung

Lung cancer is the second most common cancer in the UK, with 33779 new cases of the disease registered in 2010. [44] Worldwide, it is the biggest cause of cancer-related death, causing approximately 1.4 million deaths each year. [1]

There is considerable geographic variation in the incidence of lung cancer, broadly reflecting differences in the stage and intensity of the tobacco epidemic (i.e. prevalence and history of smoking) of different countries.[45]

Previous studies in the UK have shown that South Asians have much lower incidence rates compared to Whites, particularly amongst women. [18, 19, 46] The NCIN report also found that incidence among Blacks and Chinese was lower than Whites [32] A study by Thames Cancer Registry also found lower rates in all six individual non-White ethnic groups, with the exception of Bangladeshi men. [47]

Breast and Gynaecological cancers

Combined, breast and gynaecological cancers make up a third of all female cancer registrations in England. [44] Worldwide, they cause 0.7 million deaths each year, with breast and cervical cancer among the top 3 biggest causes of cancer-related death among females. [1]

Results from previous studies show that South Asians have much lower incidence rates of breast cancer and slightly lower or similar rates of ovarian, cervical and endometrial cancer compared to Whites. [13, 26, 29, 32] Studies among Blacks also found lower rates of breast and ovarian cancer but slightly higher rates of cervical and endometrial cancer.[12, 32, 48]

Urological cancers

Urological cancers account for about 14% of cancers diagnosed globally. [1]

A number of studies have shown increased risk of prostate cancer in 'All Blacks' [32] and in both Black Africans and Black Caribbeans [14, 49-51] and decreased risk in South Asians (including studies that looked individually at Indians, Pakistanis and Bangladeshis) [17, 30, 32, 49, 52] compared to Whites.

The NCIN report also showed that South Asians and Blacks have lower rates of kidney and bladder cancer but the risk of these cancers by their individual ethnic group is unknown. [32]

Central Nervous System (CNS) cancers

There is wide variation in the incidence of CNS cancers worldwide with the lowest rates seen in Africa and the highest rates in northern Europe. [1] There were over 9,000 new cases of CNS cancers in the UK in 2010. [53]

There is very limited data on the incidence of CNS cancers by ethnic group in the UK with the only previous study showing that Blacks and South Asians have a significantly lower incidence than Whites. [32] However this study only looked at CNS cancers as a whole and the risk by individual ethnic group is unknown.

Haematological cancers

Haematological malignancies are a diverse group of cancers which together account for 7% cancer diagnoses worldwide.[1]

Previous studies have found that, compared to Whites, South Asians have a lower risk of non-Hodgkin lymphoma (NHL), multiple myeloma and leukaemia and higher rates of Hodgkin lymphoma (in males) [13, 18, 32]. Incidence rates among Blacks are similar to those in Whites for NHL, Hodgkin lymphoma and leukaemia but higher for multiple myeloma.[32]

Other (Thyroid and Malignant Melanoma)

Thyroid cancer

There are significant international variations in thyroid cancer incidence and a study in the USA showed increased risk in South East Asians and decreased risk in Blacks. [54] There are no previous studies comparing the incidence of thyroid cancer by ethnic group in the UK.

Malignant Melanoma

The only single previous report was from NCIN and report showed a much lower risk of Malignant Melanoma in South Asians and Blacks compared to Whites. [32] Studies in the USA [55-58] and Kenya [59] have also shown the same pattern.

Childhood cancers

Beyond the first year of life, cancer is the commonest cause of death in childhood (ages 0-14) in England and Wales. [60] There are no previous studies in the UK comparing the incidence of childhood cancer by ethnic group using self-assigned ethnicity data. One study using name analysis showed that South Asian children had an increased risk of childhood cancers, mainly due to higher rates in boys, with a higher incidence of leukaemia, lymphoma and hepatic cancers.[61] Smaller regional studies have also shown higher rates of Leukaemias and Lymphomas in Pakistani children [62] and CNS cancers in Indian children.[63] There are no previous studies in Black or Chinese children.

Table 1.5 summarises the result of previous studies in the UK looking at cancer incidence for the cancers discussed above. As is shown for the vast majority of cancers (all except lung, breast, prostate, and head & neck), there is simply no data for incidence by individual ethnic group.

Table 1.5.1 summarises the result of previous studies from the USA [64] looking at cancer incidence for the cancers discussed above for South Asians and Blacks, Data is not generally available for individual South Asian groups or Chinese due to differences in the way ethnicity is recorded in the USA..

Cancer	Incidence compared to Whites							
	South Asians	Indians	Pakistanis	Bangladeshis	Blacks	Black African	Black Caribbean	Chinese
All cancers	↓	↓	↓	↓	=	↑	↓	↓
Oesophagus	↓	ND	ND	ND	↓	ND	ND	ND
Stomach	↓	ND	ND	ND	↑	ND	ND	ND
Colorectal	↓	ND	ND	ND	↓	ND	ND	ND
Liver	↑	ND	ND	ND	↑	ND	ND	ND
Gallbladder	ND	ND	ND	ND	ND	ND	ND	ND
Pancreas	↓	ND	ND	ND	=	ND	ND	ND
Head & Neck	↓(M) ↑(F)	↓(M) ↑(F)	↓	↓	↓	↓	↓	↓
Lung	↓	↓	↓	↓	↓	↓	↓	↓
Breast (female)	↓	↓	↓	↓	↓	↓	↓	↓
Prostate	↓	↓	↓	↓	↑	↑	↑	↓
Cervix Uteri	↓	ND	ND	ND	=	ND	ND	ND
Endometrium	↓	ND	ND	ND	↑	ND	ND	ND
Ovary	↓	ND	ND	ND	↓	ND	ND	ND
Kidney	↓	ND	ND	ND	↓	ND	ND	ND
Bladder	↓	ND	ND	ND	↓	ND	ND	ND
Testis	ND	ND	ND	ND	ND	ND	ND	ND
CNS cancers	↓	ND	ND	ND	↓	ND	ND	ND
Hodgkin lymphoma	↑	ND	ND	ND	=	ND	ND	ND
Non-Hodgkin lymphoma	↓	ND	ND	ND	=	ND	ND	ND
Myeloma	↓	ND	ND	ND	↑	ND	ND	ND
Leukaemia	↓	ND	ND	ND	=	ND	ND	ND
Thyroid	ND	ND	ND	ND	ND	ND	ND	ND
Malignant melanoma	↓	ND	ND	ND	↓	ND	ND	ND
Childhood	↑	↑	↑	ND	ND	ND	ND	ND

Table 1.5 Summary of the results of previous studies in the UK looking at cancer incidence.

↑	Increased risk
↓	Decreased risk
=	No significant difference
ND	No Data

Cancer		
	South Asians	**Blacks**
All cancers	↓	**=**
Oesophagus	↓	↓
Stomach	↓	↑
Colorectal	↓	↑
Liver	ND	↑
Gallbladder	ND	↑
Pancreas	ND	↑
Head & Neck	ND	↓
Lung	↓	=
Breast (female)	↓	↓
Prostate	↓	↑
Cervix Uteri	↓	**=**
Endometrium	↓	↑
Ovary	↓	↓
Kidney	↓	=
Bladder	↓	↓
Testis	ND	↓
CNS cancers	↓	↓
Hodgkin lymphoma	ND	**=**
Non-Hodgkin lymphoma	↓	↓
Myeloma	↓	↑
Leukaemia	↓	↓
Thyroid	↓	↓
Malignant melanoma	↓	↓
Childhood	ND	↓

Table 1.5.1 Summary of the results of previous studies in the USA looking at cancer incidence compared to US Whites.

↑	Increased risk
↓	Decreased risk
=	No significant difference
ND	No Data

2. Data and Methods.

2.1 Data collection

Cancers: (numerator)

Data was obtained data from the National Cancer Intelligence Network (NCIN) for all cancer registrations from January 2001 to December 2007 in England with the following information:

- cancer site coded to the International Classifications of Diseases, 10th Revision (ICD-10)[65];
- morphology coded to the International Classifications of Diseases of Oncology, 2nd and 3rd Revisions (ICD-O-2 and ICD-O-3)[66, 67];
- deprivation assessed from the income domain of the Index of Multiple Deprivation 2007 (IMD 2007)[68]
- age at diagnosis of cancer;
- sex and
- ethnicity.

Population at risk: (denominator)

Mid-year population estimates were produced by the Office of National Statistics (ONS) from 2001-2007 stratified by age, sex and ethnicity. Population data stratified by national quintiles of the income domain were provided by ONS based on the 2001 census and the same distributions applied to population data by age, sex and ethnicity for the 2001-2007 mid-year population estimates. Mid-year population estimates were used instead of the 2001 census data as there had been significant increases in the populations of particularly; South Asians and Black Africans by 2007 and using 2001 census data would have caused the denominator to be underestimated.

2.2 Deprivation

Deprivation was assessed using the income domain of the Index of Multiple Deprivation 2007 (IMD 2007) and coded according to national quintiles. The English Index of Multiple Deprivation 2004 (IMD 2004) is an area-based measure of deprivation based on a Lower Super Output Area (SOA) level measure of multiple deprivation. The area-based socioeconomic status is measured based on the general population with no difference between ethnic groups in the same neighbourhood. [68]

Area-based measures may suffer from the ecological fallacy in that the individuals living in a deprived area who develop cancer may not actually be deprived. This may be particularly true with some ethnic minority groups e.g. Pakistanis who generally live in more deprived areas but individuals have chosen to live there because there is a higher proportion of Pakistanis, even though they could afford to live in a less deprived area.

The IMD 2007 contains seven domains of deprivation:

- Income
- Employment
- Health deprivation and disability
- Education skills and training
- Barriers to housing and services
- Crime
- Living environment.

.

The primary reason for using the income component of the IMD only was that NCIN only provided data with the income component as did the ONS when they provided the denominator data.

This also explains why all other papers, using similar data sets or from the Thames Cancer Registry have also only used the income component of IMD

As shown in Table 2.2, the income domain most closely reflects the overall score and has the same ranking as ethnic with the exception of the Indian and White group which are reversed.

Also, one of the measures is health-related (health deprivation and disability) and so this measure should not be used as it may be correlated with cancer incidence (leading to confounding and / or reverse causation).

Ethnicity	Overall	Income	Employment	Education, training and skills	Health deprivation and disability	Crime	Barriers to housing & services	Living Environment
Bangladeshi	27.9	32.2	17.4	16%	14%	29%	39%	21%
Chinese	9.7	9.5	7.8	7%	11%	17%	17%	22%
Indian	8.3	9.3	6.6	8%	6%	14%	17%	12%
Pakistani	30.9	28	23.7	27%	19%	20%	21%	27%
Black African	20	24.1	14.9	11%	12%	28%	31%	16%
Black Caribbean	18.1	21.1	13.7	8%	9%	25%	28%	16%
White British	8.6	8.4	9.3	10%	10%	8%	8%	9%
Other	16.8	17.9	12.8	9%	11%	21%	24%	21%

Table 2.2 IMD 2007 scores overall and for each individual domain.[69]

2.3 Classification of ethnicity

NCIN obtained the self-assigned ethnicity for each cancer registration by record linkage to the Hospital Episodes Statistics (HES) database. If a cancer registration could not be linked to HES or if ethnicity data were missing on the HES database, then ethnicity was assigned using information recorded on cancer registry data. Prior to April 2001, ethnicity was coded both by HES and by cancer registries using the classification system of the 1991 Census. After April 2001, the codes were amended to those of the 2001 census, although 1991 ethnicity codes were accepted until 2003. For these analyses, ethnicity was classified as White (White from the 1991 Census and White British from the 2001 Census), Indian, Pakistani and Bangladeshi, (with the three groups combined to form the category 'South Asian.'), Black African, Black Caribbean (again both combined to form the category, 'Black') and Chinese.

2.4 Classification of cancers

The following cancers were analysed with ICD-10 codes shown in Table 2.1:

Cancer	**ICD-10 Code**
All cancers excluding non-melanoma of the skin	C00-C97 excluding C44
Mouth	C00-C08
Head and Neck	C00-C14 & C30-C32
Oesophagus	C15
Stomach	C16
Colorectal Colon Rectum	C18-C20 C18-C19 C20
Liver	C22
Gallbladder	C23-24
Pancreas	C25
Trachea, bronchus and lung	C33-C34
Breast (female)	C50
Malignant melanoma of skin	C43
Cervix Uteri	C53
Endometrium	C54
Ovary	C56
Prostate	C61
Testis	C62
Kidney	C64-C66 & C68
Bladder	C67
Brain and central nervous system	C70-C72
Thyroid	C73
Hodgkin lymphoma	C81
Non-Hodgkin lymphoma	C82-C85 & C96
Myeloma	C88-C90
Leukaemia	C91-C95

Table 2.4 Classification of cancers analysed with ICD-10 codes. These are the same cancers as analysed in the NCIN report but it was also possible to look at thyroid and

testis cancers due to the larger sample size obtained by analysing 7 years of data instead of 5.

Cancer incidence was analysed in the following groupings:

1. All malignant cancers excluding non-melanoma of the skin

2. Gastrointestinal

Cancers of the colon and rectum (ICD-10 codes C18-C20), oesophagus (C15), stomach (C16), liver (C22 including C22.0 - hepatocellular carcinoma) gallbladder (C23-24) and the pancreas (C25).

Morphology was used to subdivide oesophageal cancer (adenocarcinoma vs. squamous cell) and liver cancer (hepatocellular carcinoma vs. other).

Colorectal cancer was also subdivided by site (colon vs. rectum).

3. Lung

Lung cancer (ICD-10 codes C33-C34)

Morphology was used to subdivide cancers into Adeno-carcinoma, large-cell, small-cell and squamous cell cancer.

4. Head & Neck

Head and Neck Cancers (C00-C14 & C30-C32) with subdivisions into Larynx (C32), Mouth (C00-C08) and Nasopharynx (C11.)

5. Breast and Gynaecological

Cancers of the breast (ICD-10 code: C50), ovary (C56-57), cervix (C53) and endometrium (C54).

6. Urological

Cancers of the prostate (ICD-10 code C61), testes (C62), kidney (C64, C65, C66 and C68) and bladder (C67).

Morphology was used to subdivide cancers as follows:

- prostate into adenocarcinoma (ICD-O-3 codes 8140, 8141 8143, 8147, 8211, 8251, 8255, 8260-82633, 8310, 8480, 8481, 8503, 8570-8574) and other tumours;
- testes as seminoma (9060-9062, 9064) and non-seminomatous (9065-9102);
- kidney as renal cell carcinoma (8050,8140,8260,8270,8280-8312,8316-8320,8340-8344) and other;
- bladder as transitional (8050,8120-8122,8130-8131) and other.

7. CNS cancers

Cancers of the central nervous system and intra-cranial cancers were defined as those with ICD-10 codes C70-C72, C75.1-C75.3, D32, D33, D35.2-D35.4, D42, D43 and D44.3-D44.5. Cancers were then grouped by site and morphology, converting ICD-O codes from the second to the third edition as necessary. Cancers were grouped into gliomas (ICD-O-3 codes 9380-9481); meningiomas (ICD-O-3 codes 9530-9539); pituitary cancers (ICD-O-3 codes 8140/0, 8202/0, 8260/0, 8270/0, 8271/0, 8272/0, 8280/0, 8281/, 8290/0 and 8300/0) and cranial and paraspinal nerve cancers (ICD-O-3 codes 9560/0, 9540/0, 9540/3, 9571/0, 9571/3).
Gliomas were subdivided into glioblastomas (ICD-O-3 codes 9440-9442) and other gliomas (ICD-O-3 codes 9381, 9384, 9400, 9401, 9410, 9411, 9420, 9421, 9425).

8. Haematological cancers

Cancers with ICD-10 codes C81-C96. Morphology was used to group malignancies according to a previously used classification [70] based on the InterLymph hierarchical scheme for epidemiological research [71] and the Haemacare project [72]. ICD-O codes were converted from the second to third edition as necessary and only considered codes with fifth digit 3 (malignant).
Malignancies were grouped into Hodgkin lymphomas (ICD-O-3 codes 965-966); mature B-cell lymphoid malignancies (967-969 except (9675), 973, 976, 9823, 9826, 9833, 9940); mature T-cell lymphoid malignancies (970-971, 9827, 9831, 9834, 9948); other/unspecified lymphoid malignancies (959, 9675, 972, 9820, 983) and acute myeloid leukaemia (984-993 except (9860, 9863, 9875, 9876), 9984).
Mature B-cell lymphoid malignancies were grouped into diffuse large B-cell (ICD-O-3 codes 9678, 9679, 9680, 9684); follicular lymphoma (969 except (9699)); plasma cell neoplasms (973) and chronic lymphocytic leukaemia/small lymphocytic lymphoma (959, 9675, 972, 9820, 983 (except 9831, 9833, 9834)). A subgroup analysis within the mature T-cell neoplasms comparing Black Caribbeans to Whites was also done. Mature T-cell neoplasms were divided into adult T-cell leukaemia/lymphoma (ATLL) (9827) and non-ATLL.

9. Other – Thyroid and Malignant Melanoma

Thyroid - ICD-10 code C73 was used to identify all thyroid cancers and morphology codes to identify follicular and papillary subtypes. Morphology codes were used to identify follicular and papillary subtypes as follows:

- Follicular - 8290,8330,8335
- Papillary - 8050,8260,8344,8350 and morphology code >=8450 & <=8460

Malignant melanoma of skin: ICD-10 code C43

10. Childhood cancers

Morphology was used to classify cancers according to the International Classification of Childhood Cancer (ICCC-3) [73]. ICD-O codes were converted from the second to third edition as necessary. As in previous studies [74], cancers were classified into four groups corresponding to the diagnostic groups I, II, III and IV-XII of the ICCC-3. These groups are respectively:

- leukaemias and myeloproliferative and myelodysplastic diseases
- lymphomas and reticuloendothelial neoplasms
- central nervous system and intracranial and intraspinal neoplasms; and
- other solid cancers.

2.4 Statistical analyses

The primary exposure variable is self-assigned ethnicity. The potential confounding variables are: age, sex and socioeconomic status.

The primary outcome of interest is the incidence rate ratio comparing the different ethnic groups.
The secondary outcome of interest is the comparison of age-standardised rates between the ethnic group in the UK and their respective country or region of origin.

Age-standardised rates (ASRs) of cancer per 100,000 person years for all ethnic groups were calculated using direct standardisation to the 1960 Segi world population,[2] with age at diagnosis of cancer being classified into six categories: (<40, 40-49, 50-59, 60-69, 70-79 and ≥ 80 years).

Poisson regression was used to calculate incidence rate ratios (subsequently referred to as IRRs) comparing each ethnic group (and the two combined groups, South Asians and Blacks) to Whites adjusting for sex, age and income. Socioeconomic status was based on the income domain of the 2007 Multiple Index of Deprivation.

When comparing ‘South Asians’ and ’Blacks’ to Whites, results are presented as IRRs with 99% confidence intervals (CIs). Whencomparing the individual ethnic groups, results are presented as IRRs and 99% floating confidence intervals (FCIs). FCIs were calculated using the method of floating absolute risks (FAR) [75, 76] which enable valid comparisons between any two ethnic groups, even if neither one is the baseline.

The conventional method of presenting relative risks (RRs) with a single arbitrary baseline group (in this case, Whites) does not allow comparisons to be made between non-baseline groups (e.g. Indians vs Pakistanis) without reference to a baseline category [76] and produces confidence intervals that are too wide.[77] It is also therefore difficult to tell if differences between other groups are statistically significant.

FARs were developed to overcome the problem of reporting RR associated confidence intervals when the categorical risk factor (in this case ethnicity) has more than two levels. With FARs, instead of choosing one group as a reference category, each level is assigned a floated variance which describes the uncertainty in risk without reference to another level. i.e. there is no natural baseline group.

With FCIs, the standard confidence intervals for such relative risks are replaced by confidence intervals that are based on the floated variances of the log odds ratios for the groups that are being compared with each other.[77]

99% confidence intervals were calculated because of the multiple tests performed across subgroups.

Tests of heterogeneity of incidence rate ratios between ethnicities, either overall or restricted to South Asians or Blacks, were performed using the likelihood ratio test. Tests of heterogeneity of incidence rate ratios between the pre-specified subgroups were performed for South Asians, Blacks, and Chinese, using a chi-squared contrast test.

2.5 Subgroup analyses:

Sex

Pre-specified subgroup analyses were done by sex for all cancer types except for breast (insufficient male cases), gynaecological (cervix, ovary and endometrium) and andrological cancers (prostate and testis).

Age

For some cancers, where the number of cases was sufficiently large (colon and rectum, oesophagus, stomach, liver, gallbladder and the pancreas, head & neck , lung, breast, prostate, thyroid) pre-specified subgroup analysis was performed by age with cases divided

into those aged under 50 and those aged 50 or above. The age division was chosen so that cancer rates in first vs. later generations of South Asians could be examined - the percentage of South Asians born outside the UK is 97% for those aged ≥50 whereas for those aged <50 the majority (58%) were born in the UK.[78]
Subgroup analysis by age for Blacks and Chinese was also done for completeness (although it did not allow the same discrimination by generation).

2.6 Sensitivity analysis

As ethnicity information was not complete for all registered cancers, a sensitivity analysis was done using multiple imputations of the missing ethnicity values based on age, sex, income, and site of cancer.

The primary analysis was based only on cancer cases with complete data. About 20% of cancers had missing ethnicity data – all other variables were complete.

As ethnicity information was not complete for all registered cancers, sensitivity analyses were done using multiple imputations of the missing ethnicity values based on age, sex, region/ area, income, and site of cancer. (i.e. this is a model to predict ethnicity which includes the co-variates / confounders and outcome) Values were imputed 40 times as this has been thought to be a reasonable number from previous studies. [79]

Multiple imputation has advantages over the alternatives as it assumes that missing values are missing at random (MAR) as opposed to missing completely at random (MCAR) or missing not at random (MNAR). [79]

MAR: any systematic differences between the missing values and the observed values can be explained by differences in the observed data. i.e. someone with missing ethnicity living in Tower Hamlets is more likely to be Bangladeshi than any other ethnic group as Bangladeshis are the largest ethnic group in Tower Hamlets.

MCAR: there are no systematic differences between the missing values and the observed values. i.e. someone with missing ethnicity living in Tower Hamlets is equally likely to be Bangladeshi or any other ethnic group – ignoring the fact that Bangladeshis are the largest ethnic group in Tower Hamlets.

MNAR: i.e. systematic differences remain between the missing values and the observed values. i.e. someone with missing ethnicity living in Tower Hamlets is more likely to be Bangladeshi than any other ethnic group because Bangladeshis are less likely to have their ethnicity recorded compared to other ethnic groups.

It is not possible to distinguish between MAR and MNAR using observed data – therefore sensitivity analyses are needed examining the effect of different assumptions about the missing data mechanism. If the data are missing at random, and not completely at random, this could bias analyses based on complete cases.[79]

Doing the sensitivity analysis using multiple imputation allows us to test the assumption that data are MAR

All analyses were performed using Stata (Version 12) and R statistical software packages.

2.7 Graphical presentation of results

Where results are presented in the form of plots, IRRs for each ethnic group are represented by squares and their corresponding 99% FCIs by straight lines. For the combined 'South Asian' and 'Black' groups, IRRs are shown as open diamonds, whose horizontal extent indicates the 99% CI. A dashed vertical line was placed at the value of the IRRs for all South Asians and for all Blacks.

2.8 Comparison to rates in countries of origin

ASRs for each ethnic group in England were compared to rates from their country or region of origin primarily using data from the Globocan database [1]

Globocan produce estimates for the whole country and so in England this will include all ethnic groups. This should be considered in the comparisons although in practice more than 90% of cancers in England are from the ethnic group 'White' and so this will not make a significant difference to most comparisons.

Additionally. data from population-based registries within IARC's Cancer Incidence in Five Continents (Vol X) was used for Hong Kong which are also standardised using the1960 Segi world population. [80]

The majority of British Indians are from Gujarat and Punjab neither of which have population-based cancer registries and so Globocan figures for India were used. Most British Pakistanis are from Kashmir and Punjab neither of which have population-based cancer registries and so Globocan figures for Pakistan were used. Most British Bangladeshis are from Sylhet but there are no population-based cancer registries in Bangladesh and so Globocan figures for Bangladesh were used. For Blacks, Globocan estimates for Sub-Saharan Africa and the Caribbean were used as there are no population-based cancer registries in their main

countries of origin. For Chinese, The Globocan China data and the population based Hong Kong Cancer registry data were used as Hong Kong is the most common place of origin of Chinese in the UK and cancer incidence in Hong Kong differs greatly from other parts of China. [80] These comparisons are not ideal as incidence data from single countries / regions will mask intra-country / intra-regional variation but they are the best available.

For the haematological malignancies comparisons, in keeping with the Globocan classification [1] malignancies were classified according to ICD-10 code as Hodgkin lymphomas (ICD-10 code C81), non-Hodgkin lymphomas (C82-C85, C96), multiple myelomas (C88, C90) and leukaemias (C91-C95).

International comparisons were not done for childhood cancers as the vast majority of children in all ethnic groups were born in England.

2.9 Risk factors

Data on the prevalence of the most important risk factors for a number of different cancers (e.g. BMI, Tobacco and alcohol use) in each ethnic group were obtained from the nationally representative Health Survey for England

3. Results

Table 3.1a shows socio-demographic information from the 2001 census for Whites, Indians, Pakistanis, Bangladeshis, Black Africans, Black Caribbeans and Chinese. All six groups are, on average, younger than Whites and all except the Chinese are also poorer, with Pakistanis, Bangladeshis and Black Africans being the most deprived. About half of the South Asian and Black Caribbean population was born in the UK compared to only about 30% of Black Africans and Chinese.

Table 3.1b shows the number of cancer registrations by ethnic group, and missing ethnicity values, for all cancers. (C00 – C97 exc. C44) and for each grouping / cancer considered in this thesis.

Table 3.1c. shows the distribution of the population, and of registered cancers in England by ethnic group and shows that, in general, cancer incidence in each ethnic group is consistent with their population size and age.

In the figures shown below, it is possible to broadly see the effect of adjusting for income by comparing the ASRs (which don't adjust for income) with the IRRs and this will be highlighted where there was a difference in the results seen when adjusting for income.

Ethnic group		White		Indian		Pakistani		Bangladeshi		Black African		Black Caribbean		Chinese		Other Ethnicity
Census data for 2001		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N (%)
Total population		4274136 (86.8%)		1028546 (2.1%)		706539 (1.5%)		275394 (0.6%)		475938 (1.0%)		561246 (1.1%)		220681 (0.5%)		2998409 (6.3%*)
Sex	Male	20828644	48.7	511204	49.7	358043	50.7	138972	50.5	229103	48.1	259881	46.3	105913	48.0	Not included as this data were not needed for any analyses.
Age	<50	27665393	64.7	828200	80.5	625118	88.5	248841	90.4	432985	91.0	426424	76.0	184675	83.7	
	50+	15081743	35.3	200346	19.5	81421	11.5	26553	9.6	42953	9.0	134822	24.0	36006	16.3	
Deprivation	Low income	7305527	17.1	347098	33.7	455710	64.5	198884	72.2	277858	58.4	292537	52.1	49427	22.4	
	Middle income	26315786	61.6	563939	54.8	222038	31.4	69325	25.2	177234	37.2	245103	43.7	123994	56.2	
	High income	9125823	21.3	117509	11.4	28791	4.1	7185	2.6	20846	4.4	23606	4.2	47260	21.4	
Country of Birth	United Kingdom	4911150	98.0	472545	45.9	387198	54.8	127902	46.4	161050	33.8	324764	57.9	62209	28.2	
	Other	835986	2.0	556001	54.1	319341	45.2	147492	53.6	314888	66.2	236482	42.1	158472	71.8	

Table 3.1a Comparison of demographic characteristics by ethnic group in England in 2001 using data from the 2001 census.[78]

*Made up of Other White (2.7%) Irish White (1.3%) White & Black Caribbean (0.5%), White & Black African (0.2%), White & Asian (0.4%), Other mixed (0.3%) Other Asian (0.5%), Other Black (0.2%) Other (0.5%)

Cancer	White		Indian		Pakistani		Bangladeshi		Black African		Black Caribbean		Chinese		All other ethnicities		No ethnicity recorded		Total
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N
All cancers	1228584	71.2	10599	0.6	5825	0.3	1851	0.1	5573	0.3	11995	0.7	3193	0.2	97542	5.7[#]	360845	20.9	1726007
Gastrointestinal	284564	75.2	2114	0.6	1015	0.3	433	0.1	977	0.3	2511	0.7	765	0.2	21155	5.6	64977	17.2	378511
Head & Neck	37072	76.2	541	1.1	269	0.6	103	0.2	155	0.3	264	0.5	178	0.4	2921	6.0	7130	14.7	227149
Trachea, bronchus & lung	163162	71.8	762	0.3	494	0.2	285	0.1	115	0.1	901	0.4	324	0.1	12118	5.3	48779	21.5	54422
Breast and Gynaecological	182478	70.5	2194	0.8	1005	0.4	194	0.1	936	0.4	1674	0.6	540	0.2	15565	6.0	54331	21.0	258917
Urological	132278	62.5	934	0.4	491	0.2	90	0.0	861	0.4	3185	1.5	226	0.1	10624	5.0	63068	29.8	211757
CNS	31,440	74.5	449	1.1	315	0.7	74	0.2	210	0.5	367	0.9	119	0.3	2,689	6.4	6,544	15.5	42,207
Haematological	96847	72.1	1265	0.9	905	0.7	213	0.2	715	0.5	1080	0.8	250	0.2	8705	6.5	24322	18.1	134302
Thyroid	7396	65.7	178	1.6	170	1.5	70	0.6	124	1.1	142	1.3	90	0.8	1216	10.8	1877	16.7	11263
Malignant melanoma	34719	63.8	22	0.04	13	0.0	9	0.0	45	0.1	64	0.1	41	0.1	2975	5.5	16534	30.4	54422
Childhood	7523	70.6	201	1.9	277	2.6	80	0.8	192	1.8	99	0.9	40	0.4	1194	11.2	1054	(9.9)	10660

Table 3.1b Number of cancer registrations by ethnic group, and missing ethnicity values, for all cancers. (C00 – C97 exc. C44) and for each grouping / cancer. (A full breakdown of all individual cancers is also given in the tables in each applicable section below.)

[#]Made up of Other White (3.0%) Irish White (0.7%) White& Black Caribbean (0.07%), White & Black African (0.04%), White & Asian (0.05%), Other mixed (0.1%) Other Asian (0.2%), Other Black (0.2%) Other (1.2%)

Ethnic group	Population (%)	Number of registered cases of cancer (%)
White	42,747,136 (86.8)	1228584 (71.2)
Indian	1,028,546 (2.1)	10599 (0.6)
Pakistani	706,539 (1.5)	5825 (0.3)
Bangladeshi	275,394 (0.6)	1851 (0.1)
Black African	475,938 (1.0)	5573 (0.3)
Black Caribbean	561,246 (1.1)	11995 (0.7)
Chinese	220,681 (0.5)	3193 (0.2)
All other ethnicities*	2,998,409 (6.4)*	97542 (5.7)#
No ethnicity recorded	0	360845 (20.9)

Table 3.1c Distribution of the population, and of registered cancers in England by ethnic group.

*Made up of Other White (2.7%) Irish White (1.3%) White & Black Caribbean (0.5%), White & Black African (0.2%), White & Asian (0.4%), Other mixed (0.3%) Other Asian (0.5%), Other Black (0.2%), Other (0.5%).

#Made up of Other White (3.0%) Irish White (0.7%) White & Black Caribbean (0.07%), White & Black African (0.04%), White & Asian (0.05%), Other mixed (0.1%) Other Asian (0.2%), Other Black (0.2%), Other (1.2%).

3.1 All cancers

In total, there were 1,228,584 cancer registrations and ethnicity information was missing in 360,845 cases (20.9%).

Figure 3.1 shows the overall age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for all cancers (C00 – C97 exc. C44) by individual ethnic group compared to Whites. For all six cancers there is significant heterogeneity between the ethnic groups (All P<0.001). Subgroups show rates and rate ratios subdivided by sex & age.

Overall incidence of all cancers was lowest in South Asians compared to all other ethnic groups and approximately half that in Whites (P<0.001) with small differences between Indians, Pakistanis and Bangladeshis (0.55, 0.62 and 0.57, respectively, P<0.001). Both Black groups had very slightly lower incidence than Whites (P<0.001) while the incidence in Chinese was about 20% lower (P<0.001). South Asian women had about a 10% higher risk than men (P<0.001) whereas the opposite was seen in Blacks with risk being about 20% higher in men. In South Asians, all cancer risk in those aged less than 50 years was closer to that of Whites than in those aged 50 years or older (P<0.001) whereas the opposite pattern was seen in Blacks -although the differences observed were small in both groups. There was no difference by sex or age in the Chinese group.

Adjusting for income does not have a major impact for any of the ethnic groups but as expected, the effect was larger for the more deprived groups (e.g. Bangladeshis and Black Africans) than for the less deprived groups (Indians and Chinese.) Indeed, for Black Africans their ASR was slightly higher than Whites (233.7 vs. 219.7) but their IRR (0.95) was slightly lower after adjusting for income

3.1.1 Sensitivity analysis

In the sensitivity analysis which assigned missing values using multiple imputation, results very similar to those shown in Figure 3.1 were obtained.

3.1.2 Comparison to rates in countries of origin

The comparisons with international data on age-standardised incidence rates from Globocan (plus Hong Kong) are shown in Table 3.1.2. In summary, in South Asian men and women, ASRs for all cancers were higher than the rates in their countries of origin but lower than in Whites.

The same pattern was seen in Black African & Black Caribbean females.
For Black African & Black Caribbean males, however, the ASRs for all cancers were higher than the rates in their countries of origin and higher than in Whites
For Chinese men, the ASRs for all cancers were lower than in China and in Whites but for Chinese women, the ASRs for all cancers were higher than in China but lower than in Hong Kong and Whites.

It should be also be noted that all ASRs from this study are about 20% lower than their true value as ethnicity is missing for about 20% of all cancer registrations. (Assuming they are missing at random.)

3.1.3 Risk factors

Table 3.1.3 summarises data from the Health Survey for England on the prevalence of the most important risk factors for cancers overall (tobacco exposure, alcohol and obesity) in each ethnic group in England. [81]
Bangladeshi men had the highest prevalence of cigarette smoking, whereas in women Black Caribbean and White women smoked more than all other ethnic groups. Bangladeshis had the highest prevalence of chewing tobacco in both men and women. Whites and Black Caribbean men and White women had the highest alcohol consumption while Pakistanis and Bangladeshis had the lowest. The prevalence of obesity was highest in White men and Black women and lowest in both Chinese men and women.

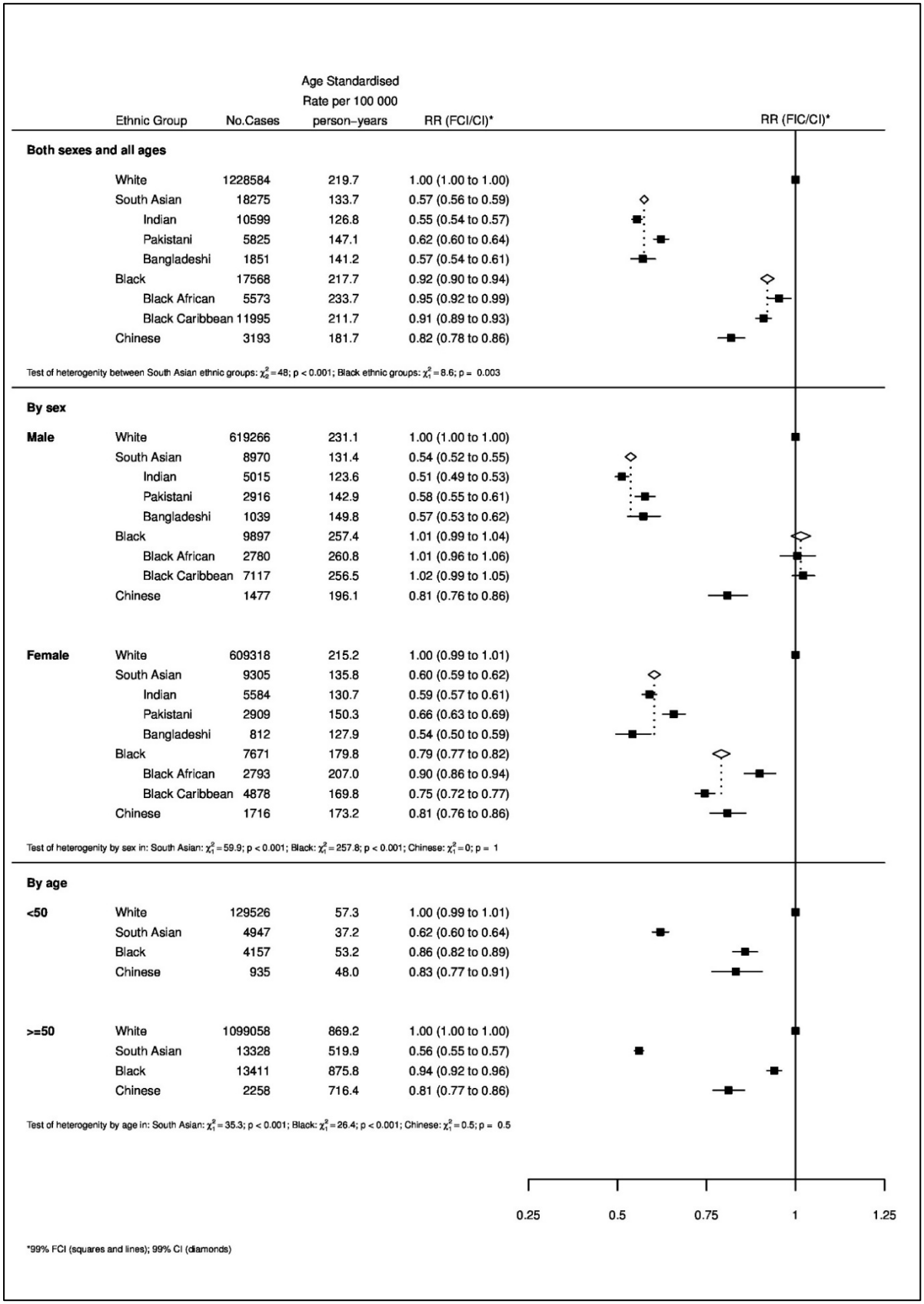

Figure 3.1 shows the overall age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for all cancers by ethnic group. Subgroups show rates and rate ratios subdivided by sex & age.

Cancer	Ethnic group	Male Age Standardised Rates		Female Age Standardised Rates	
		England	Country of origin	England	Country of origin
			Globocan*		Globocan*
All	**White**	231.1	284.0	215.2	267.3
	Indian	123.6	92.4	130.7	97.4
	Pakistani	142.9	96.0	150.3	127.7
	Bangladeshi	149.8	109.4	127.9	100.0
	African	260.8	108.9	207.0	133.9
	Caribbean	256.5	207.7	169.8	168.0
	Chinese	196.1	211.2 (236.9)	173.2	139.9 (195.5)

Table 3.1.2: Age-standardised 'All cancers' incidence rates per 100,000 people by ethnic group in England compared to rates in country or region of origin using estimates from Globocan and Cancer Incidence in Five Continents, Vol IX for Hong Kong (shown in brackets.)

Ethnicity	Prevalence of cigarette smoking. [81] (%)	Prevalence of tobacco chewing. [81] (%)	Alcohol intake 3 or more times a week. [81] (%)	Prevalence of obesity.[81] (% with BMI >30kg/m^2)
Males				
White	23	<1	41	23
Indian	20	4	18	14
Pakistani	29	2	2	15
Bangladeshi	40	14	1	6
Black African	21	Not Applicable	17	8
Black Caribbean	25	Not Applicable	28	18
Chinese	21	Not Applicable	18	3
Females				
White	23	<1	26	23
Indian	5	2	5	20
Pakistani	5	2	<1	28
Bangladeshi	2	26	<1	17
Black African	10	Not Applicable	5	31
Black Caribbean	24	Not Applicable	11	39
Chinese	8	Not Applicable	9	8

Table 3.1.3 Prevalence of some risk factors relevant for gastrointestinal cancers, by ethnic group.

3.2 Gastrointestinal cancers

In total, there were 378,511 gastrointestinal cancer registrations and ethnicity information was missing in 64,977 cases (17.2%).

Table 3.2 shows the number of cancer registrations by ethnic group, and missing ethnicity values, for each cancer.

Figures 3.2a-f shows age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for the six gastrointestinal cancers by individual ethnic group compared to Whites subdivided by sex, age, and by anatomical site or morphological type, as appropriate.

For colorectal cancer (Figure 3.2a), incidence was lowest in South Asians compared to all other ethnic groups and approximately half that in Whites (P<0.001) with similarly large reductions in risk seen separately in Indians, Pakistanis and Bangladeshis. Both Black groups had about a 20% lower incidence than Whites (P<0.001) while the incidence in Chinese was about 10% lower (P=0.02). There was no significant difference in the overall rate ratios by sex between South Asians or Chinese but incidence was slightly higher in Black women compared to men. In South Asians, colorectal cancer risk in those aged less than 50 years was closer to that of Whites than in those aged 50 years or older (P<0.001).

For oesophageal cancer (Figure 3.2b), the incidence was lower in all ethnic groups compared to Whites with South Asians, Blacks and Chinese having about half the incidence of that in Whites. There were also substantial differences between Indians, Pakistanis and Bangladeshis (IRRs of 0.51, 0.18 and 0.67 respectively, P<0.001). South Asian women had a higher risk than men (P<0.001) with a six-fold difference in risk between Pakistani and Bangladeshi women, whereas there was no difference by sex in Blacks or Chinese. There was no difference in risk by age group in any ethnic group. The lower incidence of oesophageal cancer in all ethnic groups compared to Whites was largely due to their lower incidence of adenocarcinoma rather than of squamous cell carcinoma. Bangladeshis had a six times higher risk of squamous cell carcinoma compared to Pakistanis.

For gastric cancer (Figure 3.2c), the overall incidence in South Asians was half that in Whites (P<0.001) with substantial differences between Indians, Pakistanis and Bangladeshis (0.44, 0.56 and 0.72, respectively, P<0.001). In contrast, incidence was higher in Blacks - mainly due to the higher rates in Black Caribbeans compared to Africans. South Asian women had a higher risk than men (P<0.001) with a two-fold difference in risk between Indian and

Bangladeshi women whereas there was no difference by sex in Blacks or Chinese. For South Asians, gastric cancer rates in those aged less than 50 years were much closer to Whites compared to those 50 years and older whereas the opposite pattern was seen in the Chinese (both P<0.001).

For liver cancer (Figure 3.2d), incidence was higher in all ethnic groups compared to Whites with the highest rates seen in Chinese (4 times higher). There were significant differences within the South Asian groups, with Bangladeshis having more than double the risk of Indians. There was also significant heterogeneity among blacks with Black Africans having more than three times the risk of Black Caribbeans (P<0.001). There was no difference in risk by sex or age group in South Asians or Blacks but rates were higher in Chinese men than women. The increased risk of liver cancer in all ethnic groups was largely due to their higher incidence of hepatocellular carcinoma compared to other types.

For gallbladder cancer (Figure 3.2e), incidence was also higher in all ethnic groups compared to Whites. There were significant differences within the South Asian groups, with Bangladeshis having double the risk of Indians. There was also significant heterogeneity amongst blacks with higher incidence mainly confined to Black Africans (P=0.003). There were also differences by sex, with the excess risk among South Asians and Blacks being largely confined to women, but no difference by age group.

For pancreatic cancer (Figure 3.2f), all South Asians groups had lower risks than Whites while there was no significant difference in risk for both Black groups or Chinese. There was no evidence of heterogeneity between individual South Asian or Black groups, or by sex or by age group.

3.2.1 Sensitivity analysis

In the sensitivity analysis which assigned missing values using multiple imputation, results very similar to those shown in Figure 1 were obtained.

3.2.2 Comparison to rates in countries of origin

The comparisons with international data on age standardised incidence rates from Globocan (plus Hong Kong) are shown in Table 3.2.2. In summary, in South Asians, ASRs for colorectal, gallbladder and pancreatic cancer were higher than the rates in their countries of origin but lower than in Whites; for oesophageal and gastric cancer they were lower than both their countries of origin and British Whites; and for liver cancer they were higher than both.

For Black Africans, the ASRs of colorectal and liver cancer were higher than in sub-Saharan Africa but lower than in Whites; for oesophageal cancer they were lower than both their region of origin and British Whites; and for gastric, gallbladder and pancreatic cancer they were higher than both.

For Black Caribbeans, the ASRs of colorectal, oesophageal and liver cancer were higher than in the Caribbean and British Whites but for gastric, gallbladder and pancreatic cancer they were higher than both their region of origin and British Whites.

For Chinese, the ASRs for all cancers were higher than in China and British Whites; with the exception of oesophageal cancer and colorectal cancer (in Hong Kong) where they were lower than both.

	White		Indian		Pakistani		Bangladeshi		Black African		Black Caribbean		Chinese		All other ethnic groups		No ethnicity recorded		Total
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N
Colorectal cancer	161902	77.0	1033	0.5	387	0.2	156	0.1	450	0.2	1176	0.6	371	0.2	11732	5.6	33019	15.7	210226
Oesophageal cancer	36446	78.6	267	0.5	44	0.1	56	0.1	66	0.1	213	0.5	49	0.1	2234	4.8	7004	15.1	46379
Gastric cancer	36921	74.1	238	0.5	151	0.3	68	0.1	152	0.3	560	1.1	114	0.2	2897	5.8	8702	17.5	49803
Liver cancer	11667	65.0	237	1.3	233	1.3	87	0.5	153	0.9	157	0.9	136	0.8	1270	7.1	4000	22.3	17940
Gallbladder cancer	5819	70.1	99	1.2	69	0.8	30	0.4	41	0.5	65	0.8	22	0.3	526	6.4	1558	18.9	8229
Pancreatic cancer	31809	69.2	240	0.5	131	0.3	36	0.1	115	0.3	340	0.7	73	0.2	2496	5.4	10694	23.3	45934
All six cancers	284564	75.2	2114	0.6	1015	0.3	433	0.1	977	0.3	2511	0.7	765	0.2	21,155	5.6	64977	17.2	378511

Table 3.2.1 Distribution of registered gastrointestinal cancers from 2001-2007 in England by ethnic group and missing ethnicity values.

Cancer	Ethnic group	Male Age Standardised Rates		Female Age Standardised Rates	
		England	Country or region of origin	England	Country or region of origin
Colorectal	**White**	31.9	38.6	20.3	26.2
	Indian	16.0	4.3	8.8	3.4
	Pakistani	11.4	4.9	9.8	4.2
	Bangladeshi	16.9	4.5	10.0	4.0
	African	24.0	5.6	17.2	3.6
	Caribbean	22.9	7.4	17.4	9.9
	Chinese	28.8	16.3 (39.2)[#]	18.3	8 (28.4)[#]
Oesophageal	**White**	8.7	9.8	3.3	3.5
	Indian	3.6	6.5	2.9	4.2
	Pakistani	1.3	6.2	1.0	5.7
	Bangladeshi	3.5	4.3	6.6	7.5
	African	3.4	6.6	3.5	3.0
	Caribbean	5.4	2.5	1.9	1.0
	Chinese	4.4	10.8 (9.5)[#]	1.8	7.0 (1.7)[#]
Gastric	**White**	8.3	6.9	3.2	2.9
	Indian	3.9	4.7	2	2.9
	Pakistani	5.2	8.0	2.7	4.5
	Bangladeshi	6.1	5.9	5.1	4.4
	African	8.4	4.0	6.2	2.7
	Caribbean	12.9	5.6	5.7	4.3
	Chinese	10.9	19.5 (14.7)[#]	3.7	12.4 (7.3)[#]
Liver	**White**	2.6	5.3	1.3	2.3
	Indian	4.0	3.2	1.8	1.2
	Pakistani	7.8	3.2	4.7	1.8
	Bangladeshi	9.5	4.1	4.2	3.5
	African	9.9	12	2.5	4.9
	Caribbean	3.1	3.2	2.1	3.1
	Chinese	13.6	18.1 (29.5)[#]	3.3	9.1 (7.3)[#]

Gallbladder	**White**	0.9	1.2	0.9	1.4
	Indian	0.9	1.3	1.5	2.4
	Pakistani	1.0	1.0	3	2.5
	Bangladeshi	1.8	1.6	2.9	5.4
	African	1.3	0.2	2.2	0.3
	Caribbean	1.0	0.3	1.2	1.0
	Chinese	1.6	0.7 (2.9)[#]	1	1.2 (2.8)[#]
Pancreatic	**White**	5.6	7.4	4.4	5.9
	Indian	3.3	1.1	2.4	0.8
	Pakistani	4.2	0.9	3.1	0.7
	Bangladeshi	3.0	0.4	2.4	0.4
	African	6.4	1.3	5.6	1.1
	Caribbean	7.1	2.2	4.4	2.5
	Chinese	4.4	1.5 (4.5)[#]	4.6	1.6 (3.1)[#]

Table 3.2.2: Age standardised cancer incidence rates per 100,000 people for gastrointestinal cancers by ethnic group in England compared to rates in country or region of origin using estimates from Globocan and Cancer Incidence in Five Continents, Vol IX where applicable.

* Globocan figures used are for India, Pakistan, Bangladesh, Sub-Saharan Africa, Caribbean, and China.

[#] Cancer Incidence in Five Continents (CIV) figures used are for Hong Kong (China).

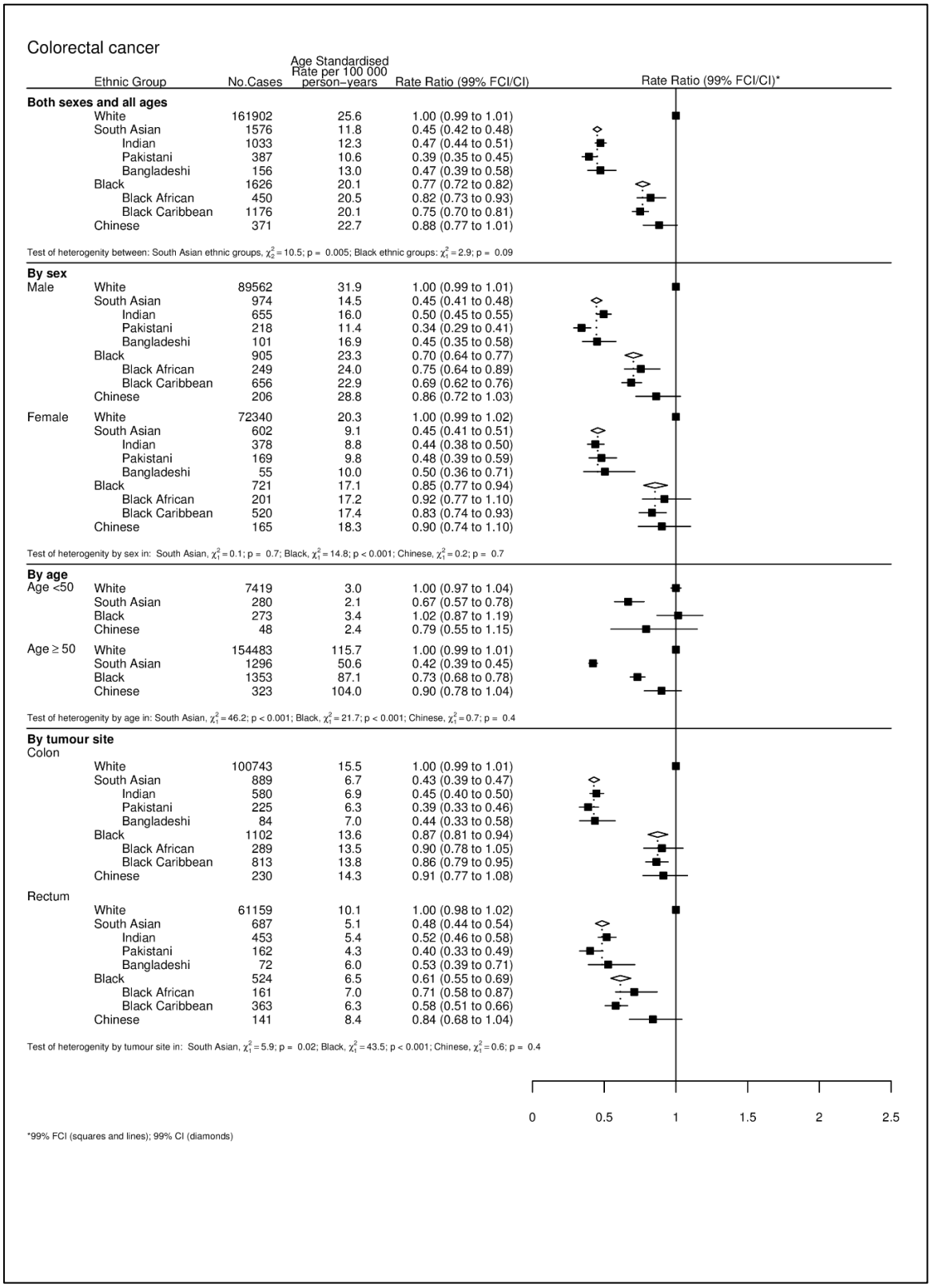

Figure 3.2a. Age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for colorectal cancer by ethnic group. Subgroups show rates and rate ratios subdivided by sex, age, and by anatomy (colon and rectum cancer.)

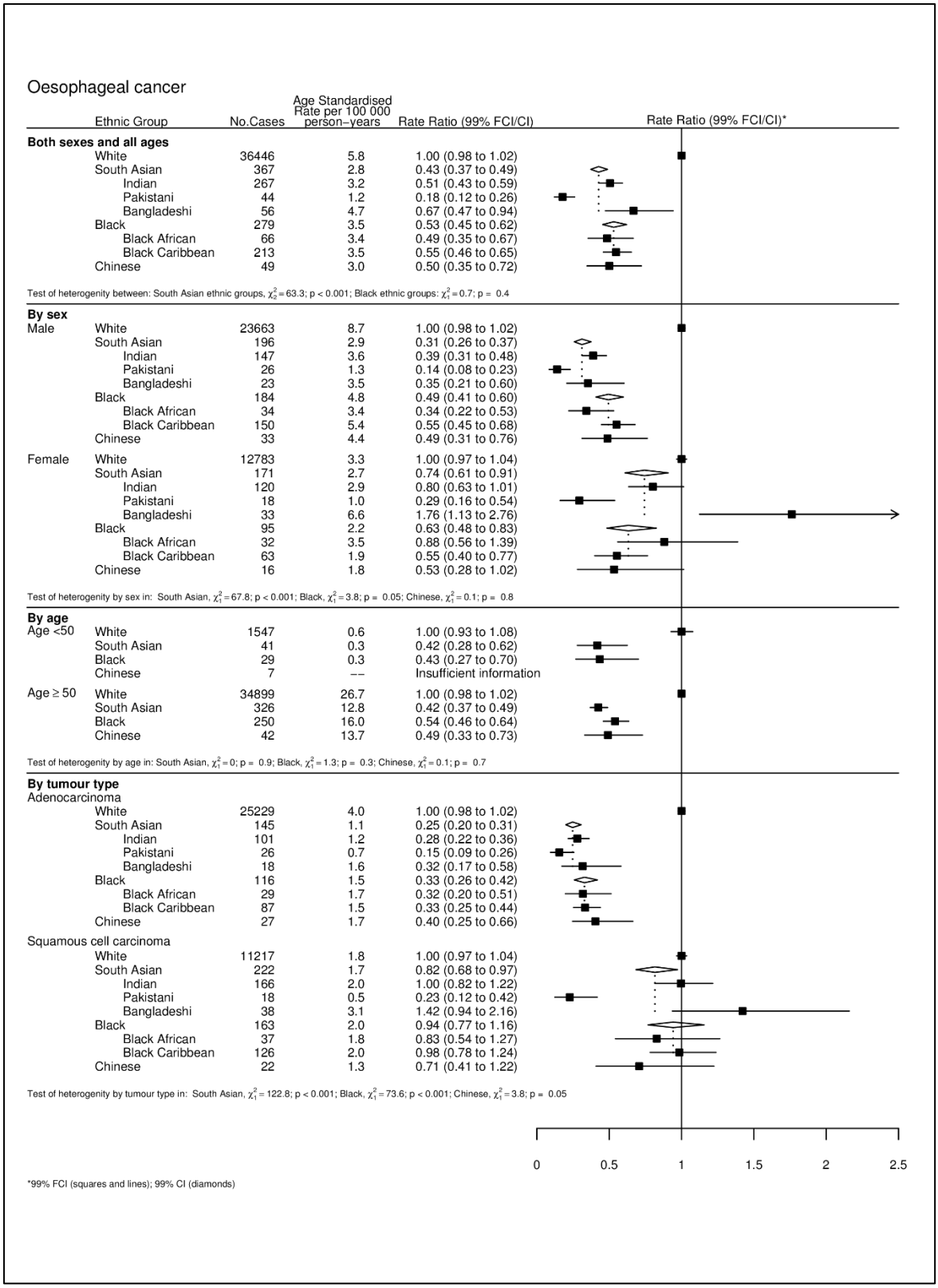

Figure 3.2b. Age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for oesophageal cancer by ethnic group. Subgroups show rates and rate ratios subdivided by sex, age, and by morphology (adenocarcinoma and squamous cell carcinoma).

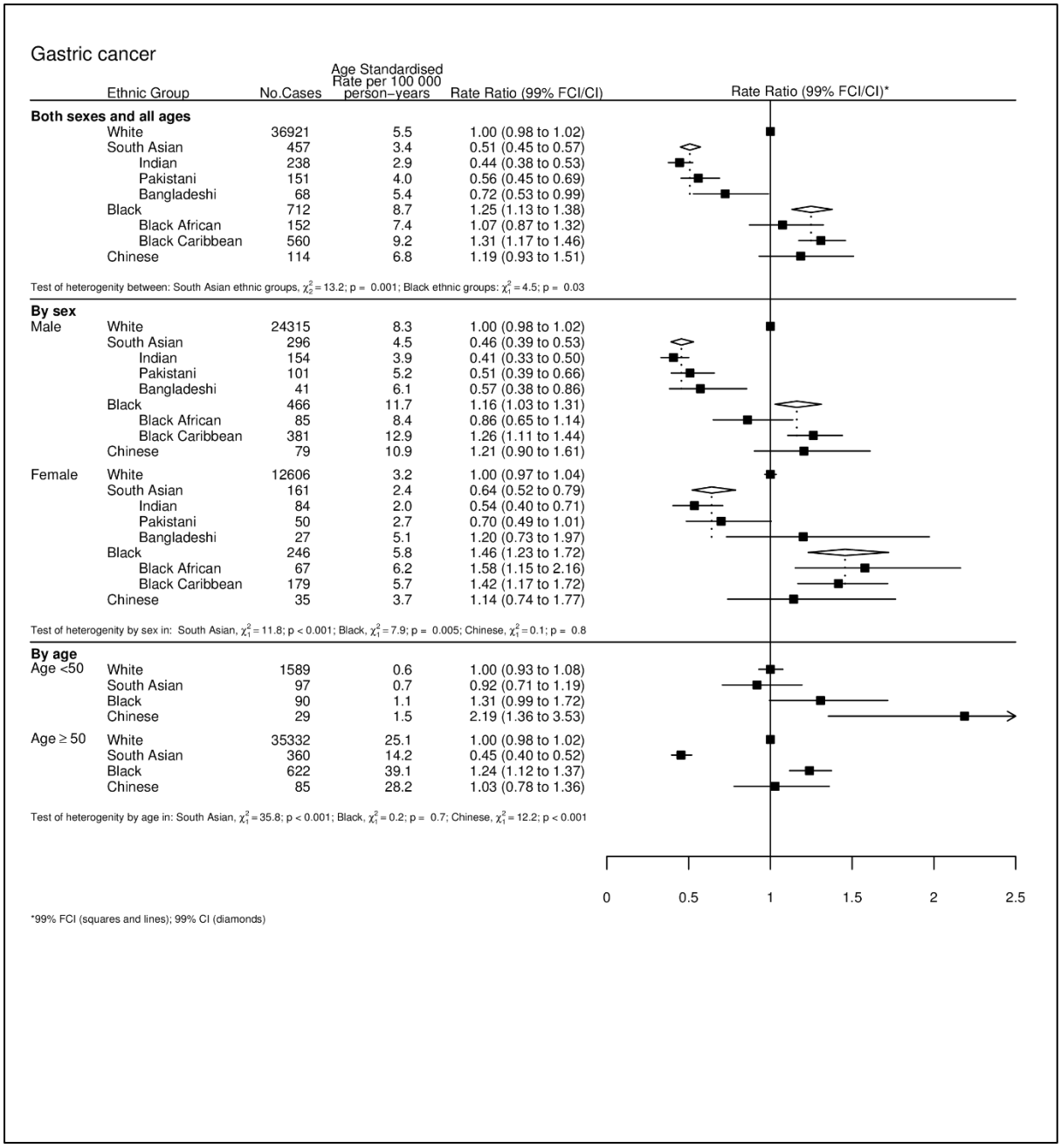

Figure 3.2c. Age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for gastric cancer by ethnic group. Subgroups show rates and rate ratios subdivided by sex and age.

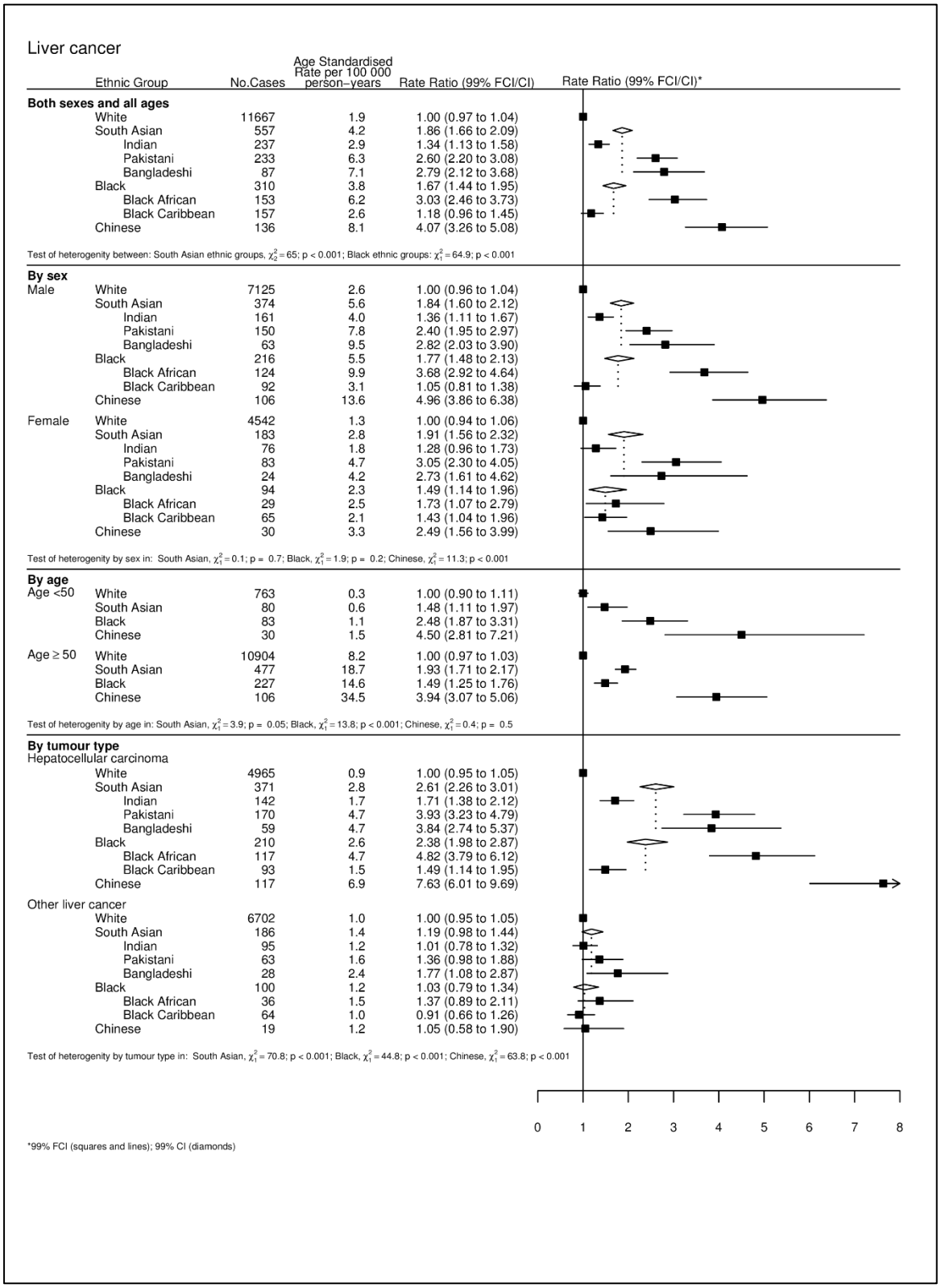

Figure 3.2d. Age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for liver cancer by ethnic group. Subgroups show rates and rate ratios subdivided by sex, age, and by morphology (hepatocellular carcinoma and other).

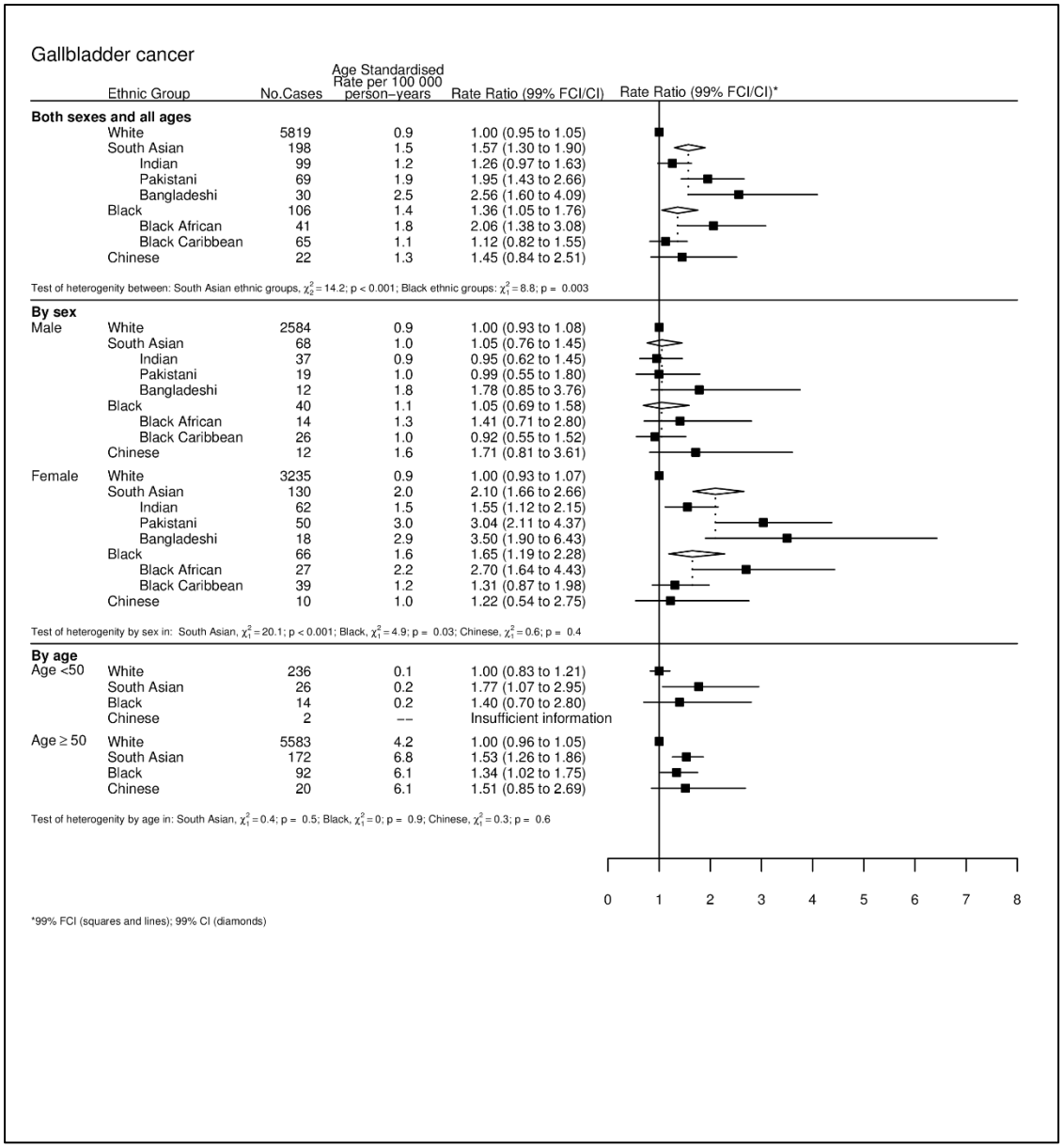

Figure 3.2e. Age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for gallbladder cancer by ethnic group. Subgroups show rates and rate ratios subdivided by sex and age.

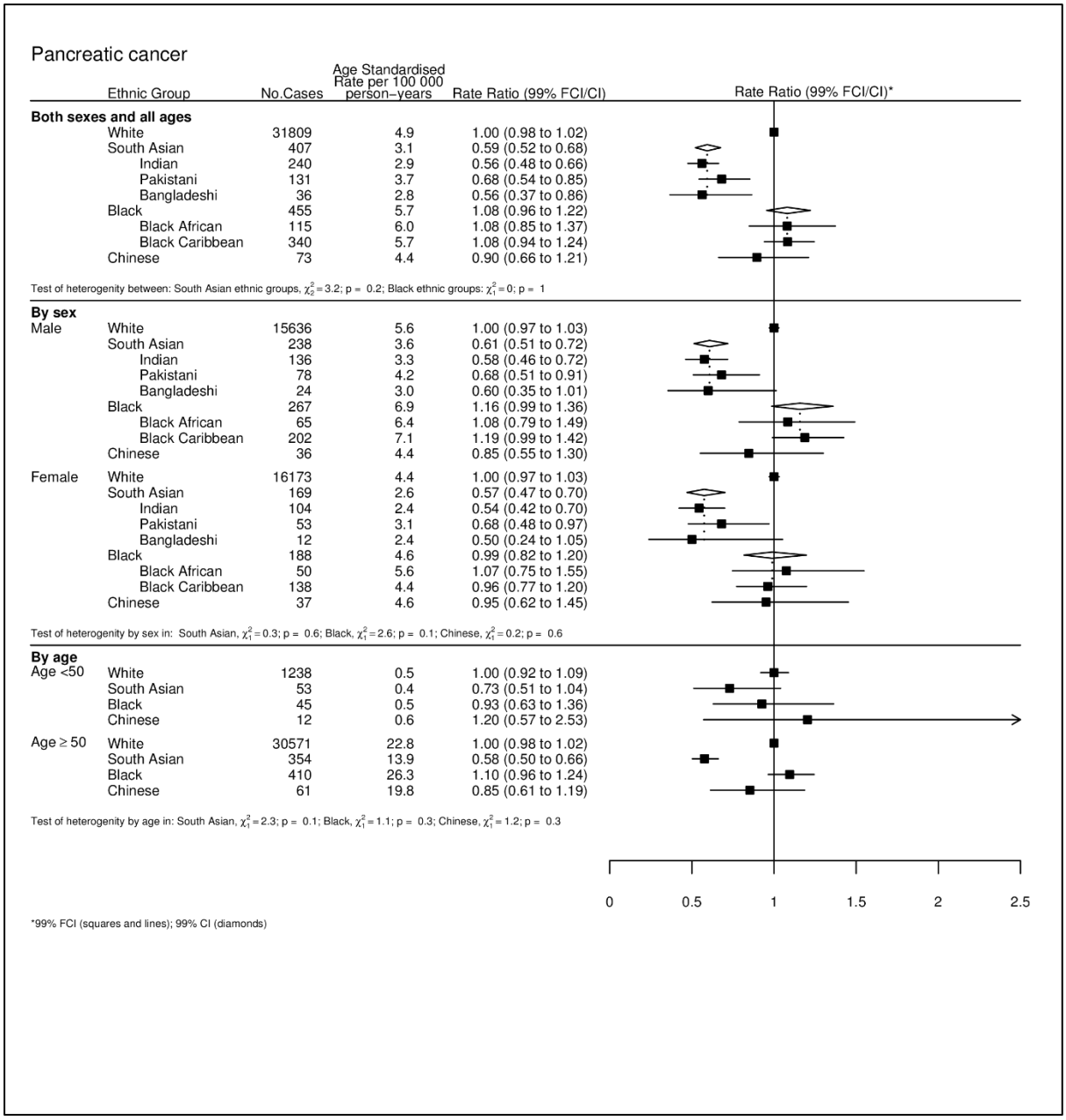

Figure 3.2f. Age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for pancreatic cancer by ethnic group. Subgroups show rates and rate ratios subdivided by sex and age.

3.3 Head & neck

In total, there were 37,072 head & neck cancer registrations and ethnicity information was missing in 7,130 cases (14.7%).

Table 3.3 shows the number of cancer registrations by ethnic group, and missing ethnicity values, for each group of cancers (mouth, larynx and nasopharynx.)

Figure 3.3 shows the overall age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for head & neck cancers by individual ethnic group compared to Whites. It shows that for both South Asians and Blacks there was no heterogeneity between the individual ethnic groups.

For head & neck cancers as a whole, incidence was lowest in both Black groups compared to all other ethnic groups and approximately half that in Whites (P<0.001) with similarly large reductions in risk seen separately in Black Africans and Black Caribbeans (no evidence of heterogeneity). All South Asian groups also had about a 30% reduced risk with no heterogeneity between Indians, Pakistanis and Bangladeshis. The incidence in Chinese was highest, about 25% higher than Whites (P<0.01). This was driven by a very high rate of nasopharyngeal carcinoma (ASR 5.1) and an IRR of 21.90 (p<0.001) (Not shown in Figure.)

Of note, although the ASRs for Bangladeshis were higher than for Whites (8.3 vs. 7.4) their IRR (0.74) was lower after adjusting for income.

There was no significant difference in the overall rate ratios by sex between Blacks or Chinese but incidence was slightly higher in South Asian women compared to men. This was driven by a higher rate of mouth cancer (IRR of 1.58 in women vs 0.85 in men, p<0.001) as shown in figure 3.3a. There was no significant evidence of heterogeneity between South Asian or Black groups by age group but in Chinese, those aged less than 50 years had much higher risk compared to those 50 years and older (IRR 1.98 vs. 0.97). Again, this was driven by the very high rates of nasopharyngeal carcinoma.

Figure 3.3a also shows higher rates of mouth cancer in Black women compared to men and that rates in Blacks aged less than 50 years had a closer risk to Whites compared to those 50 years and older. No heterogeneity by age was seen for South Asians or Chinese.

3.3.1 Sensitivity analysis

In the sensitivity analysis which assigned missing values using multiple imputation, results very similar to those shown in Figure 3.3 were obtained.

3.3.2 Comparison to rates in countries of origin

The comparisons with international data on age-standardised incidence rates from Globocan (plus Hong Kong) are shown in Table 3.3.2.

In summary, in South Asians, ASRs for mouth cancer were generally lower than the rates in their countries of origin but higher than in Whites; whereas for laryngeal cancer they were lower than both their countries of origin and Whites.

For Black Africans & Black Caribbeans, the ASRs for both mouth & laryngeal cancer were lower than both their countries of origin and Whites.

For Chinese, the ASRs for both mouth & laryngeal cancer were lower than both their countries of origin and Whites whereas for nasopharyngeal cancer (ASR in men and women combined was 5.1), they were lower than in Hong Kong (12.8 in men, 4.0 in women) but much higher than in Whites (ASR 0.2) and all other ethnic groups. (ASR 0.2 – 0.7) and for China as a whole. (ASR 2.8 in men, 1.7 in women.)

	White		Indian		Pakistani		Bangladeshi		Black African		Black Caribbean		Chinese		All other ethnicities		No ethnicity recorded		Total
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N
All head and neck cancer	37072	76.2	541	1.1	269	0.6	103	0.2	155	0.3	264	0.5	178	0.4	2921	6.0	7130	14.7	48633
Mouth	16635	74.3	358	1.6	176	0.8	44	0.2	84	0.4	106	0.5	38	0.2	1286	5.7	3672	16.4	22399
Larynx	9859	77.5	83	0.7	30	0.2	21	0.2	30	0.2	69	0.5	7	0.1	780	6.1	1845	14.5	12724
Nasopharynx	989	65.4	21	1.4	15	1.0	9	0.6	23	1.5	18	1.2	107	7.1	154	10.2	176	11.6	1512

Table 3.3 shows the number of cancer registrations by ethnic group, and missing ethnicity values, for each group of head and neck cancers (mouth, larynx and nasopharynx.)

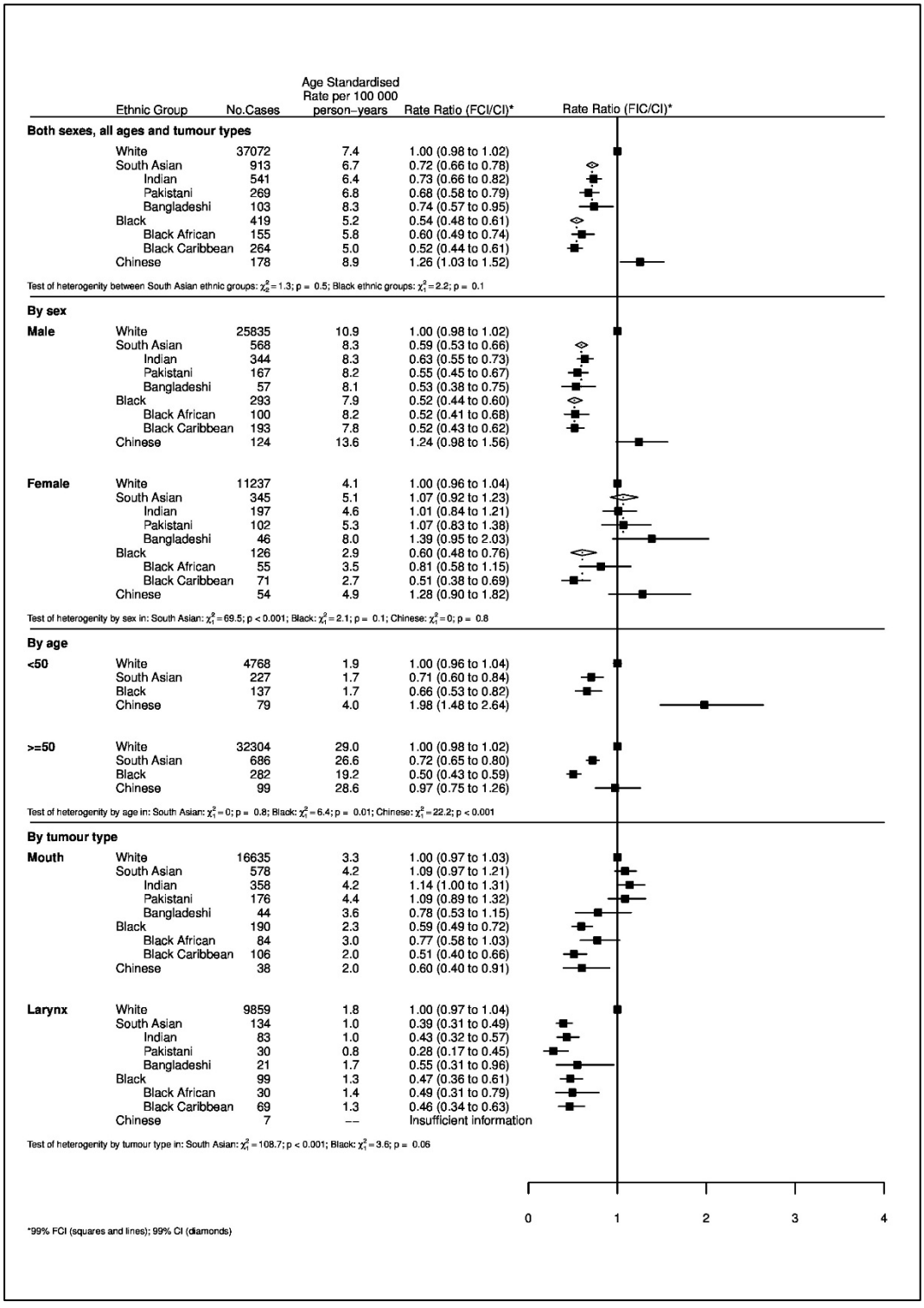

Figure 3.3. Age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for head & neck cancers by ethnic group. Subgroups show rates and rate ratios subdivided by sex, age, and by anatomy (mouth & larynx cancer.)

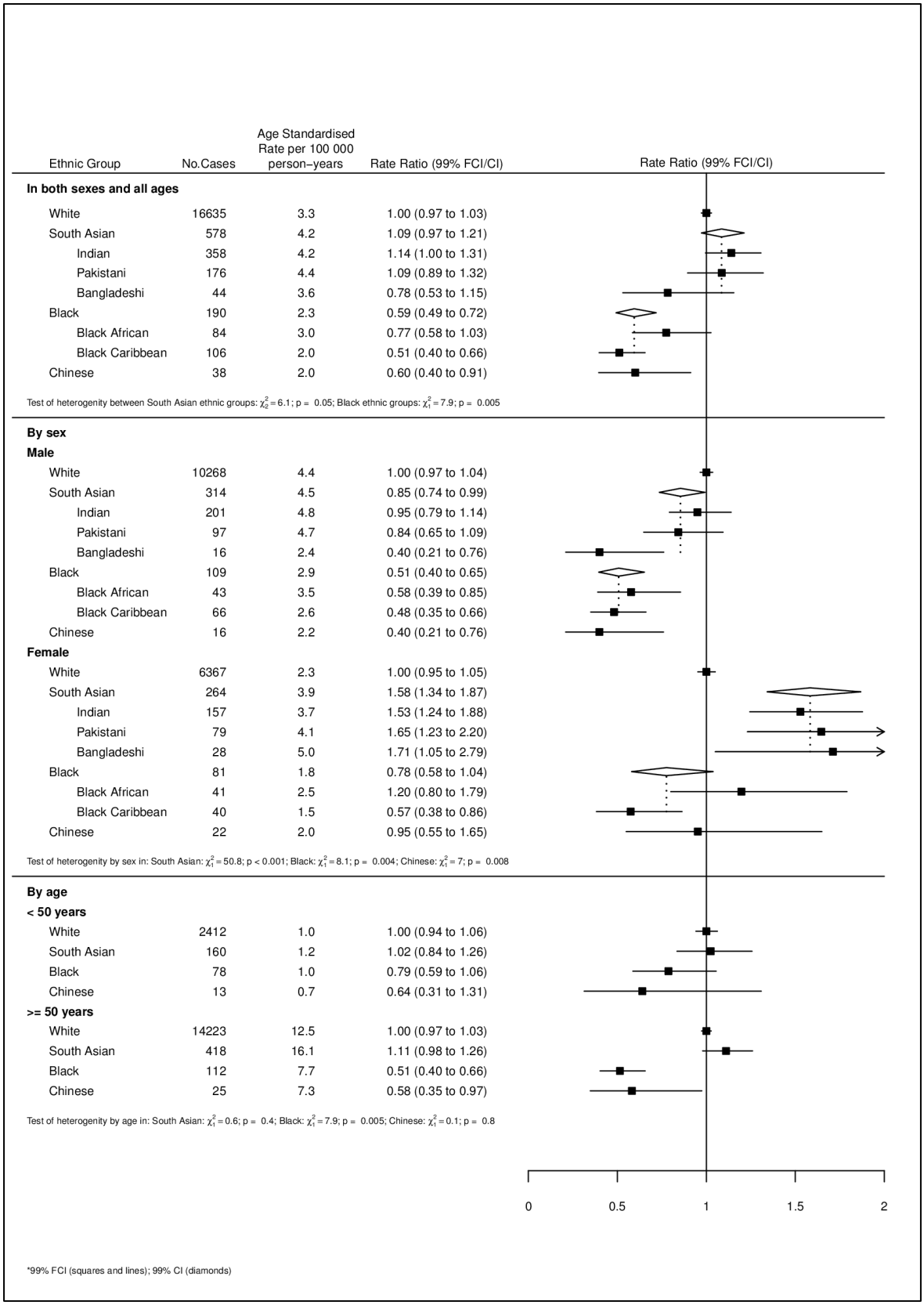

Figure 3.3a. Age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for mouth cancer by ethnic group. Subgroups show rates and rate ratios subdivided by sex and age.

Cancer	Ethnic group	Male Age Standardised Rates		Female Age Standardised Rates	
		England	Country or region of origin	England	Country or region of origin
Mouth	**White**	4.4	6.2	2.3	3.2
	Indian	4.8	10.1	3.7	4.3
	Pakistani	4.7	10.5	4.1	9.1
	Bangladeshi	2.4	13.0	5.0	5.9
	African	3.5	3.5	2.5	2.1
	Caribbean	2.5	4.8	1.5	1.8
	Chinese	2.2	1.6	2.0	0.9
Larynx	**White**	1.8*	3.3	1.8*	0.7
	Indian	1.0*	4.6	1.0*	0.5
	Pakistani	0.8*	5.0	0.8*	0.7
	Bangladeshi	1.7*	4.7	1.7*	0.8
	African	1.4*	2.1	1.4*	0.3
	Caribbean	1.3*	7.9	1.3*	0.9
	Chinese	--	2.1	--	0.2
Nasopharynx	**White**	0.2*	0.5	0.2*	0.2
	Indian	0.3*	0.5	0.3*	0.2
	Pakistani	0.3*	0.8	0.3*	0.3
	Bangladeshi	--	0.5	--	0.2
	African	0.6*	1.2	0.6*	0.7
	Caribbean	0.4*	0.4	0.4*	0.2
	Chinese	5.1*	2.7 (12.8)[#]	5.1*	1.1 (4.0)[#]

*male and female combined

Table 3.3.1: Age standardised cancer incidence rates per 100,000 people for head and neck cancer by ethnic group in England compared to rates in country or region of origin using estimates from Globocan and Cancer Incidence in Five Continents, Vol IX where applicable.

Globocan figures used are for India, Pakistan, Bangladesh, Sub-Saharan Africa, Caribbean, and China.

[#] Cancer Incidence in Five Continents (CIV) figures used are for Hong Kong (China).

3.4 Lung cancer

In total, there were 227,149 cases of lung cancer diagnosed within the study period. as shown in table 3.4, with missing ethnicity values for each subtype. Overall, ethnicity information was missing in 48,779 (21.5%) cases.

Figure 3.4 shows the age-standardised rates and rate ratios (adjusted by age, sex and income) for each ethnic group for all lung cancers combined. Incidence rates were lower than Whites for all ethnic groups; South Asians and Blacks experienced the lowest rates (IRRs of 0.34 and 0.42 respectively) with rates among Chinese being closer to those of Whites (IRR=0.70). There was strong evidence of intra-ethnic differences in the South Asian group, mainly due to the higher incidence among Bangladeshis compared to Indians and Pakistanis (RRs of 0.59, 0.29 and 0.36; $p<0.001$). There was no difference in incidence between Black Africans and Black Caribbeans.

Of note, although the ASRs for Bangladeshis were quite close to Whites (24.3 vs. 26.1) their IRR (0.59) was much lower after adjusting for income.

Rates were higher among males compared to females for all ethnic groups with strong evidence of variation in ethnic differences by sex, with substantially higher rate ratios among males for both South Asians (Male IRR = 0.42; Female IRR = 0.21) and Blacks (Male IRR = 0.51; Female IRR = 0.28) (both $p<0.001$). In contrast, there was no heterogeneity by sex among Chinese.

Comparing rate ratios between the under 50 age group and the over 50 age group revealed considerable differences among Blacks, with under 50s having higher rate ratios than their older counterparts (IRRs of 0.57 and 0.40 respectively; $p<0.001$). Similarly, Chinese under 50s had much higher rate ratios than the older 50s age group (IRRs of 0.94 and 0.68 respectively, $p<0.05$) In contrast, there was no heterogeneity by age among South Asians.

*Incidence by subtype (*Figure 3.4a)
Subtypes tended to exhibit a similar pattern, with rates being lowest among South Asians, intermediate among Blacks and Chinese, and highest in Whites. There was strong evidence of heterogeneity by subtype for all 3 major ethnic groups (all $p<0.001$).
I
IRRs for adenocarcinoma were higher than for other subtypes and rates among Chinese were very similar to those of Whites. Rates among Blacks were about 40% lower than Whites and

South Asian rates were about half that of Whites. For large cell cancers, IRRs among South Asians and Blacks were both lower than Whites (IRRs of 0.26 and 0.42 respectively). Due to low case numbers, analyses for Pakistanis, Bangladeshis & Chinese were not done.

Rate ratios for small cell lung cancer were the lowest of the 4 subtypes, with all ethnic groups experiencing considerably lower rates compared to Whites. Rates among South Asians and Blacks were approximately 20% those of Whites.
In contrast to the other 3 subtypes, rates were also substantially lower among Chinese compared to Whites, with an IRR of 0.28.

For squamous cell lung cancer, again South Asians experienced the lowest rates, but there was large variation within the group, with Bangladeshis having a much higher IRR compared to Indians and Pakistanis (IRRs of 0.77, 0.23 and 0.31 respectively, $p<0.001$). Rates among Blacks were 63% lower than Whites, while Chinese incidence rates were around half that of Whites.

3.4.1 Sensitivity analysis

In the sensitivity analysis which assigned missing values using multiple imputation, results very similar to those shown in Figure 3.4 were obtained.

3.4.2 Comparison to rates in countries of origin

The comparisons with international data on age-standardised incidence rates from Globocan (plus Hong Kong) are shown in Table 3.3.2.

In general, for all ethnic groups, rates were higher than the rates in their countries of origin but lower than in Whites. The exceptions were Bangladeshi men where rates were higher than in both Bangladesh and Whites, and Chinese men and women where they were lower than both China / Hong Kong and Whites.

	White		Indian		Pakistani		Bangladeshi		Black African		Black Caribbean		Chinese		All other ethnicities		No ethnicity recorded		Total
	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)	N
All lung cancer	163162	71.8	762	0.3	494	0.2	285	0.1	324	0.1	901	0.4	324	0.1	12118	5.3	48779	21.5	227149
Adenocarcinoma	25129	75.8	201	0.6	90	0.3	48	0.1	86	0.3	189	0.6	76	0.2	2085	6.3	5245	15.8	33149
Large cell	2866	73.2	13	0.3	9	0.2	1	0.0	3	0.1	21	0.5	7	0.2	181	4.6	816	20.8	3917
Small cell	21017	77.3	59	0.2	55	0.2	28	0.1	25	0.1	76	0.3	19	0.1	1431	5.3	4485	16.5	27195
Squamous/ epidermoid	35934	77.1	141	0.3	101	0.2	92	0.2	72	0.2	178	0.4	54	0.1	2519	5.4	7530	16.2	46621

Table 3.4 Number of cancer registrations by ethnic group, and missing ethnicity values, for all lung cancers and by cancer type.

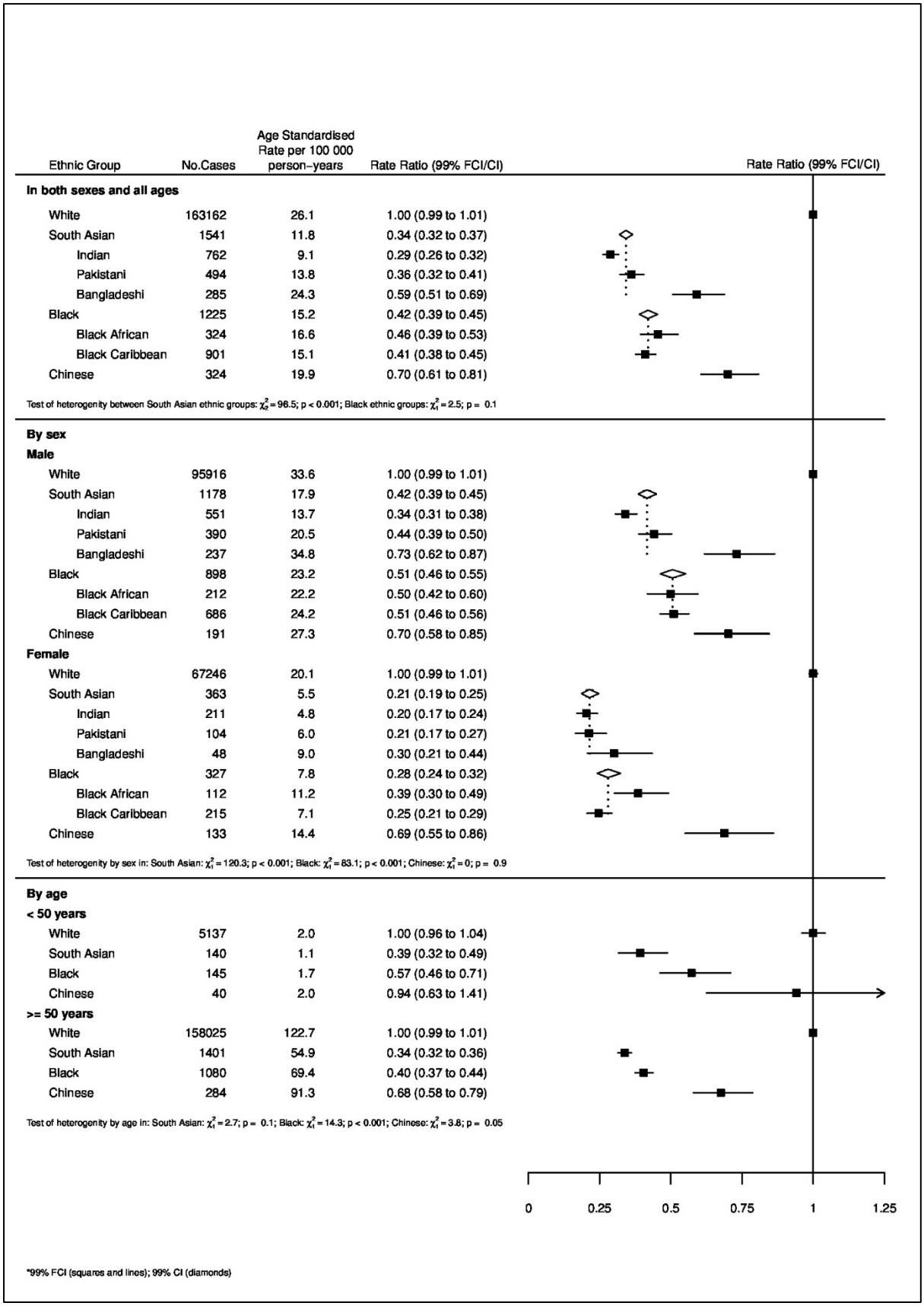

Figure 3.4 Age-standardised rates and rate ratios (adjusted by age, sex and income) for each ethnic group for all lung cancers combined.

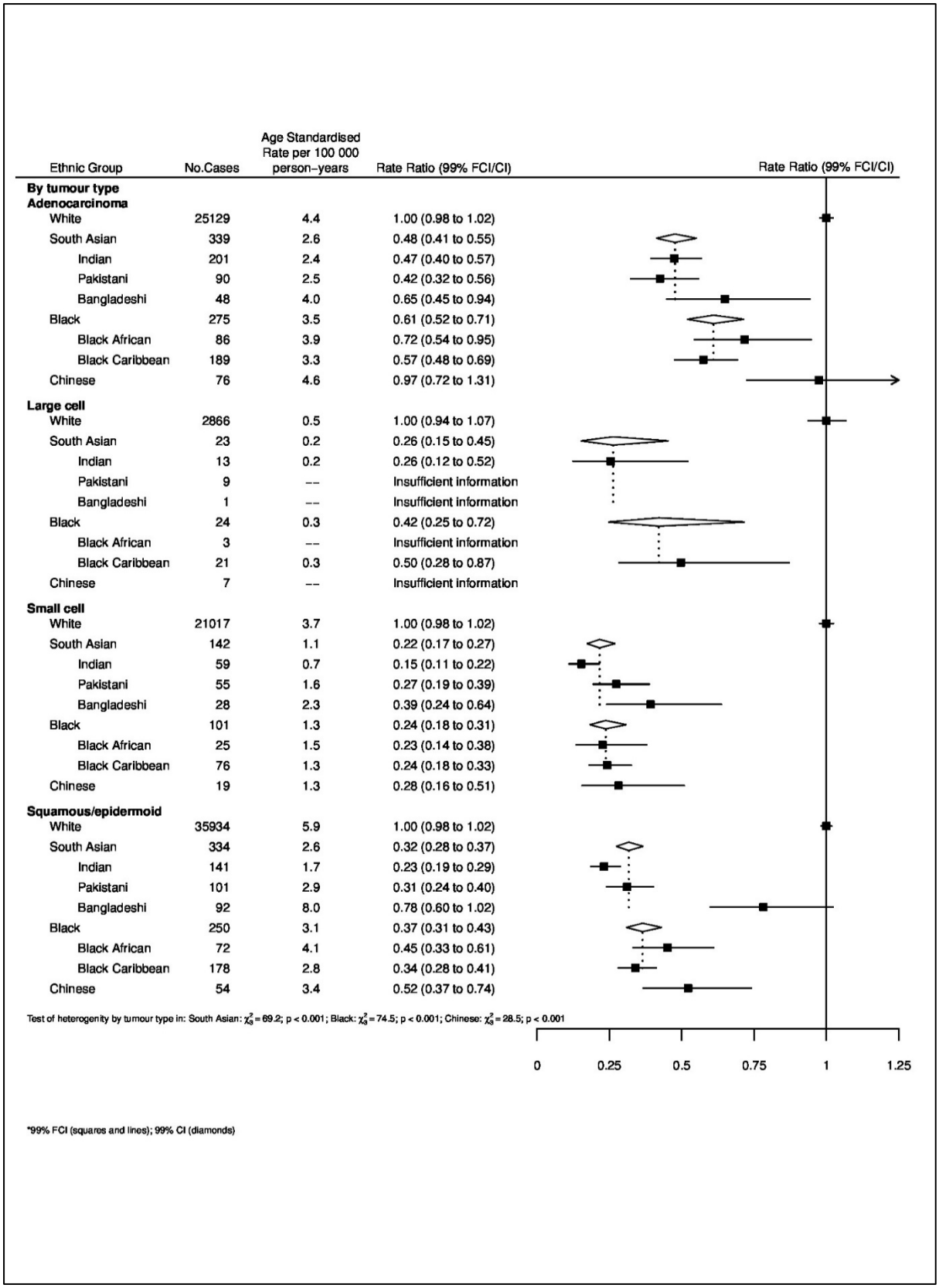

Figure 3.4a Age-standardised rates and rate ratios (adjusted by age, sex and income) for each ethnic group for lung cancer results by cancer type.

Cancer	Ethnic group	Male Age Standardised Rates		Female Age Standardised Rates	
		England	Country or region of origin	England	Country or region of origin
Lung	**White**	33.6	34.9	20.1	25.8
	Indian	13.7	11.0	4.8	3.1
	Pakistani	20.5	9.7	6.0	1.7
	Bangladeshi	34.8	16.6	9.0	3.6
	Black African	22.2	4.8	11.2	2.5
	Black Caribbean	24.2	25.8	7.1	13.5
	Chinese	27.3	52.8 (53.3) #	14.4	20.4 (21.9)#

Table 3.4.1: Age standardised cancer incidence rates per 100,000 people for lung cancer by ethnic group in England compared to rates in country or region of origin using estimates from Globocan and Cancer Incidence in Five Continents, Vol IX where applicable.

* Globocan figures used are for India, Pakistan, Bangladesh, Sub-Saharan Africa, Caribbean, and China.

Cancer Incidence in Five Continents (CIV) figures used are for Hong Kong (China).

3.5 Female Breast and Gynaecological cancers

Table 3.5.1 shows the demographic characteristics of females in each ethnic group. Bangladeshis, Pakistanis and Black Africans have the youngest populations, with only around 10% of their population being over 50 years old. These groups also have the highest levels of deprivation with Whites and Chinese being the least deprived groups. Around half of South Asians and Black Caribbeans were born in the UK compared to only around 30% of Black Africans and Chinese.

Table 3.5.2 shows the number of cancer registrations and missing ethnicity values for each cancer by individual ethnic group. Overall, there were 357,476 cases, of which 72,985 (20.4%) had no recorded ethnicity data.

Figures 3.5a and 3.5b show the age-standardised incidence rates and rate ratios (adjusted by age and income) for each ethnic group compared to Whites for breast and gynaecological cancers respectively.

For breast cancer (Fig. 3.5a), all 6 non-White ethnic groups experienced lower incidence rates compared to Whites. Incidence was lowest among South Asians, at around 70% that of Whites. However, there was considerable heterogeneity within the group with Indians and Pakistanis having almost double the rate of Bangladeshis (IRRs of 0.70, 0.72, 0.42 respectively; $p<0.001$). Rates among Blacks were around 15% lower than those of Whites, with little difference between Black Africans and Black Caribbeans. Chinese experienced similar rates to South Asians, with incidence rates around 30% lower than those of Whites.

Sub-group analysis of breast cancer cases revealed strong evidence of heterogeneity by age in both South Asians and Blacks. Among South Asians, the IRR was lower among under 50s compared to over 50s (IRRs of 0.63 and 0.71 respectively; $p=0.002$). Blacks, on the other hand, showed the reverse pattern, with under 50s showing no difference to Whites and over 50s experiencing rates around 20% lower than Whites (IRRs of 0.96 and 0.78 respectively; $p<0.001$). There was no evidence of heterogeneity by age for Chinese.

For ovarian cancer (Fig. 3.5b), incidence was lowest among South Asians and Blacks, at around 60% that of Whites. However, within the South Asian group there was strong evidence of heterogeneity, with Indians and Bangladeshis experiencing lower rates compared to Pakistanis (IRRs of 0.59, 0.56 and 0.84 respectively; $p<0.001$). There was also some evidence of heterogeneity within the Black group, with Black Africans

experiencing slightly higher rates than Black Caribbeans (IRRs of 0.74 and 0.56 respectively; p=0.01). No difference was observed between Chinese and Whites.

For cervical cancer (Fig. 3.5b), incidence was lowest among South Asians, with rates approximately two thirds lower than those of Whites. Rates among Blacks and Chinese were higher, at around 70% those of Whites. There was no evidence of heterogeneity within any of the groups.

For endometrial cancer (Fig. 3.5b), there was little difference in incidence between South Asians and Whites. However, there was strong evidence of heterogeneity within the group, with Bangladeshis experiencing around half the rates of Indians and Pakistanis (IRRs of 0.48, 0.94 and 0.94 respectively; p<0.001). Rates among Blacks were slightly higher than those of Whites, with no difference observed between Black Africans and Black Caribbeans. There was no significant difference in rates in Chinese compared to Whites.

3.5.1 Sensitivity Analysis

Assigning missing ethnicity values using multiple imputation generated results very similar to those obtained in our main analysis.

3.5.2 Comparison to rates in country of origin

Table 3.5.3 shows a comparison of the data from this study with international incidence data from Globocan (plus the Hong Kong cancer registry from CI5). For breast cancer and ovarian cancer, incidence rates were higher than those of the countries of origin and lower than in Whites. In contrast, cervical cancer rates were generally lower than both the country of origin and Whites for all ethnicities except Black Africans. Rates of endometrial cancer were slightly lower in the country of origin for Indians, Pakistanis, Bangladeshis and Black Africans, and higher for Black Caribbeans and Chinese.

Ethnic group	White		Indian		Pakistani		Bangladeshi		Black African		Black Caribbean		Chinese	
Census data for 2001	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Total population	21918492 (93%)		517342 (2.2%)		348496 (1.5%)		136422 (0.6%)		246835 (1.0%)		301365 (1.3%)		114768 (0.5%)	
Age														
<50	13747228	62.7	416091	80.4	309865	88.9	123940	90.9	224906	91.1	230232	76.4	95353	83.1
50+	8171264	37.3	101251	19.6	38631	11.1	12482	9.2	21929	8.9	71133	23.6	19415	16.9
Deprivation														
Low Income	3813688	17.4	175717	34.0	226581	65.0	99654	73.0	145962	59.1	160101	53.1	25354	22.1
Middle Income	13505394	61.6	283447	54.8	108151	31.0	33519	24.6	90493	36.7	129666	43.0	64565	56.3
High Income	4599410	21.0	58178	11.2	13764	4.0	3249	2.4	10380	4.2	11598	3.8	24849	21.7
Country of birth														
UK	21469693	98.0	232005	44.8	192021	55.1	63750	46.7	81451	33.0	172756	57.3	30185	26.3
Other	448799	2.0	285337	55.2	156475	44.9	72670	53.3	165382	67.0	128612	42.7	84582	73.7

Table 3.5.1. Comparison of demographic characteristics for **females** by ethnic group in England in 2001 using data from the 2001 census.[78]

	White		Indian		Pakistani		Bangladeshi		Black African		Black Caribbean		Chinese		All other ethnic groups		No ethnicity recorded		Total
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N
Breast cancer	182478	70.5	2194	0.8	1005	0.4	194	0.1	936	0.4	1674	0.6	540	0.2	15565	6.0	54331	21.0	258917
Ovarian cancer	30579	72.5	288	0.7	185	0.4	42	0.1	117	0.3	181	0.4	101	0.2	2404	5.7	8289	19.6	42186
Cervical cancer	12113	69.7	129	0.7	66	0.4	22	0.1	150	0.9	137	0.8	54	0.3	1367	7.9	3351	19.3	17389
Endometrial cancer	28449	73.0	398	1.0	161	0.4	27	0.1	131	0.3	338	0.9	111	0.3	2355	6.0	7014	18.0	38984
All four cancers	253619	70.9	3009	0.8	1417	0.4	285	0.1	1334	0.4	2330	0.7	806	0.2	21691	6.1	72985	20.4	357476

Table 3.5.2. Distribution of registered breast and gynaecological cancers from 2001-7 in England by ethnic group, including missing ethnicity values.

Cancer Site	Ethnic group	Female Age-Standardised Rates	
		England	Country or region of origin
Breast	White	73.5	87.7
	Indian	50.7	22.9
	Pakistani	51.8	31.5
	Bangladeshi	28.1	27.2
	Black African	62.8	26.3
	Black Caribbean	59.0	39.1
	Chinese	51.6	21.6 (52.1)*
Ovary	White	11.6	9.9
	Indian	6.8	5.7
	Pakistani	9.5	5.8
	Bangladeshi	6.3	4.0
	Black African	8.9	4.0
	Black Caribbean	6.4	4.3
	Chinese	9.8	3.8 (6.2)*
Cervix	White	7.0	7.5
	Indian	3.0	27.0
	Pakistani	3.3	19.5
	Bangladeshi	4.0	29.8
	Black African	10.1	31.7
	Black Caribbean	5.2	20.8
	Chinese	4.8	9.6 (6.8)*
Endometrium	White	5.3	14.0
	Indian	4.9	1.9
	Pakistani	4.5	2.8
	Bangladeshi	2.0	0.3
	Black African	6.2	2.6
	Black Caribbean	6.0	9.0
	Chinese	6.3	11.1 (12.0)*

Table 3.5.3 Age-standardised incidence rates per 100,000 people for breast and gynaecological cancers by ethnic group in England compared to rates in country of origin using estimates from Globocan [1] and Cancer Incidence in Five Continents, Vol IX where applicable . *CI5 figure for Hong Kong.

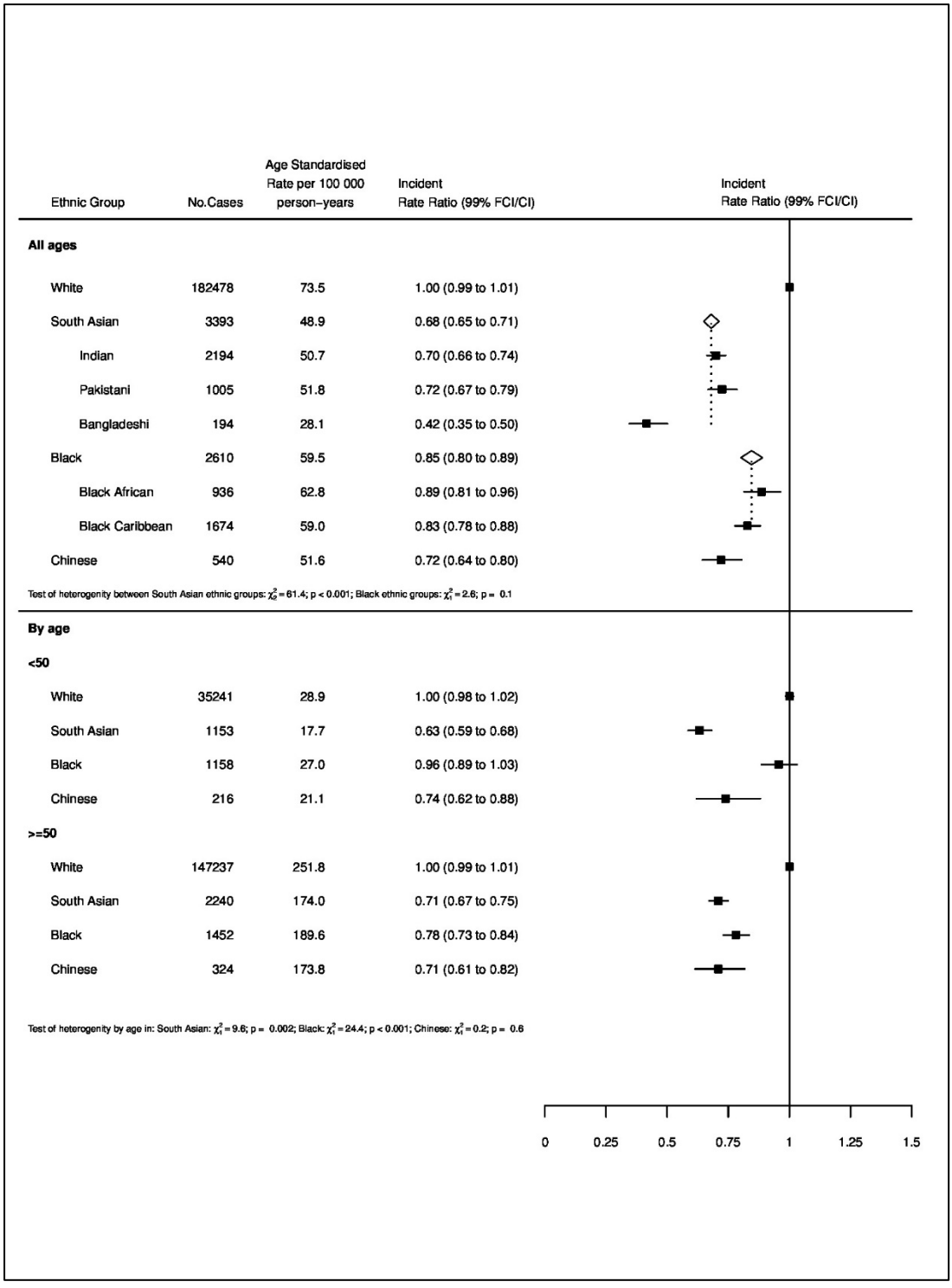

Figure 3.5a. Age-standardised incidence rates and rate ratios (adjusted by age and income) for breast cancer by ethnic group. Subgroups show rates and rate ratios subdivided by age. FCI - 99% floating confidence interval; CI – 99% confidence interval.

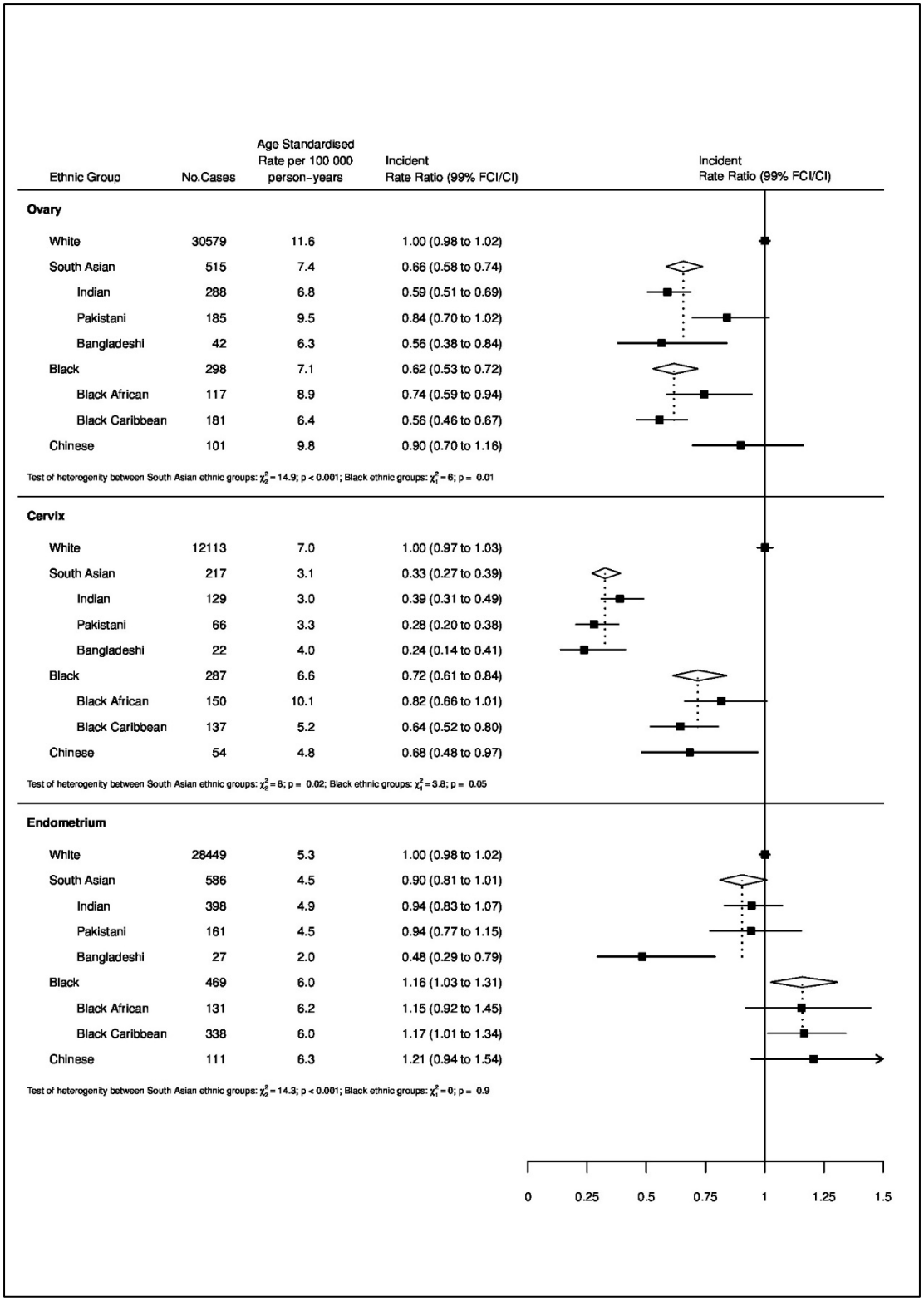

Figure 3.5b. Age-standardised incidence rates and rate ratios (adjusted by age and income) for ovarian, cervical and endometrial cancer by ethnic group. FCI - 99% floating confidence interval; CI – 99% confidence interval.

3.6 Urological cancers

Table 3.6.1 shows socio-demographic information from the 2001 census for males only for Whites, Indians, Pakistanis, Bangladeshis, Black Africans, Black Caribbeans and Chinese. All six groups are, on average, younger than Whites and all except Chinese are also poorer, with Pakistanis, Bangladeshis and Black Africans being the most deprived.

Table 3.6.2 shows the number of cancer registrations by ethnic group, and missing ethnicity values for each cancer. In total there were 329,524 urological cancer registrations and ethnicity information was missing in 81,767 (24.8%) cases.

Figures 3.6a-d shows the overall age-standardised incidence rates and rate ratios, adjusted by age, sex and income, for the four urological cancers by individual ethnic group compared to Whites.

For kidney cancer (Figure 3.6a), the overall incidence in Chinese and South Asians was about half that in Whites, with risk in Indians significantly lower than in Pakistanis and Bangladeshis. (IRRs of 0.47, 0.67 and 0.66 respectively, P<0.001). The incidence in Blacks was also lower than Whites with higher rates in Black Africans than Black Caribbeans. (IRRs of 0.94 and 0.67 respectively, P= 0.002). These trends were maintained in subgroup analyses by cancer type. Across all ethnicities, risk was higher in men than women but the relative risk compared to Whites was similar in men and women for all non-White groups.

For bladder cancer (Figure 3.6b), the overall incidence in South Asians and Blacks was nearly two thirds lower than in Whites with no significant difference between Indians, Pakistanis and Bangladeshis, or between Black Africans and Black Caribbeans. The risk in Chinese was about half that of Whites. These trends were maintained in subgroup analyses by cancer type. Across all ethnicities, risk was higher in men than women but the relative risk compared to Whites was similar in men and women for all non-White groups.

For prostate cancer (Figure 3.6c), the overall incidence in South Asians was almost half that in Whites with substantial differences between Indians, Pakistanis and Bangladeshis (IRRs of 0.55, 0.64 and 0.33 respectively, P<0.001) with Chinese also having a lower incidence than Whites. The incidence in both Black Caribbeans and Black Africans was more than double that of Whites. These trends were confirmed in subgroup analyses by both age and cancer type; Black Caribbeans and Black Africans displayed the highest incidence in both those aged

less than and greater than 50 and in both adenocarcinoma and ‘other’ types of prostate cancer.

For testicular cancer (Figure 3.6d), incidence in all ethnic groups was much lower than in Whites, about a third in South Asians and Chinese with Blacks having the lowest incidence and lower rates in Black Africans than Black Caribbeans. These trends were maintained in subgroup analyses by cancer type and also showed that South Asians have a higher incidence of non-seminomatous cancers compared to seminomas.

3.6.1 Sensitivity analysis

In the sensitivity analysis which assigned missing values using multiple imputations, results very similar to those shown in figure 3.6 were obtained.

3.6.2 Comparison to rates in countries of origins

Table 3.6.3 compares international data on age standardised incidence rates from GLOBOCAN (plus the Hong Kong cancer registry from CI5).

For prostate cancer, incidence rates in South Asians and Chinese were much higher than their countries of origin and lower than in Whites. In contrast, rates in both Black groups were much higher than both the country of origin and Whites. For testicular cancer and kidney cancer, rates for all ethnicities were higher than their country of origin but lower than Whites. In contrast, for bladder cancer, with the exception of Bangladeshis, rates were lower in all ethnic groups than both their country of origin and Whites.

Ethnic group	White		Indian		Pakistani		Bangladeshi		Black African		Black Caribbean		Chinese	
Census data for 2001	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Total population	20828644 (92.8%)		511204 (2.3%)		358043 (1.6%)		138972 (0.6%)		229103 (1.0%)		259881 (1.2%)		105913 (0.5%)	
Age														
<50	13918165	66.9	412109	80.6	315253	88.1	124901	89.9	208079	90.8	196192	75.5	89322	84.3
50+	6910479	33.1	99095	19.4	42790	11.9	14071	10.1	21024	9.2	63689	24.5	16591	15.7
Deprivation														
Low Income	3491839	16.7	171381	33.5	229129	64.0	99230	71.4	131896	57.6	132436	51.0	24073	22.7
Middle Income	12810392	61.5	280492	54.9	113887	31.8	35806	25.8	86741	37.7	115437	44.4	59429	56.1
High Income	4526413	21.7	59331	11.6	15027	4.2	3936	2.8	10466	4.6	12008	4.6	22411	21.2
Country of birth														
UK	20441457	98.1	240539	47.1	195175	54.5	64153	46.2	152006	58.5	79598	34.7	32024	30.2
Other	387187	1.9	270666	52.9	162868	45.5	74816	53.8	107875	41.5	149504	65.3	73889	69.8

Table 3.6.1. Comparison of demographic characteristics for **males** by ethnic group in England in 2001 using data from the 2001 census.

Cancer	White		Indian		Pakistani		Bangladeshi		Black African		Black Caribbean		Chinese		All other ethnic groups		No ethnicity recorded		Total
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N
Prostate	132278	62.5	934	0.4	491	0.2	90	0.0	861	0.4	3185	1.5	226	0.1	10624	5.0	63068	29.8	211757
Testes	50133	81.2	223	0.4	117	0.2	42	0.1	69	0.1	186	0.3	62	0.1	3135	5.1	7762	12.6	61729
Kidney	7890	65.7	88	0.7	65	0.5	8	0.1	17	0.1	28	0.2	18	0.2	831	6.9	3064	25.5	12009
Bladder	32775	74.4	246	0.6	170	0.4	58	0.1	146	0.3	239	0.5	57	0.1	2465	5.6	7873	17.9	44029
All four cancers	223076	67.7	1491	0.5	843	0.3	198	0.1	1093	0.3	3638	1.1	363	0.1	17055	5.2	81767	24.8	329524

Table 3.6.2. Distribution of registered urological cancers from 2001-2007 in England by ethnic group and missing ethnicity values.

Cancer Site	Ethnic group	Age Standardised Rates	
		England	Country or region of origin
Prostate	White	44.9	72.9
	Indian	23.7	3.7
	Pakistani	26.2	5.2
	Bangladeshi	14.0	1.9
	Black African	99.2	21.2
	Black Caribbean	110.1	71.1
	Chinese	34.6	4.3 (24.2) [#]
Testes	White	11.6	6.6
	Indian	6.8	0.6
	Pakistani	9.5	0.9
	Bangladeshi	6.3	1.0
	Black African	8.9	0.4
	Black Caribbean	6.4	0.7
	Chinese	9.8	0.4 (2.0) [#]
Kidney*	White	5.9	8.4
	Indian	3.0	1.1
	Pakistani	4.3	1.3
	Bangladeshi	4.2	1.1
	Black African	5.5	1.1
	Black Caribbean	4.5	2.7
	Chinese	3.4	2.8 (5.2) [#]
Bladder*	White	7.2	7.3
	Indian	2.7	2.8
	Pakistani	3.2	5.4
	Bangladeshi	3.7	2.6
	Black African	3.6	3.7
	Black Caribbean	3.1	5.8
	Chinese	3.9	5.5 (4.1)[#]

Table 3.6.3 Age-standardised incidence rates per 100,000 people for urological cancers by ethnic group in England compared to rates in country of origin using estimates from Globocan. and Cancer Incidence in Five Continents, Vol IX where applicable.

*Male and female combined

[#] Cancer Incidence in Five Continents, Vol IX for Hong Kong in brackets.

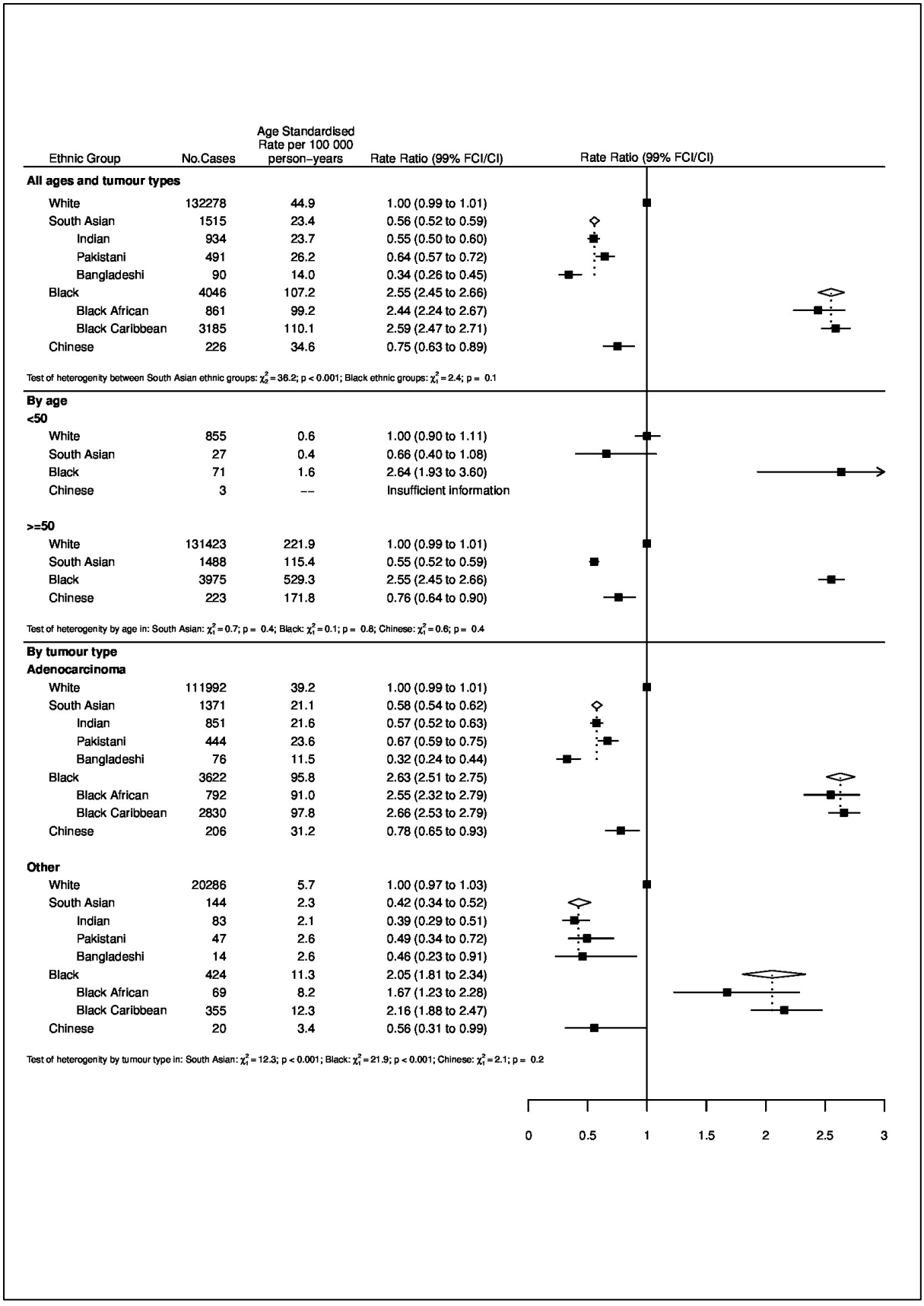

Figure 3.6a. Age-standardised incidence rates and rate ratios (adjusted by age and income) for prostate cancer by ethnic group. Subgroups show rates and rate ratios subdivided by age and morphology (adenocarcinoma and other.)

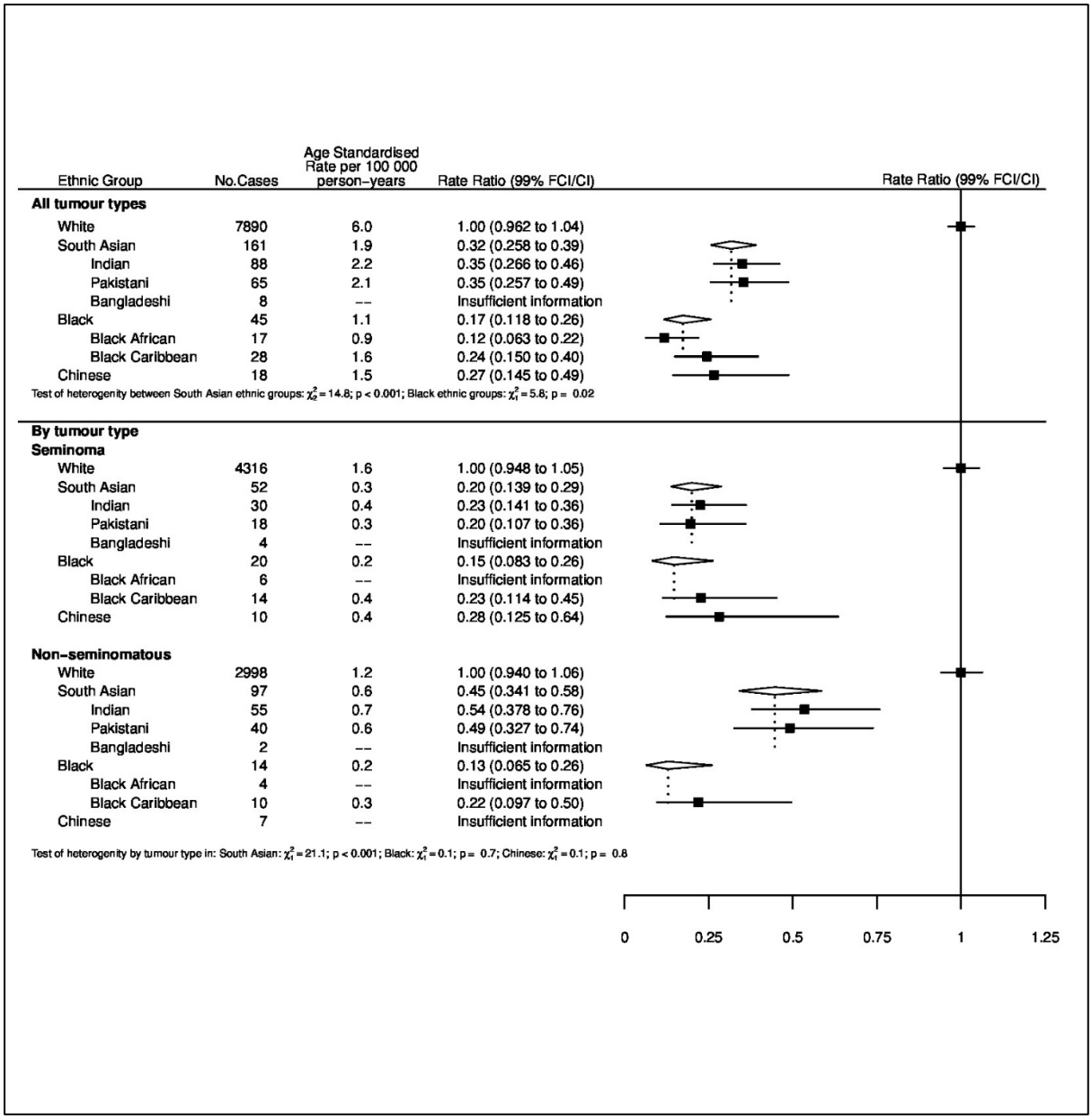

Figure 3.6b. Age-standardised incidence rates and rate ratios (adjusted by age and income) for testicular cancer by ethnic group. Subgroups show rates and rate ratios subdivided by morphology (seminoma and non-seminomatous).

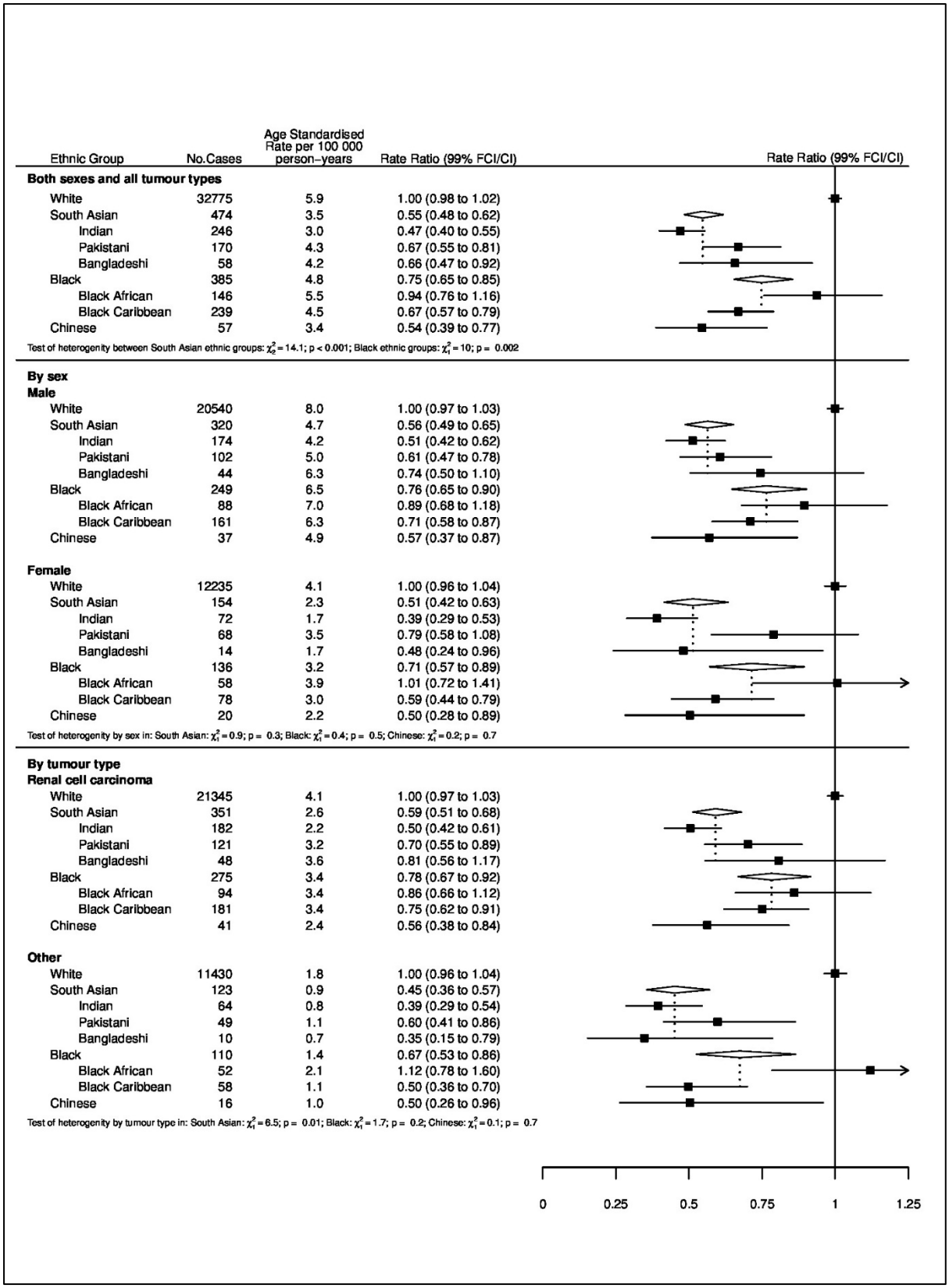

Figure 3.6c. Age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for kidney cancer by ethnic group. Subgroups show rates and rate ratios subdivided by sex and morphology (renal cell cancer & other.)

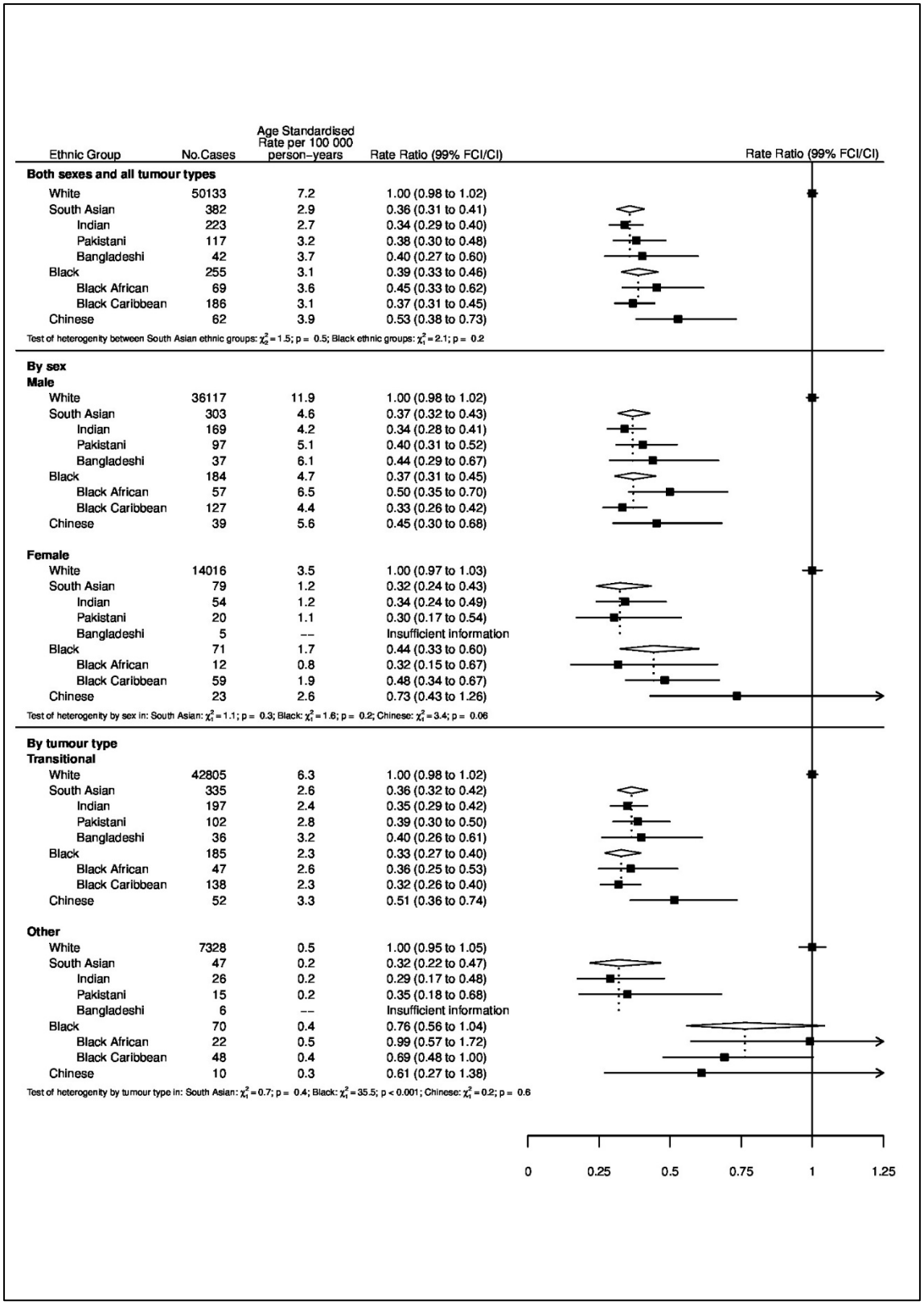

Figure 3.6d. Age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for bladder cancer by ethnic group. Subgroups show rates and rate ratios subdivided by sex and by morphology (transitional cell cancer & other.)

3.7 Central Nervous System cancers

Table 3.7.1 shows the number of central nervous system (CNS) cancer cases in England 2001-2007 by cancer type and ethnicity. There were 42,207 cases of gliomas, meningiomas, pituitary and cranial and paraspinal nerve cancers in total. Of these, 6,544 cases (15.5%) had no ethnicity recorded.

Figure 3.7a shows age-standardised rates (ASR) and incidence rate ratios (IRR) for gliomas, subdivided by sex and cancer type (glioblastomas and other gliomas). Whites had a significantly higher incidence rate of all gliomas than every other ethnic group. There was no heterogeneity between the different Black and South Asian ethnic groups or by sex. A similar pattern was seen for both glioblastoma and other gliomas (all gliomas, excluding glioblastomas).

Figure 3.7b shows age-standardised rates (ASR) and incidence rate ratios (IRR) for meningiomas, cranial and paraspinal nerve cancers, and pituitary cancers by ethnicity. For meningiomas, Blacks had a significantly higher incidence rate than all other ethnic groups, but there was no heterogeneity between Black Africans & Caribbeans. ($p>0.05$). There was significant heterogeneity between the South Asian ethnic groups ($p<0.001$), with Pakistanis (IRR=1.27) experiencing over double the rate of cancers compared to Bangladeshis (IRR=0.51).

For cranial and paraspinal nerve cancers, the differences observed in incidence rates between ethnicities were not significant.

For pituitary cancers, Blacks again had a significantly higher incidence rate than every other ethnic group - nearly three times higher than Whites and double that of South Asians and Chinese. There were only two cases in Bangladeshis – much lower than for Indians or Pakistanis, reflected in the finding of significant heterogeneity between South Asian ethnic groups ($p<0.001$).

Sensitivity Analysis

Missing ethnicity values were assigned by multiple imputation and the results were extremely similar to those presented in Fig. 1 and 2.

Comparison to Rates in Countries of Origin

Table 3.7.2 shows ASRs of central nervous system cancers (ICD-10 codes C70-72) for individual ethnic groups in England compared with the country or region of origin. Amongst men, all ethnic groups had a higher rate than their country of origin with the exception of Chinese men, where a higher incidence rate in Hong Kong was seen. British Bangladeshi and Black African men had a particularly high incidence rate in England compared with their country of origin.

Amongst women, most ethnic groups also had a higher rate in England, with the exception of Black Caribbeans, where a higher incidence rate was observed in the Caribbean. Again, British Bangladeshi and Black African women had a particularly high incidence rate in England compared to their country of origin.

CNS Cancers	White		Indian		Pakistani		Bangladeshi		Black African		Black Caribbean		Chinese		All other ethnic groups		No ethnicity recorded		Total
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N
Glioblastomas	10077	78.3	99	0.8	59	0.5	26	0.2	26	0.2	58	0.5	15	0.1	707	5.5	1803	14.0	12870
Other Gliomas	8893	73.1	148	1.2	105	0.9	27	0.2	62	0.5	83	0.7	39	0.3	851	7.0	1950	16.0	12158
Meninges	7358	73.5	94	0.9	79	0.8	11	0.1	58	0.6	104	1.0	30	0.3	672	6.7	1601	16.0	10007
Cranial & Paraspinal nerve	2317	72.0	35	1.1	29	0.9	8	0.2	12	0.4	15	0.5	13	0.4	165	5.1	622	19.3	3216
Pituitary	2795	70.7	73	1.8	43	1.1	2	0.1	52	1.3	107	2.7	22	0.6	294	7.4	568	14.4	3956
All five cancers	31440	74.5	449	1.1	315	0.7	74	0.2	210	0.5	367	0.9	119	0.3	2689	6.4	6544	15.5	42207

Table 3.7.1. Number of CNS cancer cases in England 2001-2007 by ethnicity, and number of patients with missing ethnicity.

Cancer	Ethnic group	Male Age Standardised Rates		Female Age Standardised Rates	
CNS cancers		England	Country or region of origin	England	Country or region of origin
	White	6.3	6.3	4.2	4.1
	Indian	3.9	2.1	2.6	1.2
	Pakistani	4.4	3.4	3.2	2.1
	Bangladeshi	3.8	1.2	3.2	0.7
	Black African	3.0	0.9	3.2	0.7
	Black Caribbean	4.5	3.3	2.7	3.3
	Chinese	3.5	4.2 (3.4)#	2.7	3.7 (2.2)#

Table 3.7.2 Age standardised cancer incidence rates per 100,000 people for CNS cancers by ethnic group in England compared to rates in country or region of origin using estimates from Globocan and Cancer Incidence in Five Continents, Vol IX where applicable.

* Globocan figures used are for India, Pakistan, Bangladesh, Sub-Saharan Africa, Caribbean, and China.

Cancer Incidence in Five Continents (CIV) figures used are for Hong Kong (China).

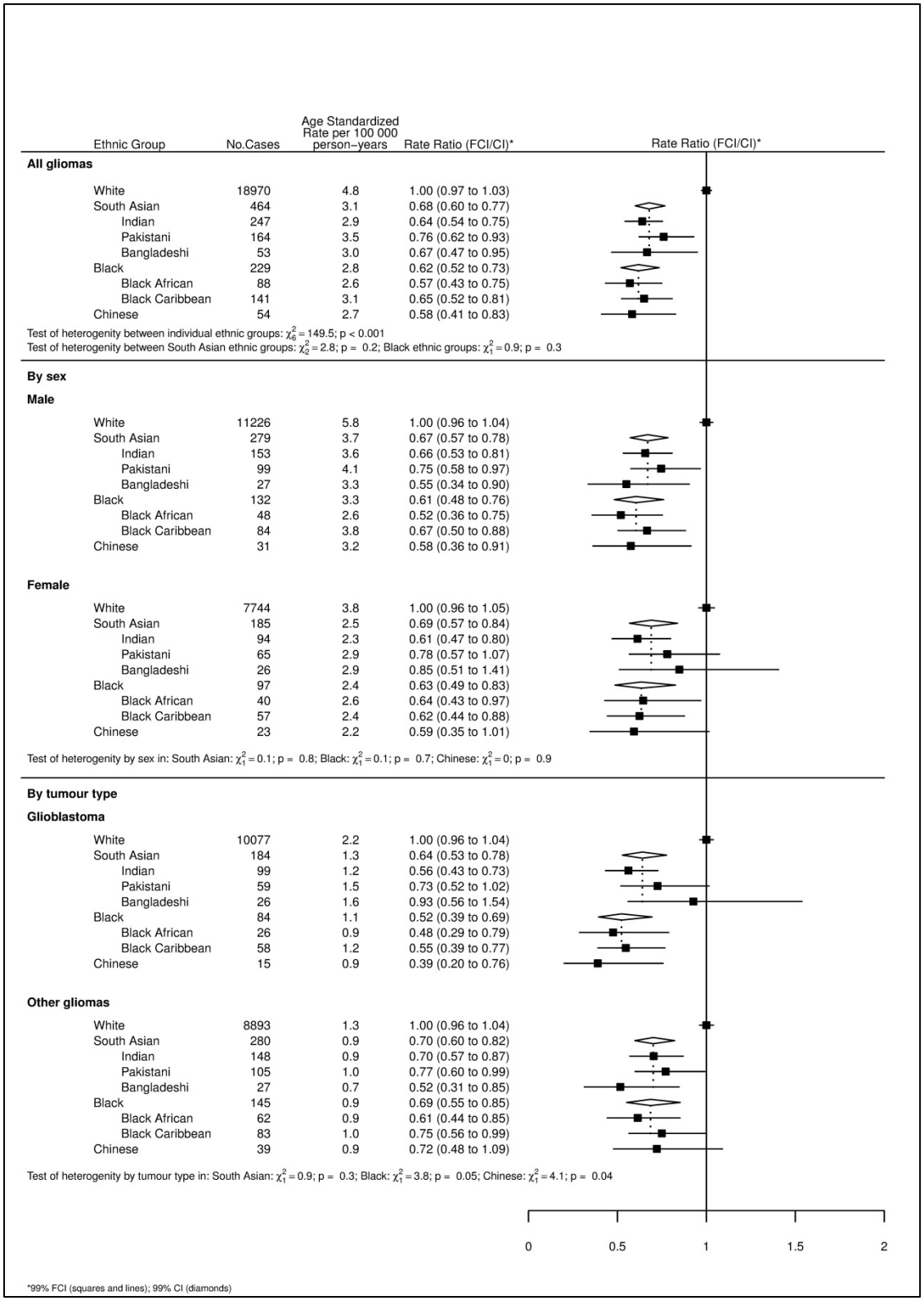

Figure 3.7a. Age-standardised incidence rates and rate ratios by ethnicity for all gliomas, all gliomas by sex, glioblastomas and other gliomas. Tests of heterogeneity by sex, between all ethnicities and between Black and South Asian ethnic groups are also shown.

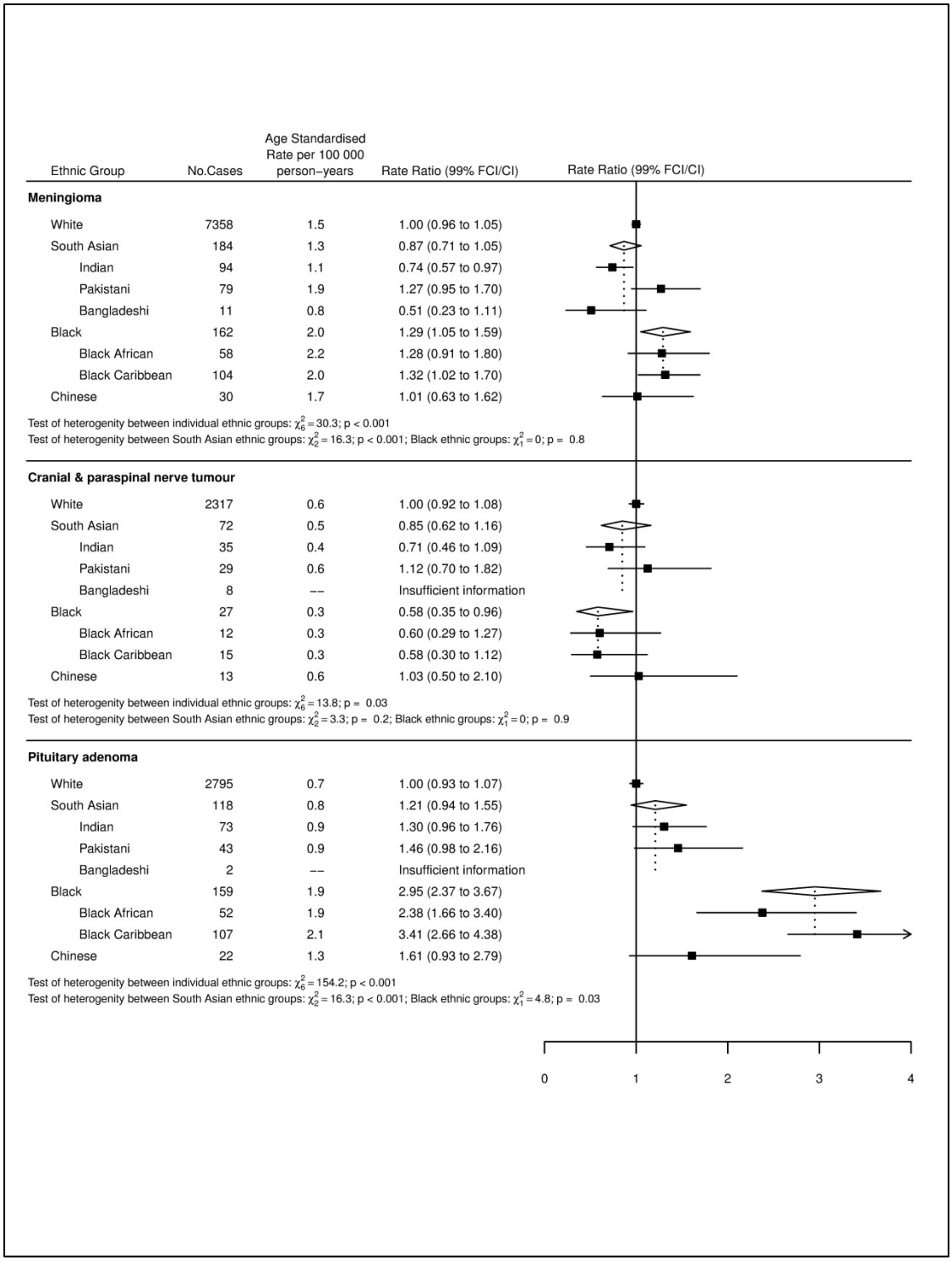

Fig. 3.7b. Age-standardised incidence rates and rate ratios for meningioma, cranial and paraspinal nerve cancers and pituitary cancers by ethnicity. Tests of heterogeneity between all ethnicities and between the Black and South Asian ethnic groups are also shown.

3.8 Haematological malignancies

Table 3.8.1 shows the total number of haematological cancer registrations during the study period with missing ethnicity values for each subtype. Overall, there were 134,302 haematological cancer registrations and ethnicity information was missing in 24 322 (18.1%) of these cases.

Figures 3.8a-d show the age-standardised rates and incidence rate ratios for each individual haematological malignancy, subdivided by sex and, for the mature B-cell neoplasms, by subtype.

For Hodgkin lymphoma (Fig 3.8a), incidence rates were similar among all major ethnic groups. There was significant heterogeneity between the South Asian groups, with rates among Pakistanis and Indians being higher than those of Bangladeshis (IRRs of 1.33, 1.13 and 0.66 respectively; $p<0.001$). There was also heterogeneity by sex among South Asians, with increased rates among males but not females (IRRs of 1.28 and 0.96 respectively; $p=0.01$). Among Blacks, there was little difference in incidence between individual ethnic groups or by sex.

The incidence of mature B-cell neoplasms (Fig 3.8b) was lowest among South Asians and Chinese, among whom rates were around 20% and 40% lower than those of Whites respectively. Conversely, rates among Blacks were about 20% higher. In addition, relative rates among South Asians and Blacks differed considerably between the different B-cell neoplasm subtypes (both $p<0.001$).

For diffuse large B-cell lymphoma (Fig 3.8b), incidence among Blacks and Chinese was lower than that of Whites. No significant difference was observed for South Asians as a whole. However, there were substantial differences within both the South Asian and Black groups; rates in Pakistanis (IRR=1.34) were almost double those in Indians (IRR=0.73) and Bangladeshis (IRR= 0.59) and rates in Black Africans (IRR=1.54) were more than 3 times higher than those of Black Caribbeans (IRR=0.45)

For follicular lymphoma (Fig 3.8b), rates were lowest among Chinese and Blacks, intermediate among South Asians and highest among Whites. There was little difference in risk between Black Caribbeans and Blacks Africans, with incidence rates in both groups around 60% lower than that of Whites. There were, however, differences between the South Asian groups -

Pakistanis showed the highest rates, followed by Indians and Bangladeshis (IRRs of 1.11, 0.68 and 0.54 respectively).

Rates of plasma cell neoplasms (Fig 3.8b) were similar among all 3 South Asian groups, Chinese and Whites. Blacks showed by far the highest rates, with both Black groups experiencing rates around 2.5 times higher than those of Whites.

For chronic lymphocytic leukaemia / small lymphocytic leukaemia (CLL/SLL) (Fig 3.8b), incidence was considerably lower among South Asians and Blacks, having rates around 60% and 65% those of Whites respectively. Rates among Chinese were similar to those of Whites.

For the mature T-cell neoplasms (Fig 3.8c), rates in South Asians were similar to Whites but there was significant heterogeneity within the group (p=0.006). Blacks showed by far the highest incidence, with rates more than 3 times higher than those of Whites. There was also heterogeneity within the group, with Black Caribbeans rates higher than Black Africans (IRRs of 3.60 and 2.19 respectively; p=0.009). Additionally, there was heterogeneity by sex among Blacks, with a greater IRR observed among females than males (IRRs of 4.14 and 3.10 respectively; p=0.003). Case numbers for the mature T-cell neoplasms were small meaning there were insufficient cases to carry out analyses for the Chinese and Bangladeshis. Further analysis (data not shown) revealed that 38% of the mature T-cell neoplasm cases among Black Caribbeans were Adult T-cell Leukaemia/Lymphoma (ATLL), compared to 17% in Black Africans and 3% in Whites. Analysing ATLL alone, the IRR for Black Caribbeans compared to Whites was 38.2 (99% CI=22.01-66.25). There was also strong evidence of heterogeneity between ATLL and non-ATLL mature T-cell neoplasms (IRR=2.29; 99% CI=1.65-3.19) (p<0.001).

For the ‘other lymphoid’ group (Fig 3.8d), the majority of which were malignant lymphoma (non-Hodgkin), not otherwise specified (45%), or malignant lymphoma, not otherwise specified (28%), there was no difference in incidence between Whites and South Asians or Chinese. Nor was there strong evidence of heterogeneity among the South Asian groups. In contrast,, Blacks experienced higher incidence rates compared to Whites (IRR = 1.29; 99% CI=1.14-1.47), which was largely due to the higher rates among Black Africans (IRR = 1.67 compared to Black Caribbeans (IRR = 1.06). There was no difference in rate by sex in any ethnic group.

For AML (Fig 3.8e), there was no significant difference between Whites and any other ethnic group nor was there evidence of intra-ethnic group heterogeneity.

Sensitivity analysis

Assigning missing ethnicity values using multiple imputation generated results very similar to those obtained in the main analysis.

3.8.2 Comparison to rates in country of origin (ICD-10)

Table 3.8.2 compares age-standardised incidence rates from this study with international data from Globocan and the cancer registry in Hong Kong. Rates are shown for the 4 major cancers coded by ICD-10. For all 4 cancers, the incidence among the individual South Asian and Black ethnic groups in England was higher than in their country of origin. In general, rates among Chinese were similar to those recorded by the Hong Kong cancer registry. The very high rates of multiple myeloma observed in both Black groups in England are in contrast to the much lower rates seen in sub-Saharan Africa and the Caribbean.

	White		Indian		Pakistani		Bangladeshi		Black African		Black Caribbean		Chinese		All other ethnic groups		No ethnicity recorded		Total
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N
Hodgkin lymphoma	6553	70.0	195	2.1	159	1.7	31	0.3	71	0.8	91	1.0	29	0.3	859	9.2	1375	14.7	9363
Mature B cell	57841	73.7	588	0.7	398	0.5	83	0.1	334	0.4	588	0.7	105	0.1	4516	5.8	14061	17.9	78514
Mature T cell	2681	61.8	29	0.7	34	0.8	9	0.2	35	0.8	104	2.4	3	0.1	289	6.7	1152	26.6	4336
Other lymphoid	18631	68.9	305	1.1	216	0.8	69	0.3	214	0.8	210	0.8	74	0.3	2048	7.6	5267	19.5	27034
Acute myeloid leukaemia	11205	74.0	148	1.0	98	0.6	21	0.1	62	0.4	88	0.6	40	0.3	995	6.6	2479	16.4	15136
All five cancers	96847	72.1	1265	0.9	905	0.7	213	0.2	715	0.5	1080	0.8	250	0.2	8705	6.5	24322	18.1	134302

Table 3.8.1 Distribution of registered haematological cancers from 2001-2007 in England by ethnic group and missing ethnicity values.

Cancer	Ethnicity	Male		Female	
		England	Country or region of origin	England	Country or region of origin
		ASR	ASR	ASR	ASR
Hodgkin lymphoma	White	2.4	2.9	1.9	2.3
	Indian	3.0	0.9	1.8	0.4
	Pakistani	3.7	1.2	2.4	0.6
	Bangladeshi	1.8	1.4	1.1	0.7
	Black African	2.0	1.2	1.4	0.6
	Black Caribbean	2.5	1.0	1.5	0.9
	Chinese	1.7	0.5 (0.9)*	1.0	0.3 (0.5)*
Non-Hodgkin lymphoma	White	10.3	13.1	7.4	9.3
	Indian	7.8	3.0	5.7	1.8
	Pakistani	11.4	4.0	7.3	2.8
	Bangladeshi	8.5	4.3	5.1	2.6
	Black African	13.7	5.5	10.8	3.8
	Black Caribbean	8.8	4.4	6.3	3.1
	Chinese	8.0	2.5 (8.1)*	4.9	1.7 (5.3)*
Multiple myeloma	White	3.7	4.9	2.4	3.2
	Indian	3.2	0.9	2.1	0.7
	Pakistani	3.3	1.0	1.9	0.8
	Bangladeshi	1.9	0.2	2.4	0.2
	Black African	8.6	0.9	5.8	0.7
	Black Caribbean	8.3	2.2	5.7	1.8
	Chinese	1.9	0.4 (1.8)*	1.4	0.3 (1.3)*
Leukaemia	White	7.8	10.4	4.9	6.6
	Indian	5.3	3.5	3.9	2.6
	Pakistani	8.1	4.2	5.1	3.4
	Bangladeshi	4.4	0.9	2.9	1.3
	Black African	6.0	2.8	5.4	2.0
	Black Caribbean	6.9	4.3	4.2	3.3
	Chinese	7.6	5.3 (5.8)*	4.2	4.7 (4.4)*

Table 3.8.2. Age-standardised incidence rates per 100,000 people for major haematological malignancies coded by ICD-10 by ethnic group in England compared to rates in country or region of origin using estimates from Globocan and Cancer Incidence in Five Continents, Vol IX where applicable.

[#]Cancer Incidence in Five Continents (CIV) figures used are for Hong Kong (China).

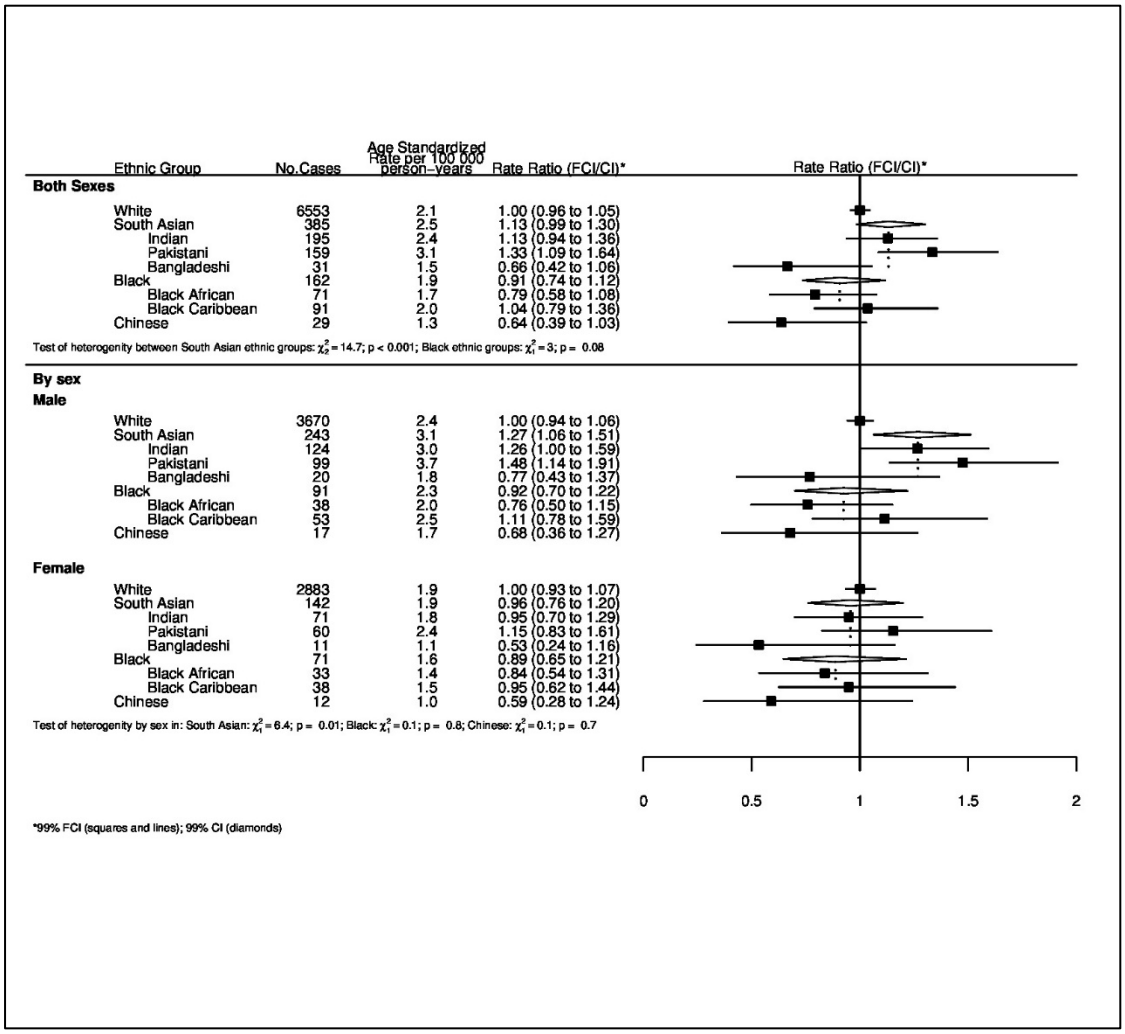

Figure 3.8a. Age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for Hodgkin lymphoma by ethnic group. Subgroups show rates and rate ratios subdivided by sex.

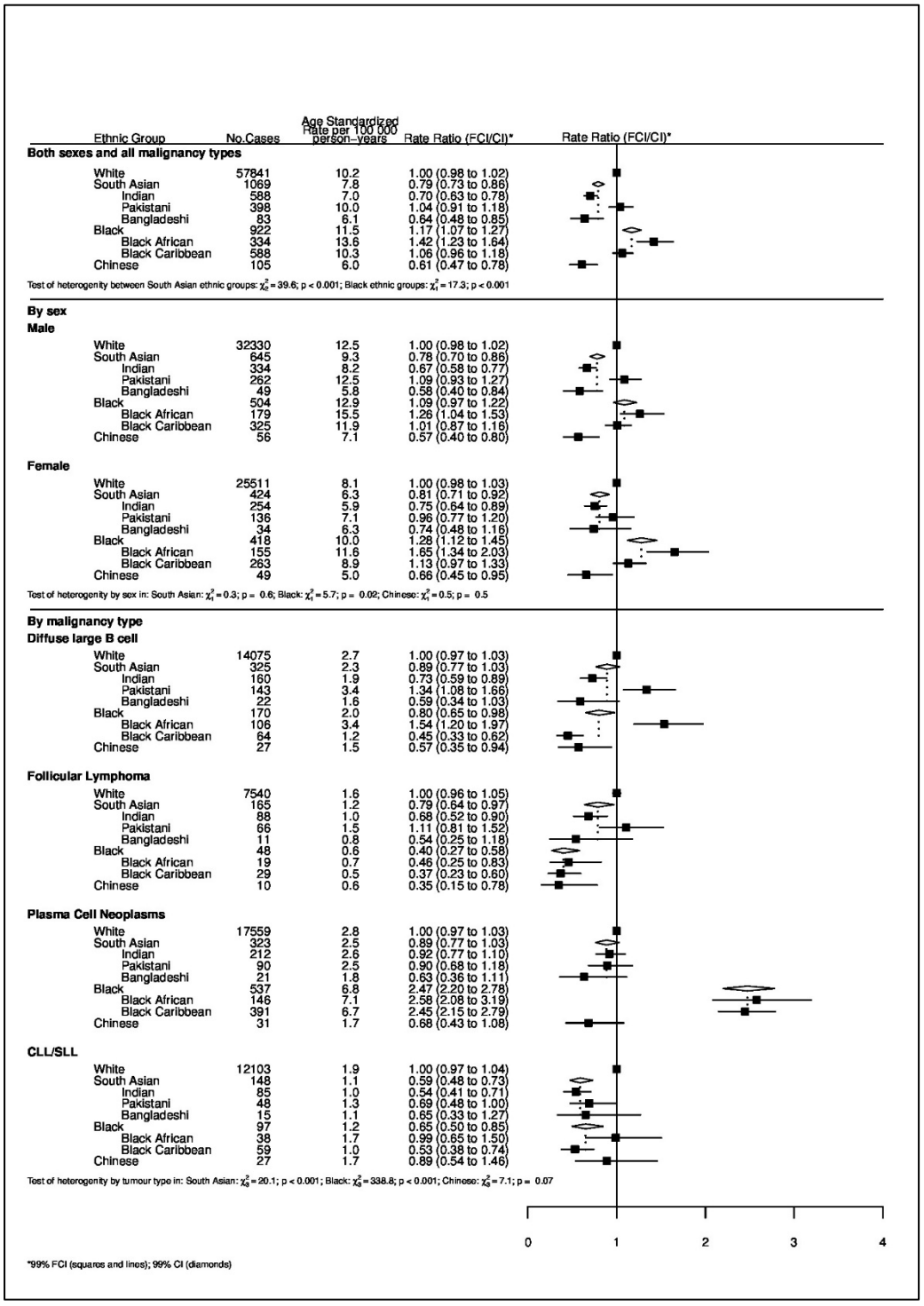

Figure 3.8b. Age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for mature B-cell neoplasms by ethnic group. Subgroups show rates and rate ratios subdivided by sex and subtype.

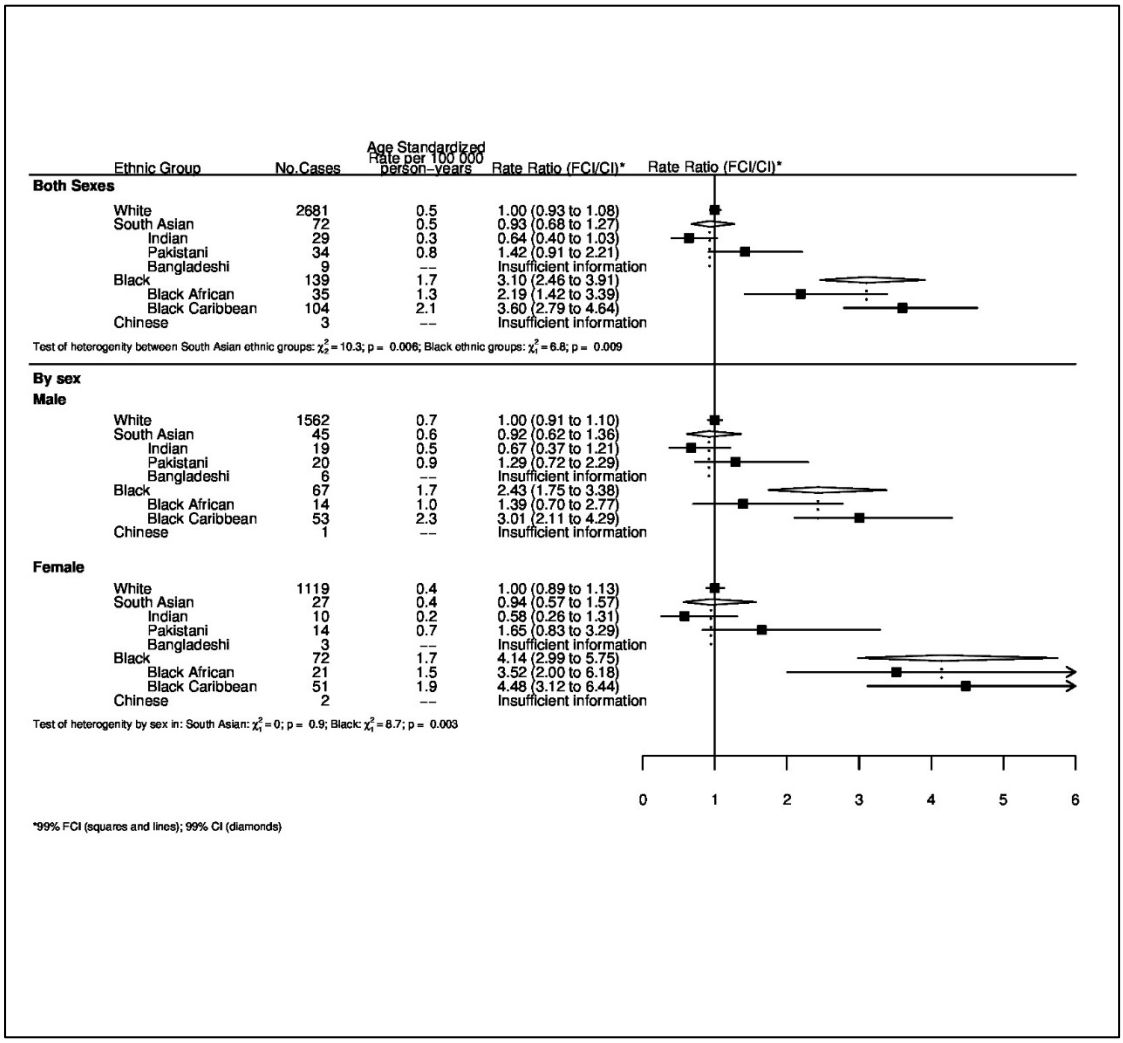

Figure 3.8c. Age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for mature T-cell neoplasms by ethnic group. Subgroups show rates and rate ratios subdivided by sex.

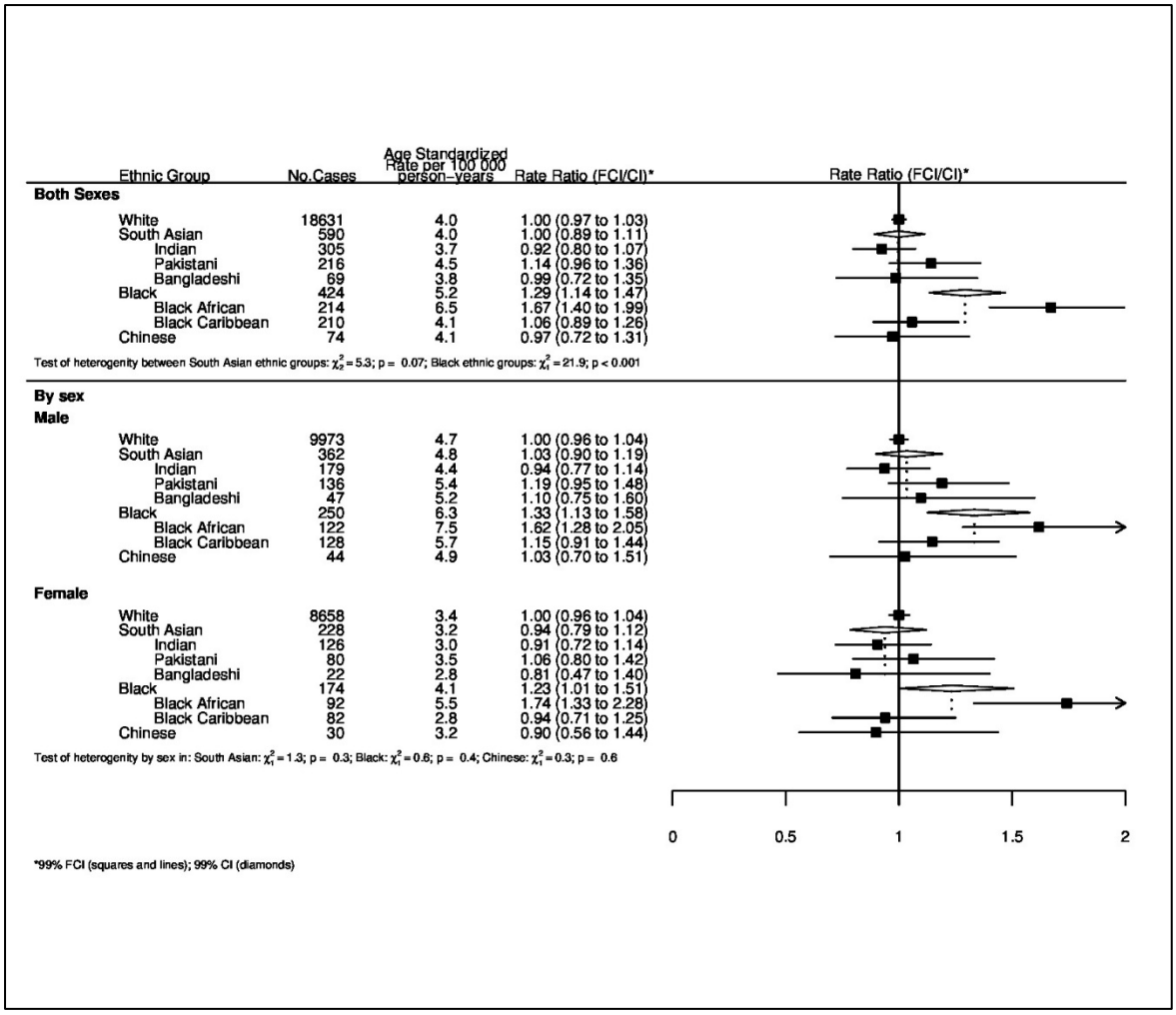

Figure 3.8d. Age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for 'other lymphoid' neoplasms by ethnic group. Subgroups show rates and rate ratios subdivided by sex.

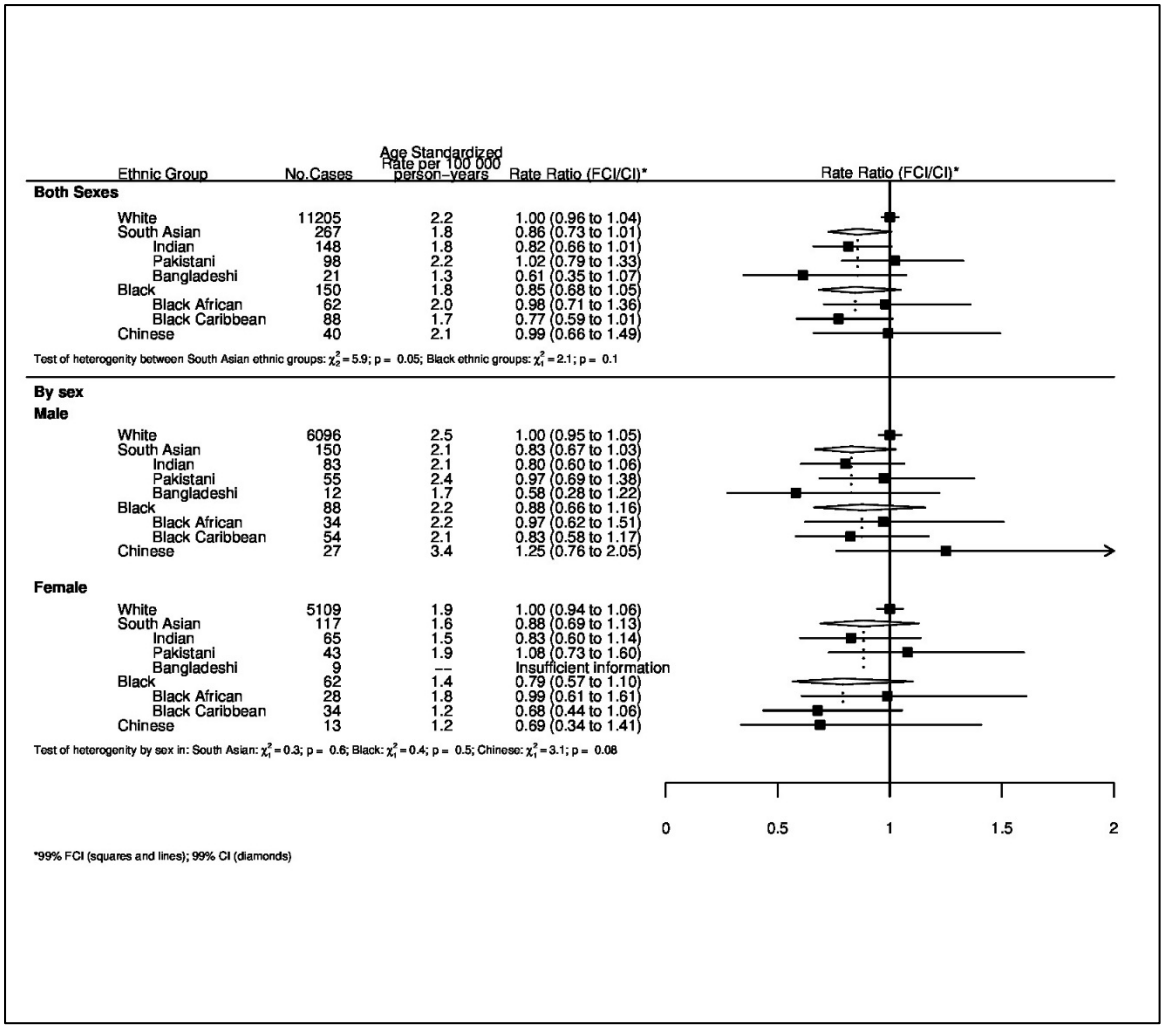

Figure 3.8e. Age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for acute myeloid leukaemia (AML) by ethnic group. Subgroups show rates and rate ratios subdivided by sex.

3.9 Other (Thyroid & Malignant Melanoma)

3.9.1 Thyroid

In total, there were 11,263 thyroid cancer registrations and ethnicity information was missing in 1,877 cases (16.7%).

Table 3.9.1 shows the total number of thyroid cancer registrations with missing ethnicity values for each subtype.

For all thyroid cancers (Figure 1) there was a higher incidence in all ethnic groups (except Indians) compared to Whites, with significant heterogeneity between the groups (p<0.001) Amongst South Asians, the rates were higher in both British Pakistanis (IRR 1.79)and British Bangladeshis (IRR 1.99)), but not in British Indians (IRR 1.09)demonstrating heterogeneity between these groups (p <0.001). In Blacks, the incidence of thyroid cancer was also higher in both Africans (IRR 1.69,) and Caribbeans (IRR 1.56)) but with no heterogeneity between these groups (p=0.5). The risk for thyroid cancer was highest in Chinese (IRR 2.14)).

However, as also shown in Figure 1, in South Asians the rate of follicular thyroid cancer was not higher than in British Whites, whereas the IRR for papillary thyroid cancer was higher (IRR 1.47). This difference is mainly due to the lower incidence of follicular thyroid cancer in Indians (IRR 0.55)) whereas the incidence of both follicular and papillary thyroid cancers was higher in both the Pakistanis (Follicular: IRR 1.95, 99% FCI 1.29-2.96, Papillary: IRR 1.85, 99% FCI 1.46-2.36) and Bangladeshis (Follicular: IRR 3.15, 99% FCI 1.84-5.41, Papillary: IRR 1.63, 99% FCI 1.07-2.07).

In Blacks, the incidence of both follicular and papillary thyroid cancers was higher than in Whites. However, the incidence rate ratios were higher in follicular (IRR 2.09)) than in papillary (IRR 1.34)) with significant heterogeneity between the two (p=0.003).

The opposite pattern was seen in Chinese, with incidence rate ratios being higher for papillary cancer (RR 2.64) than follicular cancer (RR 1.38) again with significant heterogeneity between the two (p=0.03).

Sensitivity analysis

In the sensitivity analysis which assigned missing values using multiple imputation, results very similar to those shown in Figure 3.9.1 were obtained.

Comparison to rates in countries of origin

The comparisons with international data on age-standardised incidence rates from Globocan (plus Hong Kong) are shown in Table 3.9.1a.

In summary, for all ethnic groups, ASRs for thyroid cancer were higher than the rates in their countries of origin and that in Whites. The exception was in Chinese where the ASRs were lower than Hong Kong but higher than in Whites (and the GLOBOCAN estimate for China as a whole.)

	White		Indian		Pakistani		Bangladeshi		Black African		Black Caribbean		Chinese		All other ethnicities		No ethnicity recorded		Total
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N
Follicular cancer	1762	70.7	20	0.8	39	1.6	23	0.9	32	1.3	43	1.7	13	0.5	203	8.2	357	14.3	2492
Papillary cancer	4195	63.8	128	2.0	115	1.8	38	0.6	67	1.0	73	1.1	72	1.1	808	12.3	1076	16.4	6572
Other Cancer	1439	65.4	30	1.4	16	0.7	9	0.4	223	1.1	26	1.2	5	0.2	205	9.3	444	20.2	2199
All Cancers	7396	65.7	178	1.6	170	1.5	70	0.6	124	1.1	142	1.3	90	0.8	1216	10.8	1877	16.7	11263

Table 3.9.1: Distribution of thyroid cancers from 2001-2007 in England by ethnic group and missing ethnicity values.

Ethnic group	Male Age Standardised Rates		Female Age Standardised Rates	
	England	Country or region of origin	England	Country or region of origin
		Globocan*		Globocan*
White	1.0	1.4	3.0	4.1
Indian	1.4	0.9	2.9	1.8
Pakistani	1.8	0.7	5.2	2.0
Bangladeshi	2.4	0.4	7.1	1.4
African	1.8	0.9	5.4	1.7
Caribbean	1.5	0.8	4.8	3.0
Chinese	1.9	0.8 (2.5)	6.3	2.1 (7.8)

Table 3.9.1a: Age standardised cancer incidence rates per 100,000 people for thyroid cancer by ethnic group in England compared to rates in country or region of origin using estimates from GLOBOCAN and Cancer Incidence in Five Continents, Vol X where applicable.

* GLOBOCAN figures used are for India, Pakistan, Bangladesh, Sub-Saharan Africa, Caribbean, and China.

Cancer Incidence in Five Continents (CIV) figures used are for Hong Kong (China).

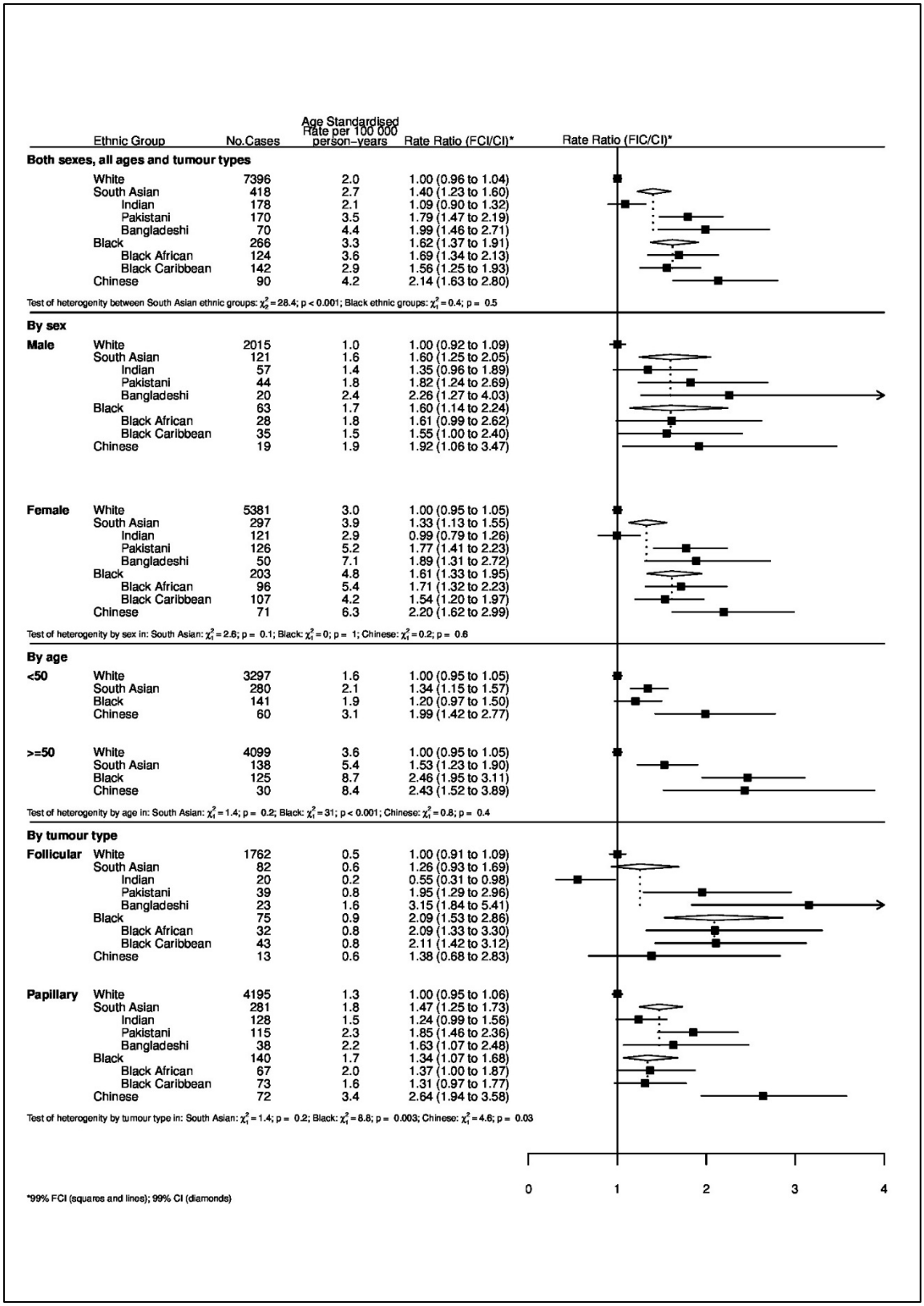

Figure 3.9.1 Age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for thyroid cancer by ethnic group. Subgroups show rates and rate ratios subdivided by sex, age, and by morphology (follicular and papillary.)

3.9.2 Malignant Melanoma

In total, there were 54,422 Malignant Melanoma cancer registrations and ethnicity information was missing in 16,534 cases (30.4%).

Table 3.9.2 shows the number of cancer registrations by ethnic group, and missing ethnicity values, for malignant melanoma.

Sensitivity analysis

In the sensitivity analysis which assigned missing values using multiple imputation, results very similar to those shown in Figure 3.9.1 were obtained.

Comparison to rates in countries of origin

The comparisons with international data on age standardised incidence rates from Globocan (plus Hong Kong) are shown in Table 3.9.2a.

In general, for all ethnic groups, ASRs for malignant melanoma were higher than the rates in their countries of origin but lower than that in Whites. (ASRs for England are about 30% underestimated due to missing data.)

	White		Indian		Pakistani		Bangladeshi		Black African		Black Caribbean		Chinese		All other ethnicities		No ethnicity recorded		Total
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N
Malignant melanoma	34719	63.8	22	0.04	13	0.02	9	0.02	45	0.1	64	0.1	41	0.1	2975	5.5	16534	30.4	54422

Table 3.9.2: Distribution of malignant melanomas from 2001-2007 in England by ethnic group and missing ethnicity values.

Ethnic group	**Male Age Standardised Rates**		**Female Age Standardised Rates**	
	England	**Country or region of origin**	**England**	**Country or region of origin**
White	7.1	13.7	8.5	15.6
Indian	0.1	0.2	0.4	0.2
Pakistani	0.1	0.3	0.2	0.2
Bangladeshi	0.1	0.2	0.1	0.1
African	1.8	1.2	1.9	1.4
Caribbean	0.6	0.8	1.8	0.7
Chinese	3.2	0.6	1.8	0.5

Table 3.9.2a: Age standardised cancer incidence rates per 100,000 people for malignant melanoma by ethnic group in England compared to rates in country or region of origin using estimates from GLOBOCAN and Cancer Incidence in Five Continents, Vol X where applicable.

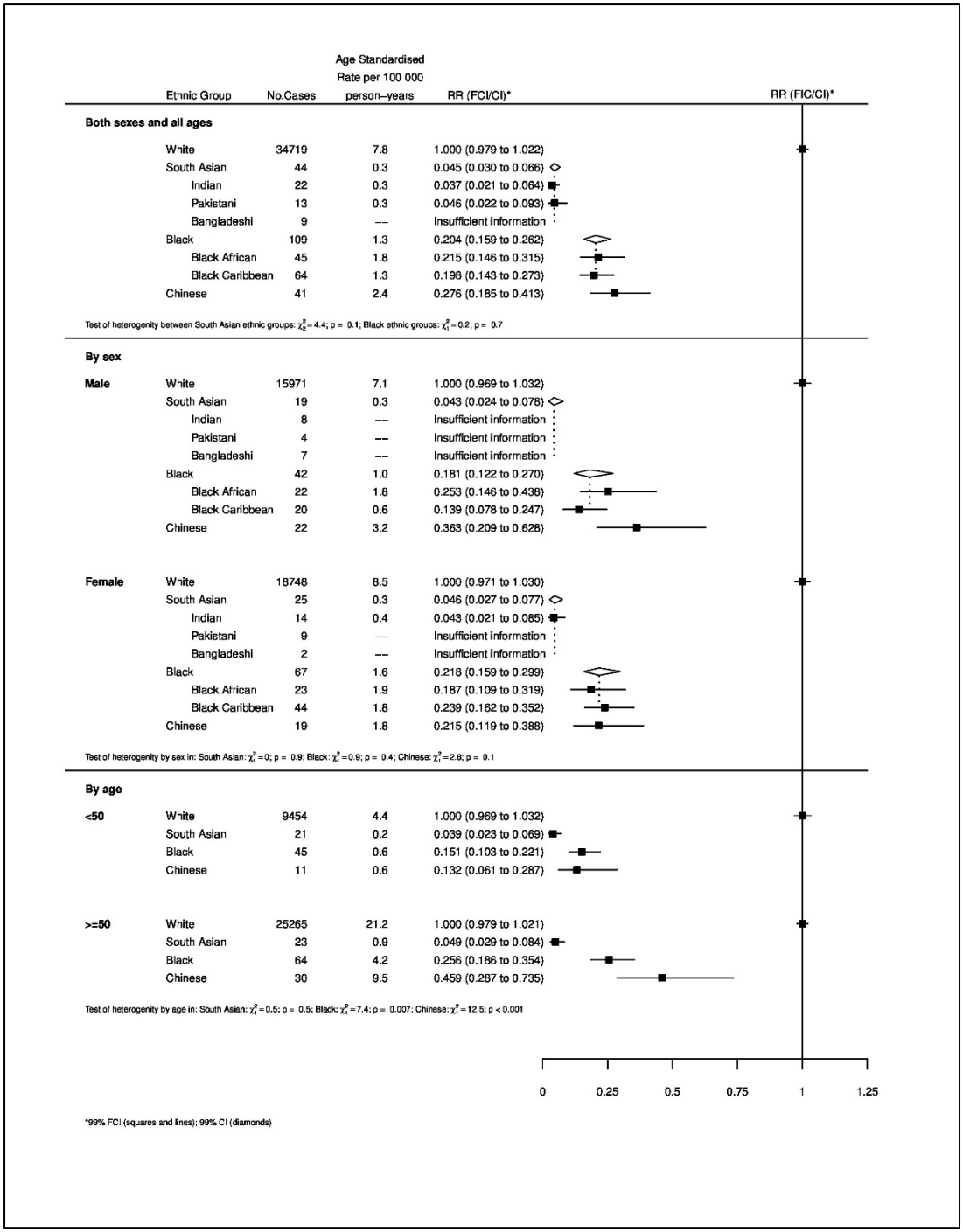

Figure 3.9.2 Age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for Malignant melanoma by ethnic group. Subgroups show rates and rate ratios subdivided by sex and age.

3.10 Childhood cancers

Demographic information for children (aged 0-14) in England from the 2001 Census is shown in Table 3.10a. The total childhood population in England was 9,277,814 of which the majority (84.2%) were White. There is a greater proportion of older children (10-14) amongst Whites, Indians, Black Caribbeans and Chinese, with the reverse being seen in Pakistanis, Bangladeshis and Black Africans. Levels of deprivation also differed with the majority of Pakistanis, Bangladeshis, and Blacks having low incomes and the remaining ethnic groups being mostly middle or high income. The majority of children were UK born, though the proportion varies between different ethnic groups from 68% in Black Africans to 93% in Black Caribbeans and Indians.

Table 3.10b shows the total number of childhood cancer registrations with missing ethnicity values for each subtype. There were 7523 cancers with 1054 (9.9 %) having no ethnicity data recorded.

For all cancers (Figure 3.10a), there was little difference in risk between South Asians and Whites. However, there was strong evidence of heterogeneity within the group with Pakistanis at greater risk than Indians or Bangladeshis (IRRs of 1.19, 0.95 and 0.83 respectively, p= 0.005). Risks among Blacks were higher than those of Whites, with no difference observed between Black Africans and Black Caribbeans.

For leukaemias (Figure 3.10b), the risk among South Asians was approximately 30% higher than that of Whites. Again, there was evidence of heterogeneity within this group with Pakistanis at greater risk than Indians or Bangladeshis (IRRs of 1.58, 1.20 and 1.13 respectively, p= 0.03).

For lymphomas and reticuloendothelial neoplasms (Figure 3.10c), both South Asians and Blacks were at increased risk. The risk for South Asians was approximately 50% higher than Whites with little evidence of heterogeneity within this group. The risk for Blacks was approximately 75% higher than for Whites. Subgroup analysis revealed some evidence of heterogeneity by sex in South Asians - ; the relative risk for males was higher than for females (IRRs of 1.79 and 0.94 respectively, p = 0.03).

For CNS cancers (Figure 3.10d), the risk for South Asians was 25% lower than that of Whites with Pakistanis at lower risk than Indians (IRRs of 0.68 and 0.95 respectively.)

For other solid cancers (Figure 3.10e), while the risk for South Asians was similar to Whites, there was evidence of heterogeneity within this group. Indians and Bangladeshis were at lower risk than Pakistanis (IRRs = 0.64, 0.76 and 1.09 respectively; p = 0.007). The risk for Blacks was approximately 40% higher than Whites with some evidence of heterogeneity between Black Africans and Black Caribbeans (IRRs of 1.59 and 1.09 respectively; p = 0.05).

Sensitivity Analysis

The incidence rate ratios for each (and all) cancers were very similar after sensitivity analyses (using multiple imputations of the missing ethnicity values based on age, sex, income and site of cancer)

Ethnic group	White		Indian		Pakistani		Bangladeshi		Black African		Black Caribbean		Chinese		Other Ethnicity	
Census data for 2001	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Total population	7812159	84.1	218508	2.4	232507	2.5	99713	1.1	136170	1.5	106616	1.1	36523	0.4	635618	6.9
Sex: Male	4005190	51.3	111778	51.2	118661	51.0	50691	50.8	68602	50.4	53423	50.1	18507	50.7	324055	51.0
Female	3806969	48.7	106730	48.8	113846	49.0	49022	49.2	67568	49.6	53193	49.9	18016	49.3	311563	49.0
Age: 0-4	2416850	30.9	67805	31.0	83949	36.1	36154	36.3	50484	37.1	32135	30.1	10356	28.4	228505	36.0
5-9	2638626	33.8	71642	32.8	76931	33.1	32206	32.3	46081	33.8	35661	33.4	11345	31.1	210037	33.0
10-14	2756683	35.3	79061	36.2	71627	30.8	31353	31.4	39605	29.1	38820	36.4	14822	40.6	197076	31.0
Deprivation: low	1557414	19.9	81580	37.3	158961	68.4	75330	75.5	87592	64.3	60267	56.5	9023	24.7	221578	34.9
middle	4622489	59.2	113946	52.1	66152	28.5	22574	22.6	44348	32.6	43320	40.6	20051	54.9	314577	49.5
high	1632256	20.9	22982	10.5	7394	3.2	1809	1.8	4230	3.1	3029	2.8	7449	20.4	99463	15.6
Country of birth: UK	*	*	202371	92.6	211770	91.1	88068	88.3	92266	67.8	99095	92.9	28963	79.3	.	.
Other	*	*	16,137	7.4	20,737	8.9	11645	11.7	43904	32.2	7521	7.1	7,560	20.7	.	.

Table 3.10.1 - Comparison of demographic characteristics for children (aged 0-14) by ethnic group in England in 2001 using data from the 2001 census.

*Data unavailable

	White		Indian		Pakistani		Bangladeshi		Black African		Black Caribbean		Chinese		All other ethnicities		No ethnicity recorded		Total
Cancer	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N
Leukaemias	2329	72	72	2.2	115	3.6	34	1.1	35	1.1	28	0.9	10	0.3	376	11.7	224	7.0	3223
Lymphomas & reticuloendothelial neoplasms	761	65	34	2.9	33	2.8	13	1.1	37	3.2	4	0.3	2	0.2	138	11.9	137	11.8	1159
CNS & intracranial & intraspinal neoplasms	1694	72	46	2.0	38	1.6	7	0.3	36	1.5	30	1.3	3	0.1	255	10.9	234	10.0	2343
Other solid cancers	2739	70	49	1.2	91	2.3	26	0.7	84	2.1	37	0.9	25	0.6	425	10.8	459	11.7	3935
All cancers	7523	71	201	1.9	277	2.6	80	0.8	192	1.8	99	0.9	40	0.4	1194	11.2	1054	9.9	10660

Table 3.10.2 Number of childhood cancer registrations by ethnic group, and missing ethnicity values, for each group of cancers.

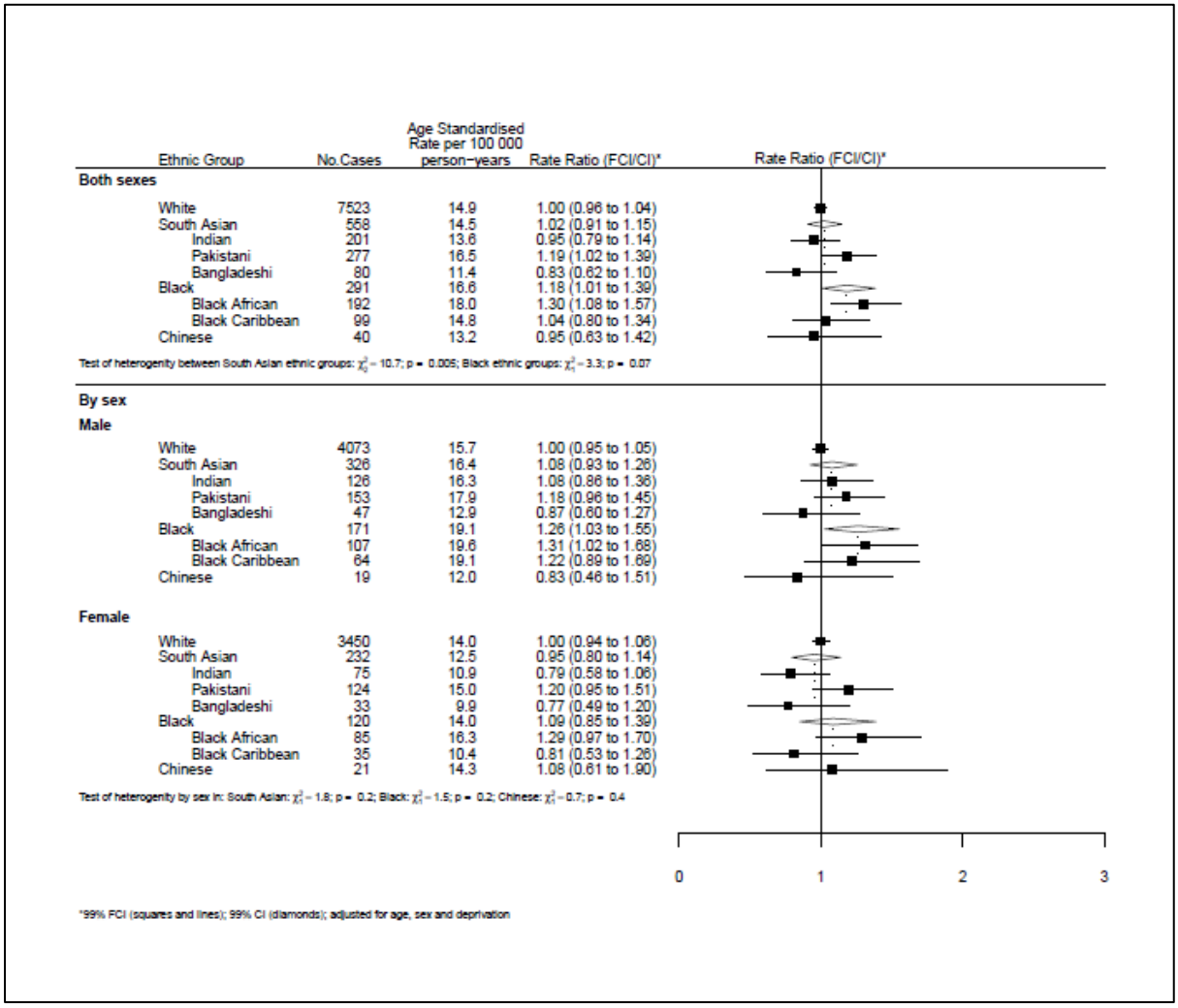

Figure 3.10a Age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for All childhood cancers by ethnic group. Subgroups show rates and rate ratios subdivided by sex.

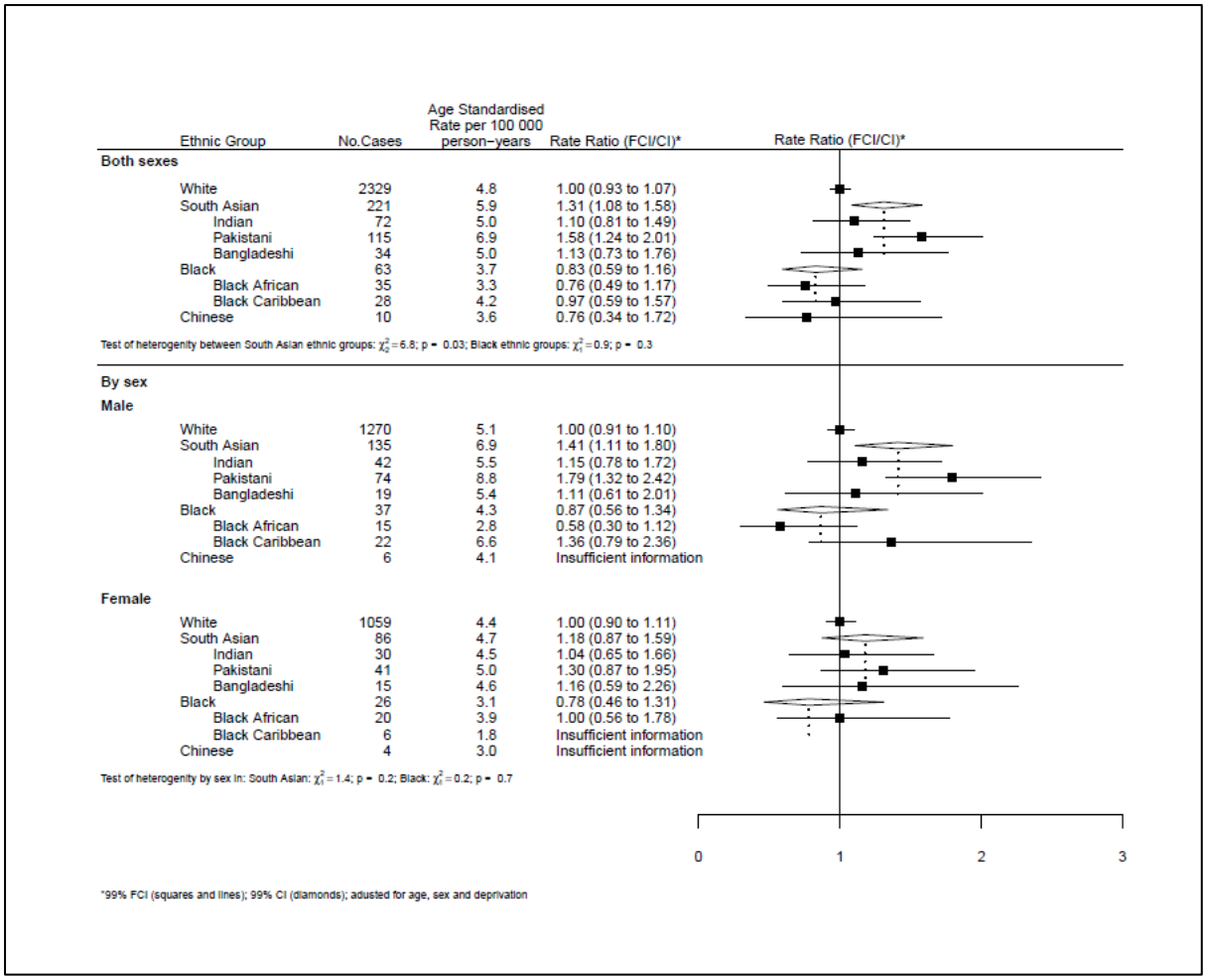

Figure 3.10b Age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for childhood Leukaemias by ethnic group. Subgroups show rates and rate ratios subdivided by sex.

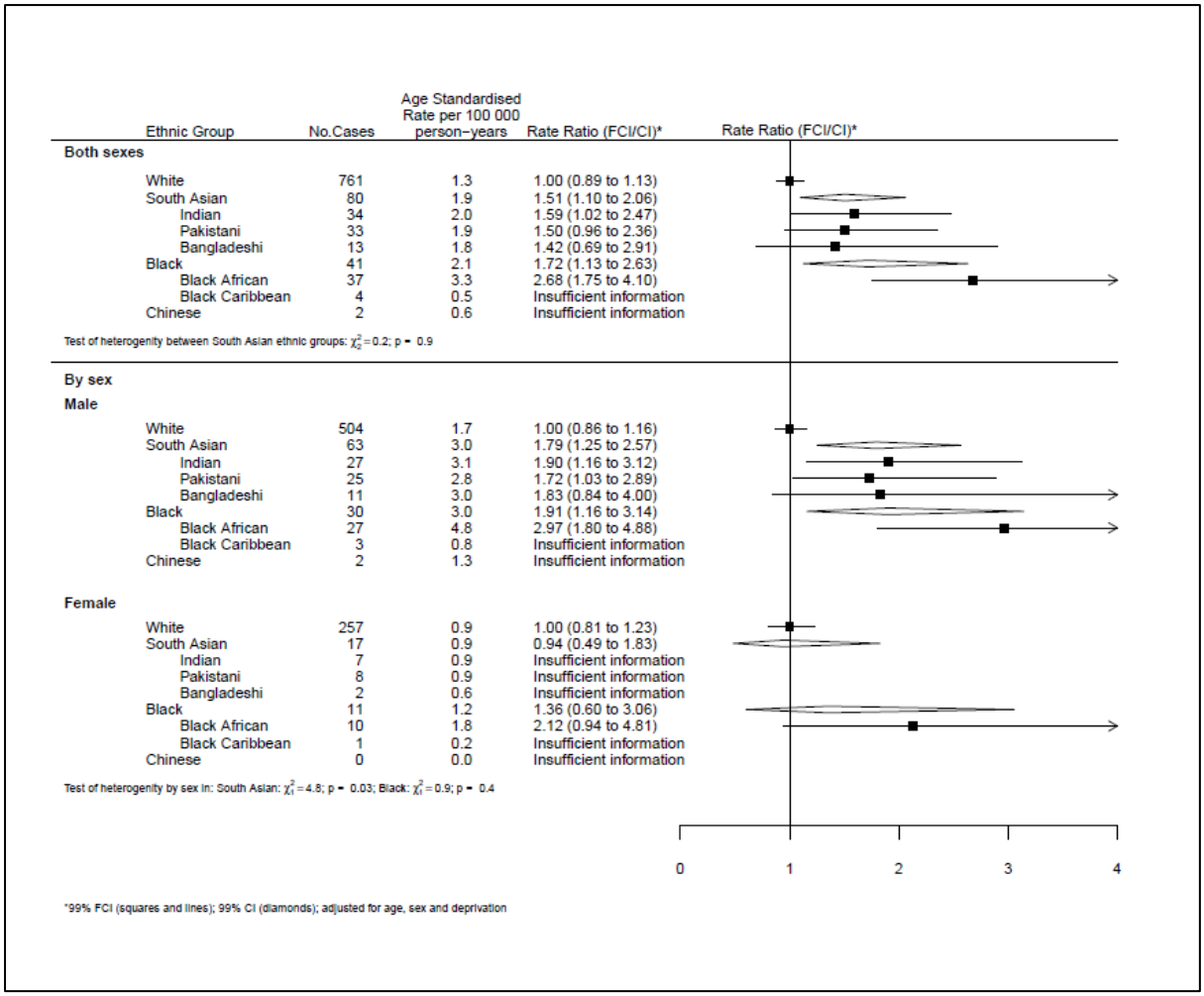

Figure 3.10c Age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for childhood Lymphomas cancers by ethnic group. Subgroups show rates and rate ratios subdivided by sex.

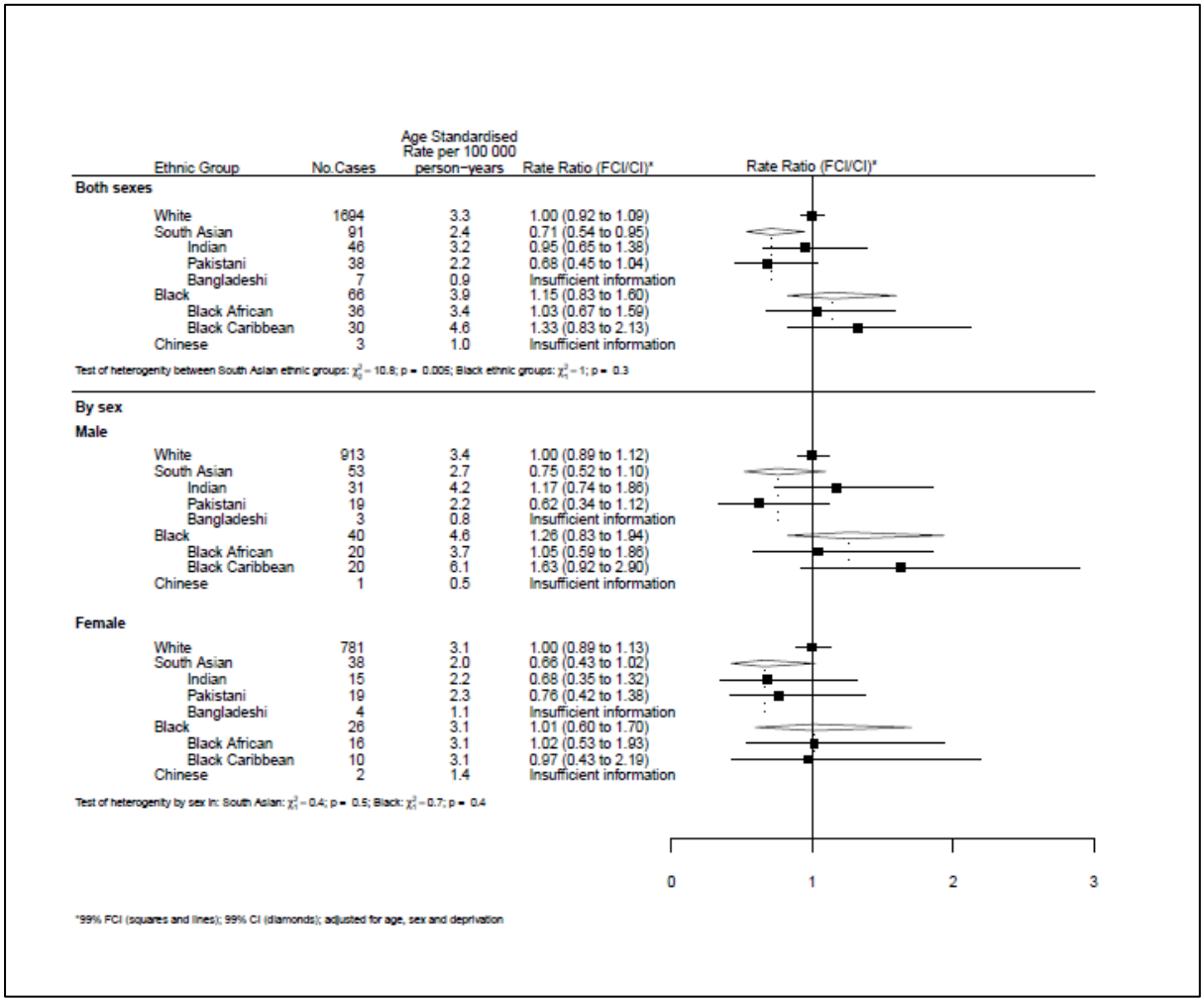

Figure 3.10d Age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for childhood CNS cancers by ethnic group. Subgroups show rates and rate ratios subdivided by sex.

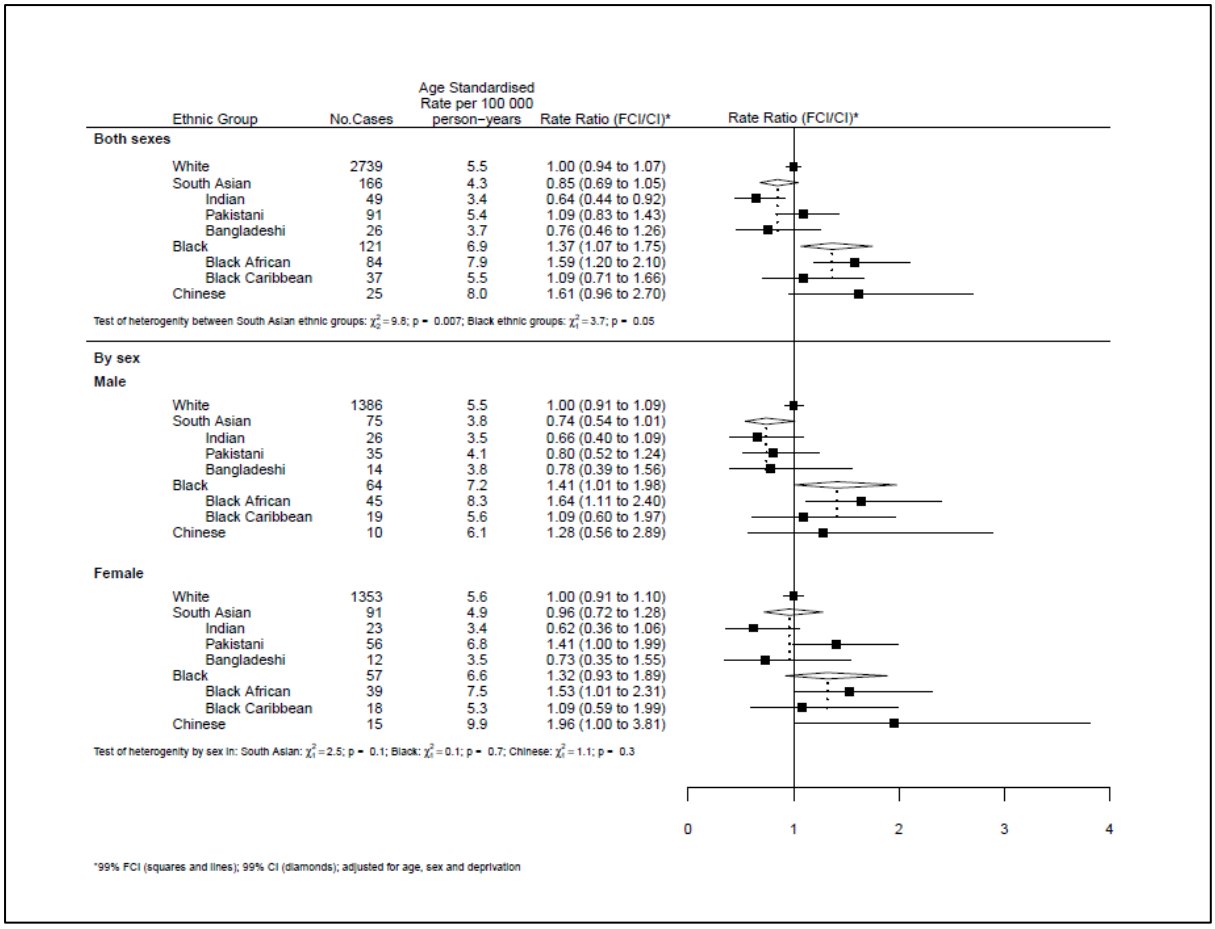

Figure 3.10e Age-standardised incidence rates and rate ratios (adjusted by age, sex and income) for childhood 'Other solid cancers' by ethnic group. Subgroups show rates and rate ratios subdivided by sex.

3.11 Summary tables

Table 3.11.1 provides a summary of the results of this study comparing incidence of cancer by ethnic group to Whites. This clearly shows that there are different patterns of risk across different cancers for each of the ethnic groups with some having higher incidence, some lower incidence and some the same. It also shows that for the vast majority of cancers in South Asians (20 out of 25), there is significant heterogeneity by individual ethnic group ($p<0.01$). This is less so in Blacks with significant heterogeneity by individual ethnic group seen in 7 out of 25 categories.

Table 3.11.2 shows the ethnic group ranking for 'all cancers' and each cancer analysed above. This shows that, although Whites are the highest rank for 'all cancers' and for the largest number of individual cancers (11 out of 25), there is very significant variation overall ***with every ethnic group ranking first, and last, for at least one cancer.***

Table 3.11.3 summarises the comparison of the IRR between those under 50 and over 50 in South Asians and Blacks for those cancers where the comparison was made. This shows that in South Asians, for most cancers there was no difference but for stomach, colorectal and liver, the IRR was closer to Whites in those aged <50 than those >50 and for breast cancer, the opposite was true. In Blacks, the picture was mixed with the IRR being closer to Whites in those aged <50 than those >50 for Colorectal, Head & Neck, Lung, Breast and Thyroid cancers with the opposite being seen in 'All cancers', Liver cancer and malignant melanoma and no difference in the others.

Table 3.11.4 summarises the comparison of the ASRs in each ethnic group to their country / region of origin and to British Whites. As noted above, that all ASRs from this study are about 20% lower than their true value as ethnicity is missing for about 20% of cancer registrations. (Assuming they are missing at random.)

Cancer	Incidence compared to Whites							
	South Asians	Indians	Pakistanis	Bangladeshis	Blacks	Black African	Black Caribbean	Chinese
All cancers	↓*	↓	↓	↓	=*	↑	↓	↓
Oesophagus	↓*	↓	↓	↓	↓	↓	↑	↓
Stomach	↓*	↓	↓	↓	↑	↑	↑	↑
Colorectal	↓*	↓	↓	↓	↓	↓	↓	=
Liver	↑*	↑	↑	↑	↑*	↑	↑	↑
Gallbladder	↑*	↑	↑	↑	↑*	↑	↑	↑
Pancreas	↓	↓	↓	↓	=	=	=	=
Head & Neck	↓(M) ↑(F)	↓(M) ↑(F)	↓(M) ↑(F)	↓(M) ↑(F)	↓	↓	↓	↑
Lung	↓*	↓	↓	↓	↓	↓	↓	↓
Breast (female)	↓*	↓	↓	↓	↓	↓	↓	↓
Prostate	↓*	↓	↓	↓	↑	↑	↑	↓
Cervix Uteri	↓*	↓	↓	↓	↓	↑	↓	↓
Endometrium	↓*	↓	↓	↓	↑	↑	↑	↑
Ovary	↓*	↓	↓	↓	↓*	↓	↓	↓
Kidney	↓*	↓	↓	↓	↓*	↑	↓	↓
Bladder	↓	↓	↓	↓	↓	↓	↓	↓
Testis	↓*	↓	↓	↓	↓	↓	↓	↓
CNS cancers	↓	↓	↓	↓	↓*	↓	↓	↓
Hodgkin lymphoma	↑*	↑	↑	↑	=	=	=	↓
Non-Hodgkin lymphoma	↓*	↓	↑(M) ↓(F)	↓	↑*	↑	↓	↓
Myeloma	↓*	↓	↓	↓	↑	↑	↑	↓
Leukaemia	↓*	↓	=	↓	↓	↓	↓	=
Thyroid	↑*	↑	↑	↑	↑	↑	↑	↑
Malignant melanoma	↓	↓	↓	↓	↓	↓	↓	↓
Childhood	=*	=	↑	=	↑	↑	=	=

↑	Increased risk
↓	Decreased risk
=	No significant difference
*	Significant heterogeneity by individual ethnic group (p<0.01)

Table 3.11.1 Summary of the results of this study comparing incidence of each cancers by ethnic group to Whites.

Cancer	1st Rank	2nd Rank	3rd Rank	4th Rank	5th Rank	6th Rank	7th Rank
All cancers	W	BA	BC	C	P	I	B
Mouth	I	P	W	B	BA	C	BC
Head and Neck	C	W	B	I	P	BA	BC
Oesophagus	W	B	BC	I	BA	C	P
Stomach	BC	C	BA	W	B	P	I
Colorectal	W	C	BA	BC	B	I	P
Liver	C	BA	B	P	I	BC	W
Gallbladder	B	BA	P	C	I	BC	W
Pancreas	BA	BC	W	C	P	I	B
Trachea, bronchus and lung	W	C	B	BA	BC	P	I
Breast (female)	W	BA	BC	P	C	I	B
Prostate	BC	BA	W	C	P	I	B
Cervix Uteri	W	BA	C	BC	I	P	B
Endometrium	C	BC	BA	W	I	P	B
Ovary	W	C	P	BA	I	BC	B
Kidney	W	BA	BC	P	B	I	C
Bladder	W	C	BA	B	P	I	BC
Testis	W	I	P	C	BC	BA	B
Brain and central nervous system	W	P	B	BC	I	BA	C
Hodgkin lymphoma	P	I	BC	W	BA	B	C
Non-Hodgkin lymphoma	BA	P	W	BC	B	C	I
Myeloma	BA	BC	W	P	I	B	C
Leukaemia	P	W	C	BC	BA	I	B
Thyroid	C	B	P	I	BA	BC	W
Malignant melanoma of skin	W	C	BA	BC	P	I	B
Childhood	BA	P	BC	W	I	C	B

Key:
W = White,
I = Indian, P = Pakistani, B = Bangladeshi
BA = Black African, BC = Black Caribbean
C = Chinese

Table 3.11.2 Ethnic group ranking for ‘all cancers’ and each individual cancer analysed.

Cancer		
	South Asians	**Blacks**
All cancers	✓	X
Oesophagus	=	=
Stomach	✓	=
Colorectal	✓	✓
Liver	✓	X
Gallbladder	=	=
Pancreas	=	=
Head & Neck	=	✓
Lung	=	✓
Breast (female)	X	✓
Prostate	=	=
Thyroid	=	✓
Malignant melanoma	=	X

✓	**closer to Whites in those aged <50 than >50**
X	**closer to Whites in those aged >50 than <50**
=	**No significant difference**

Table 3.11.3 Cancers in which the IRR was closer to Whites in those aged <50 than those aged >50.

Cancer	Indians	Pakistanis	Bangladeshis	Black African	Black Caribbean	Chinese (compared to Globocan)	Chinese (compared to Hong Kong)
All cancers	✓	✓	✓	X (HTB)	X (HTB) (M) ✓ (F)	X (LTB) (M) ✓ (F)	X (LTB) (m) X (LTB) (f)
Oesophagus	X (LTB)	X	X	X	✓	X	
Stomach	X (LTB)	X (LTB)	✓	X (HTB)	X (HTB)	✓	✓
Colorectal	✓	✓	✓	✓	✓	✓	X (LTB)
Liver	X (HTB)	X (HTB)	X (HTB)	✓	✓	✓	✓
Gallbladder	↑	X HTB)	X (HTB)(M) ✓ (F)	X (HTB)	X (HTB)	X (HTB)	✓
Pancreas	✓	✓	✓	✓	✓	✓	✓
Oral	✓	✓	X (LTB) (M) ✓ (F)	✓	X (LTB)	✓	
Lung	✓	✓	X (HTB)	X (HTB)	✓	✓	X (HTB)
Breast (female)	✓	✓	✓	✓	✓	✓	✓
Prostate	✓	✓	✓	X (HTB)	X (HTB)	✓	✓
Cervix Uteri	X (LTB)	X (LTB)	X (LTB)	✓	X (LTB)	X (LTB)	X (LTB)
Endometrium	✓	✓	✓	X (HTB)	✓	✓	✓
Ovary	✓	✓	✓	✓	✓	✓	✓
Kidney	✓	✓	✓	✓	✓	✓	X (LTB)
Bladder	X (LTB)	X (LTB)	✓	✓	X (LTB)	X (LTB)	✓
Testis	✓	✓	✓	✓	✓	✓	✓
CNS cancers	✓	✓	✓	✓	✓	X (LTB)	✓
Hodgkin lymphoma	X (HTB)	X (HTB)	✓	✓	X (HTB)	✓	✓
Non-Hodgkin lymphoma	✓	✓	✓	X (HTB)	✓	✓	✓
Myeloma	✓	✓	✓	X (HTB)	X (HTB)	✓	✓
Leukaemia	✓	X (HTB)	✓	✓	✓	✓	✓
Thyroid	X (HTB)	X (HTB)	X (HTB)	X (HTB)	X (HTB)	X (HTB)	✓
Malignant melanoma	✓	X (LTB)	X (LTB)	✓	✓	✓	✓

M (Male)	
F (Female)	

✓	Fits usual pattern – i.e. Rate in ethnic group is between country of origin and Whites
(X) HTB	Does not fit usual pattern – Rate in ethnic group higher than both country of origin and Whites
(X) LTB	Does not fit usual pattern - Rate in ethnic group lower than both country of origin and Whites

Table 3.11.4 Summary table comparing ASRs for each cancer by ethnic group to their country / region of origin and to British Whites.

4. Discussion

In this study, cancer incidence rates in England for the six main 'non-White' ethnic groups in England - South Asian (Indian, Pakistani and Bangladeshi), Black (African and Caribbean) and Chinese were compared to Whites and to each other using self–assigned ethnicity data.

4.1 All cancers & some general observations

Although the incidence of 'all cancers' was generally lower in the non-White ethnic groups (Black Africans were slightly higher) than British Whites (consistent with previous studies as outlined in the introduction), there was significant variation in many cancer types which will be discussed further below.

A summarised in tables 3.11.1 and 3.11.2, although for many cancers incidence is lower in non-White ethnic groups, this is not true for many others.

For example, South Asians have higher rates of Head & Neck, liver, gallbladder, Hodgkin lymphoma and thyroid cancer and Blacks have higher rates of: Stomach, liver, gallbladder, prostate, endometrium , non-Hodgkin lymphoma, thyroid cancer and myeloma, and childhood cancers.

So, while Whites are the highest rank for 'all cancers' and for the largest number of individual cancers (11 out of 25) there is very significant variation overall with every ethnic group ranking first, and last, for at least one cancer.

The lowest rates seen for each cancer may give some indication of the potential for prevention in other ethnic groups.

These different patterns of cancer risk across each of the different ethnic groups as well as differences by sex, age, and cancer subtype, suggest that the findings of this study are unlikely to be due to systematic reporting biases in any of the ethnic groups compared to Whites. The increased risks in particular of many cancers in ethnic minority groups supports the absence of an under-reporting bias which has been a concern due to ethnic groups having historically poorer access to healthcare including cancer screening. [7, 82, 83].

Also, where the level of risk factors by ethnicity was known, findings were generally in keeping with what would be expected (e.g. Smoking Tobacco and lung cancer, chewing

tobacco & Head & Neck cancer, Hepatitis B and liver cancer, HIV and lymphoma, parity and breast cancer) further giving confidence that the other differences in incidence where risk factors are unknown are real.

In South Asians, for the vast majority of cancers (20/25), there was significant heterogeneity of risk between Indians, Pakistanis and Bangladeshis highlighting the importance of analysing them separately. In general, this was due to difference in magnitude of risk although in some cases the direction of risk was also different (e.g., Non-Hodgkin Lymphoma and Childhood cancers.)

For Black Africans and Black Caribbeans this heterogeneity of risk was also apparent in 7 out of 25 cancers again mainly due to difference in magnitude of risk although for Non-Hodgkin Lymphoma and Kidney cancer the direction of risk was also different.

This is to be expected for the majority of cancers given the differences between the diets, habits and socio-cultural practices of the three South Asian groups and between Black Africans and Black Caribbeans.

For certain cancers, however, the incidence was unusually high or low in all three South Asian groups or both Black groups which is suggestive of genetic predisposition (e.g. Prostate, Myeloma, Pituitary in Blacks, Gallbladder & Thyroid in South Asiana) or protection (melanoma in Blacks and South Asians.)

The lower incidence of many cancers in South Asians, even when the majority of them have spent most of their lives in the UK or were born here, is striking. This contrasts with, for example, the experience of Japanese migrants to the USA who were found to have similar rates of a number of cancers (e.g. colorectal) to White Americans within one generation [5]. This could be due to dietary factors, with most South Asians still maintaining a fairly typical South Asian diet, or there may be genetic differences which provide some protection against certain cancers. There may also be potential for cancer prevention if, for example, aspects of the diet are found to be protective. It is also interesting to note that while the incidence of some cancers (e.g. lung, breast and colon) are lower in South Asians, rates of diabetes and ischaemic heart disease are higher than in Whites, even though some of the risk factors are similar [84].

The reduced risk of cancers seen in this study is unlikely to be due to competing risks of death – i.e. the idea that ethnic minorities are dying from other causes before they have a

chance to develop cancer. This is both because generally the average age of incident cancer is much lower than life expectancy and cancer deaths occur at a younger age than the other most common causes of death (i.e. Cardiovascular disease and Dementia).[85] Also, those born in South Asia, Africa and the Caribbean actually have lower overall and premature mortality than those born in England.**[86]**

And whilst some of these differences can be accounted for through known risk factors, many of the large differences in the incidence of many cancers seen across the different ethnic groups are not explicable and suggest that important, potentially modifiable, causes of these cancers are still to be discovered.

The very low rates seen for some cancers (e.g. oesophageal cancer in British Pakistanis) may also indicate the potential for reducing incidence in other ethnic groups, especially where risk factors are known (e.g. tobacco, alcohol and obesity for oesophageal cancer.)

Initial descriptive studies like this one highlight differences by ethnic group and are important as they allow for better public health planning and targeted initiatives. For particular cancers, the differential risk may also impact on the index of clinical suspicion in different ethnic groups.

Finally, the changes in cancer risk seen in non-White ethnic groups in England, both in first- and second-generation immigrants may also give an indication of what could happen in the future in their countries of origin as they undergo rapid epidemiological transitions. Cancer rates in many of these countries have already started to increase and cancer treatment and screening services are often inadequate and people often have to pay out-of-pocket for treatment. This will have major global health implications and highlights the importance of tackling the modifiable risk factors now before cancer rates increase further.

4.1.1. Effect of age

In general, cancer incidence in South Asians tended to be closer to that of Whites among those aged under 50 years (most of whom were born in the UK or migrated as children [13]) than among those older than 50 years (virtually all born outside the UK). [78] The notable exception was for breast cancer in under 50s. (Discussed further in section 4.5.)

This is consistent with environmental exposures, particularly at younger ages, being important in the aetiology of these cancers and it is unlikely that ethnicity itself (or genetic factors) are

responsible for most of the observed differences in incidence with ethnicity acting as a proxy for environmental / lifestyle factors (smoking, chewing tobacco, alcohol, diet, etc.)[4]

The pattern in Blacks was more mixed with may reflect the different patterns of migration for Black African and Black Caribbeans, and so is harder to interpret.

4.1.2 Effect of adjusting for deprivation (income).

In the figures shown above, it was possible to broadly see the effect of adjusting for income by comparing the ASRs (which don't adjust for income) with the IRRs.

In general, adjusting for income reduces the IRR for most ethnic groups as they are more deprived than Whites. This did not have a major impact for most cancers but as expected, the effect was larger for the more deprived groups (e.g. Bangladeshis and Black Africans) than for the less deprived groups (Indians and Chinese.)

In general the biggest effect was seen for the tobacco-related cancers in men (as the prevalence of smoking is higher in men for all ethnic groups) For example, when looking at lung cancer in men - which is known to have a higher risk in lower socio-economic groups due to higher smoking prevalence[87] and the ASRs and IRRs are compared, it can be seen that although the ASRs for White men and Bangladeshi men are similar, after adjusting for income, Bangladeshis have a much lower risk – which suggest that the difference seen in risk is due to the higher smoking prevalence in Bangladeshis - i.e. income is confounded by smoking and in effect you are adjusting for smoking prevalence.

4.1.3. Comparison to country of origin

In general, as would be expected for most cancers (where environment is the most important risk factor), the incidence in the migrant population was between the country / region of origin and Whites. This would be explained by change in environment for migrants with the adoption of 'Western' habits and lifestyle [4] and may also be partly due to under-reporting in the country / region of origin.

However, there were some notable exceptions (as shown in Table 3.11.4) with the somewhat unusual finding that the incidence in the ethnic group was higher than both country / region of origin and Whites. (e.g. Cancers of the Thyroid, Prostate, Stomach, Gallbladder, Myeloma, non-Hodgkin lymphoma in Blacks and of the Thyroid, Liver, Gallbladder & Hodgkin lymphoma in South Asians.) This is likely to be due to under-diagnosis or under-reporting in many of the

countries of origin due to the limited access to healthcare facilities and lack of comprehensive cancer registration.[1] Also, there may be a genetic predisposition to developing these cancers in these ethnic groups which means they maintain high incidence even after migration. This is discussed further below in relation to the individual cancers.

For other cancers (mainly in South Asians) incidence in the ethnic group was lower than both country / region of origin and Whites (e.g. Stomach, Cervix, Malignant Melanoma) reflecting a reduction in exposure to the harmful risk factor after migration (e.g. reduced exposure to H. Pylori, HPV, Ultraviolet B radiation)

Risk factors

In discussing the interpretation of the results of this study, findings for the aetiology of individual cancer sites are discussed below in relation to the prevalence of known risk factors by ethnicity, the most important of which were summarised in table 3.1.3.

1.2 **Gastrointestinal cancers**

In general, the 'non-White' groups had a lower incidence of colorectal, oesophageal and pancreatic cancer compared to Whites but a higher incidence of liver and gallbladder cancer. Gastric cancer incidence was lower in South Asians but higher in Blacks and Chinese. There were significant differences in risk between Indians, Pakistanis and Bangladeshis for cancer of the oesophagus, stomach, liver and gallbladder and between Black Africans and Caribbeans for liver and gallbladder cancer. Previous reports comparing cancer incidence in South Asians to Whites using self-assigned ethnicity, and South Asians to non-South Asians using name analysis, are broadly consistent with these results. [16, 20, 27, 32, 37, 39, 40, 88]

Colorectal cancer incidence rates in all three South Asian groups are much lower than in Whites as well as the other ethnic groups, particularly in first generation immigrants. This is unexpected given the experience of other migrant groups (e.g. Japanese migrants to the USA and South East Asian migrants to Australia) who were found to have similar rates of colon cancer to White Americans within one generation. [5, 6] The low rates for all three groups suggest that life-long vegetarianism, which is practised by some Indians, but not by Pakistanis or Bangladeshis, is unlikely to explain this.

Although there was some evidence of reduced bowel cancer screening uptake by South Asians compared to Whites in the national bowel cancer screening pilot study [82] the national screening programme began in 2006 and did not cover the whole of England until 2009 and so is unlikely to have affected these results but could have an impact in the future.[89]

The lower incidence of oesophageal cancer in all ethnic groups compared to Whites is striking and is due almost entirely due to the much lower incidence of adenocarcinoma. This cannot be explained by known risk factors such as obesity (prevalence varies significantly by ethnic group) [81] although a previous study also found that Whites had an increased risk of Barrett's oesophagus and Oesophagitis compared to South Asians and Blacks.[90] Squamous Cell Carcinoma rates, in contrast, were similar across all ethnic groups with the exception of Pakistanis, where they were very low (and also much lower than in Pakistan itself.)[1] Again, this is not readily explainable by known risk factors (Pakistani men have higher levels of cigarette smoking than Whites) [81] although it may be partly explained by their lower consumption of alcohol [81] (for religious reasons). The higher risk in Bangladeshi women could be due to their habit of chewing paan [81] (betel quid, usually including tobacco and areca nuts), which has been reported to increase the risk of oesophageal cancer. [91]

The lower incidence of gastric cancer in South Asian men may be due to their lower exposure to *Helicobacter pylori* compared to Whites [92] - Indians also smoke less but Pakistani and Bangladeshi men smoke more. [81] Although Indian and Pakistani women have higher exposure to H. Pylori[92], their very low levels of smoking [81] may explain their lower risk. The higher rates in Bangladeshi women could again be due to chewing paan as this may increase the risk of gastric cancer. [93] Higher rates in Chinese (who are mainly first generation) reflects the higher incidence in China but the higher rates in Black Caribbeans are unexpected - being higher than both Whites and their countries of origin (which could be due to under-diagnosis and under-registration in the Caribbean.)

The higher incidence of liver cancer in South Asians is likely to be due to their higher prevalence of Hepatitis B and C infection.[40, 94, 95] However, the substantial differences between Indians, Pakistanis and Bangladeshis are not fully explained by this or their alcohol intake. [81] Bangladeshis may have a higher risk due to their higher prevalence of tobacco smoking and chewing paan, which have been shown be associated with an increased risk of liver cancer. [96] The higher incidence in Black Africans and Chinese (who are both mainly first generation) reflects the very high rates in their countries of origin where Hepatitis B infection is endemic [97] and is confirmed by the high prevalence rates among Blacks in the UK. [98] The higher incidence in all ethnic groups is confined to hepatocellular carcinoma which is also consistent with the higher exposure to Hepatitis B and C being the most relevant risk factor.

The reasons for the higher incidence of gallbladder cancer in South Asian women are unclear, but do reflect the incidence in their countries of origin. In contrast the high incidence in Black Africans was unexpected being higher than both Whites and their countries of origin (which could due to under-diagnosis and under-registration in sub-Saharan Africa.)

Similarly, the lower incidence of pancreatic cancer in South Asians is not easily explained but does reflect the incidence in their countries of origin.

1.3 **Head & Neck cancers**

In general, the ‘non-White’ groups had a lower incidence of head & neck cancers compared to Whites with the exception of Chinese who had a higher rate which was driven by extremely high rates of nasopharyngeal cancer. South Asian women were also found to have a higher risk of mouth cancer. These results are consistent with previous reports. [17, 28, 32, 41-43]

The lower overall risks in South Asians & Blacks is likely to be due to the lower overall exposure to both tobacco and alcohol and compared to Whites [81] whereas the higher incidence of mouth cancer in South Asian females is probably due to their higher prevalence of chewing paan [81] (which includes tobacco) which is known to increase the risk of mouth cancer. [41, 99] This is an example of where a migrant group has maintained an aspect of their lifestyle from their country of origin.

Human Papilloma Virus (HPV) is also a known risk factor for some Head & Neck cancers [100] but the prevalence of infection by ethnic group in the UK is unknown. However, South Asians tend to have fewer sexual partners than Whites or Blacks.[101]

The Chinese in Hong Kong are known to have very high rates of Nasopharyngeal cancers and this is maintained in Chinese migrants to the UK consistent with the main risk factors which are thought to be genetic susceptibility and early Epstein Barr virus (EBV) infection. [102]

4.4 Lung cancer

Overall, age- and socioeconomic-adjusted incidence rates were lower among all non-White ethnic groups compared to Whites, with the lowest rates being found among South Asians, followed by Blacks and Chinese. Similar patterns were found among the subtypes. However, the magnitude of these differences was greater for squamous, small-cell and large-cell compared to adenocarcinoma. There was also strong evidence of intra-ethnic differences, most notably the higher rates among Bangladeshis compared to their South Asian counterparts.

The results of previous reports that used cancer registration and HES linkage are broadly consistent with the results of this study [32, 47]. This is the first study to analyse ethnic difference in the incidence of individual subtypes of lung cancer.

Rates of lung cancer in non-Whites were generally much lower compared to Whites, reflecting lower smoking rates (particularly amongst women) [81] and consistent with previous studies. [18, 19, 46]. Bangladeshi males were the exception – they have the highest risk, consistent with the fact that they smoke the most (40%). [81]

The magnitude of the reduced risk differed by subtype and largely reflected how important smoking is to the risk of that subtype. For example, it was lowest in adeno-carcinoma, and highest in small-cell lung cancer, consistent with the strength of their association with smoking [103].

Furthermore, these results show that South Asians should not be viewed as a homogenous group with respect to their risk of lung cancer, and the very low rates seen in e.g. Indians may indicate the potential for reducing incidence in other ethnic groups.

4.5 Breast and Gynaecological Cancers

Overall, there were considerable differences in the incidence of all four cancers by ethnic group with incidence rates for breast, ovarian and cervical cancer highest among Whites, whereas the incidence of endometrial cancer was highest among Blacks. Furthermore, there was strong evidence of heterogeneity within the South Asian group, with Bangladeshis having the lowest rates of all four cancers.

The results for breast cancer were broadly consistent with previous studies from the UK. [26, 29, 48, 104] The particularly low incidence of breast cancer among South Asians can be largely explained by known risk factors - on average, South Asians in England have more children, are more likely to breastfeed, less likely to use HRT, much more likely not to drink alcohol, and have a lower height than Whites. [10, 81, 105] Indeed, at least in women over 50, rates among South Asians were actually similar to Whites once incidence rates were adjusted for known risk factors. [10]

Bangladeshis were found to have much lower rates than both Pakistanis and Indians, even after adjustment for socioeconomic status. This is consistent with other studies [29, 106] and can again be explained by known risk factors – Bangladeshi women have higher parity, a greater likelihood of breastfeeding, younger average age at first birth and lower prevalence of obesity compared to Indian and Pakistanis.[81, 105-107]

Contrary to what might be expected, the risk for South Asians compared to Whites was lower among under-50s compared to over-50s as a much higher proportion of South Asians aged under 50 are UK born (58% vs. 3% for over-50s .[78]) Therefore, we would expect the risk factors, and therefore incidence rates, for this group to be closer to those of Whites. Indeed, there have been significant falls in parity amongst South Asian women over the last 40 years (from 4 to 2.5) whereas the rate in White women has stayed fairly constant (less than 2). [105] Although a previous study of breast cancer in ethnic groups found that rates for Bangladeshis and Whites were much closer in younger compared to older age groups, there was no clear effect of age among Indians or Pakistanis.[29] However, a study of South Asians in Leicester did find that rates of breast cancer among South Asians between 1990 and 1999 increased towards those reported for Whites, which was assumed to be due to younger generations adopting more western lifestyles and reproductive behaviours.[19]

The lower incidence rates of breast cancer among Blacks compared to Whites can also be largely explained by known risk factors, with Blacks having more children, being younger at

first birth, more likely to breastfeed, less likely to use HRT and less likely to drink alcohol. [10, 81] And again, in women over 50, rates among Blacks were similar to Whites once incidence rates were adjusted for known risk factors. [10] When analysed by age, there was a marked difference in the Black-White ratio between under-50s and over-50s – with rates much closer to Whites in the younger women, a finding that has also been reported in previous studies. [48, 104] This is despite the fact that parity amongst blacks (about 2) has not declined over the last 40 years. [105] Studies from the US have also reported a 'Black-White crossover', with higher rates of breast cancer in Blacks compared to Whites in the younger age groups and the reverse pattern in older age groups. [108]

The low rates of breast cancer among Chinese have been reported previously [29, 32, 109] and are consistent with very lower rates of breast cancer in China compared to Western countries.[1, 80] The results in British Chinese women is unexpected as Chinese women have had the lowest parity of all ethnic groups in England since the 1980s. [105] although they have a higher prevalence of some protective factors including short stature, low BMI, and relatively low alcohol consumption.[81]

There is some evidence of differential uptake of breast cancer screening services by ethnic group which could affect incidence rates in the above 50s (screening starts at age 50). Analysis of data from the NHS breast cancer screening program from 1989 - 2004 using name analysis showed that rates of uptake were lower in South Asians compared to Whites. [82] More recent data from London using self-assigned ethnicity showed that uptake was highest in White women with similar uptake in Indians, Black Caribbeans and Chinese with Pakistani, Bangladeshi and Black African women being significantly less likely to attend. [110] Another study in London also showed that Indian women were more likely to have screen-detected breast cancer than White women, whereas Black African and Black Caribbean women were less likely. [111]

This is the first study to compare the incidence of gynaecological cancers by their individual ethnic groups. ((i.e. Indian, Pakistani, Bangladeshi, Black African and Black Caribbean).

Rates of ovarian cancer among Blacks and South Asians were lower than Whites, findings which are consistent with studies from both the UK and US.[32, 112] This may be due to the higher parity, longer duration of breastfeeding and lower HRT use among both these groups.[10, 105, 106] The higher incidence in Pakistanis compared to Indians and Bangladeshis may be due to lower oral contraceptive use and low initiation of breastfeeding. [107, 113] However, data on the prevalence of most risk factors by individual ethnic group is

scarce. In contrast, rates of ovarian cancer among Chinese were similar to Whites. This is unexpected given that their rates of breast cancer (which shares several major risk factors with ovarian cancer[114]) were much lower. However, the results in Chinese are consistent with them having the lowest parity of all ethnic groups in England.[105]

The results for cervical cancer were broadly similar to those found previously [32, 115] with the very low rates seen in South Asians likely to be due to their sexual behaviour. Indians and Pakistanis tend to be older at first intercourse, have fewer sexual partners, and are less likely to be sexually active than their White counterparts.[101, 113] They are also less likely to attend for cervical screening. [83, 116]

Incidence rates among Black Caribbeans were also lower than those of Whites which was somewhat surprising as there is very little difference between the number of sexual partners, average age at first intercourse. [101, 113] However this could be partly explained by their lower uptake of cervical screening. [83, 116] Furthermore, previous studies from both England and the US have shown higher cervical cancer incidence rates among Blacks relative to Whites.[32, 117] The results of this study are likely to have been confounded by socioeconomic differences - before adjusting for socioeconomic status, rates among Black Africans were actually higher than those of Whites.

HPV vaccination would not have had any effect on the results of this study as it was only introduced in England in 2008. [118]

In contrast with the other cancers studied, Blacks, specifically Black Caribbeans, had the highest rates of endometrial cancer but there was no difference in incidence between South Asians, Chinese and Whites, consistent with previous reports.[32] However, there was strong evidence of intra-ethnic differences in the South Asian group, with rates among Bangladeshis around 50% lower than those of Indians, Pakistanis which may be explained by their lower prevalence of obesity, high parity, and higher levels of breastfeeding.[81, 106] Obesity is known to increase the risk of endometrial cancer and therefore higher levels of obesity in Black women may account for some of their increased risk.[119] Ethnic differences in the rate of hysterectomies could also contribute to these differences but there is currently no data available on hysterectomy rates by ethnicity in the UK.

Rates of breast, ovarian and endometrial cancer observed among the non-White ethnic groups were generally higher than their countries of origin. [1] Although this may be due to under-diagnosis or poor registration in these countries, it may also be indicative of migrants' lifestyles

and reproductive behaviour becoming more similar to that of Whites. Cervical cancer rates, on the other hand, were lower than their countries / regions of origin.[1] This is likely to be due to the better quality and coverage of cervical screening in this country compared to less-developed countries,[120] which can allow for detection and treatment of precursor lesions.[121]

Furthermore, in contrast to Indians and Pakistanis, who have much higher rates than their countries of origin and closer to Whites, rates among Bangladeshis were similar to those in Bangladesh.[1]

4.6 Urological cancers

Overall, urological cancers were diagnosed less often in all the 'non-White' ethnic groups, except prostate cancer in Blacks, which demonstrated a higher incidence than in Whites. These findings are consistent with current literature [32] although there are no previous studies which present incidence by individual ethnic group for kidney, bladder and testes cancers.

For prostate cancer, previous UK studies have shown that Black Africans and Black Caribbeans demonstrated a higher incidence than Whites [30-32, 49, 51] Studies in the USA also show increased incidence in men with African ancestry, even after migration to areas of lower prevalence.[122] The specific cause of increased prostate cancer risk amongst Blacks is unknown. Reviews of known risk factors for prostate cancer have found limited environmental explanation for the racial differences in incidence.[49, 50, 123] However, dietary factors have been implicated, including intake of animal fats and products.[124] Increased risk amongst Blacks has also been attributed to genetic factors including variants of the genes of the enzymes involved in androgen biosynthesis and metabolism,[125]

Although the much higher rates seen in Black Africans and Caribbean in England compared to their regions of origin is consistent with a change of environment causing the increase, the very low rates seen in sub-Saharan Africa almost certainly underestimate the true incidence due to under-reporting & under-diagnosis due to decreased access to healthcare and screening. Rates are generally higher in black populations everywhere – Blacks in the US , Blacks in the UK and sub-Saharan Africa and the Caribbean, (where they are almost double compared to other similarly developed regions). [1]. The increased risk seen in Blacks in the UK is most likely due to the change in environment in genetically susceptible populations as well as better access to healthcare and opportunistic screening (e.g. Prostate Specific Antigen (PSA) testing.) The role of genetics is reinforced by the fact that both black Africans and Caribbeans display increased prostate cancer incidence, despite different countries of origin; lifestyles and environments.

Previous reports have also demonstrated reduced prostate cancer incidence in South Asians, as well as Indians, Pakistanis and Bangladeshis individually compared with Whites, [16, 17, 30, 32, 52] The reduced incidence amongst South Asians has been associated with religion and differences in diet. [35, 37]. Further, it has been suggested that South Asians meet with more obstacles when accessing health care resources [7, 126], and so may receive less diagnostic and screening (PSA) tests, although this would also be expected to be seen in

Blacks[7], where the incidence is actually higher. Bangladeshis displayed a substantially lower incidence of prostate cancer than Pakistani and Indians and this may be due to their lower prevalence of obesity [81] which has been linked to an increased risk of prostate cancer,[127] Prostate cancer incidence in Chinese was lower than Whites reflecting lower incidence in China / Hong Kong.

For renal cancer, a previous study showed that South Asians had a lower incidence of renal cell carcinoma compared with Whites, consistent with these results.[128] Smoking is a known risk factor for renal cell carcinoma [129] and these results are consistent with smoking prevalence by ethnic group.[81]

For bladder cancer, previous reports indicate a lower incidence amongst south Asians. [32] Again, smoking is a known risk factor for bladder cancer [130] and these results are broadly consistent with smoking prevalence by ethnic group with the exception of Bangladeshis who have the highest smoking prevalence.[81]

For testicular cancer, previous studies have also revealed a lower incidence amongst Asians and Blacks [31] consistent with this study. This may be due to inter-ethnic variations in environmental factors acting prenatally or early in childhood. [131] Cryptorchidism, a known risk factor of testicular cancer, may also vary between ethnicities, with reports of reduced incidence amongst Black babies [132] but data is not available for South Asians.

4.7 CNS Cancers

Although rates of CNS cancers overall were generally lower in non-White ethnic groups this masks significant variation by subtype. So, although Whites were significantly more likely to develop gliomas and glioblastoma than South Asians, Blacks or Chinese, Blacks were nearly three times more likely to develop pituitary cancers and meningiomas than Whites or South Asians.

For gliomas, there are no previous studies in the UK but the results were broadly consistent with published data from the USA [133].There are few proven risk factors for glioma but there is evidence for both environmental and genetic factors being important. [134, 135]. Genome-wide association studies have identified eight single nucleotide polymorphisms (SNPs) in seven genes which are significantly associated with glioma development[136] and it has previously been demonstrated that the frequency of some of these polymorphisms varies by ethnicity[137]. With reference to environmental factors, exposure to ionising radiation is a known risk factor for glioma [135, 136] but there is no evidence that this varies by ethnic group in England. Atopic disease has been shown be associated with a reduced risk of glioma [136] and South Asians and Blacks have been shown to have higher rates of new asthma consultations than Whites [138]. Children with a birth weight of over 4kg have been shown to have an increased risk of developing astrocytoma, a form of glioma[139] and South Asian and Black babies are more likely to be low birth weight than White babies. [140]. This could provide a partial explanation for these results.

For meningiomas, both Black groups had higher incidence rates consistent with previous studies in the USA [133].(There are no previous studies in the UK.) Genetic and environmental risk factors have been identified for meningioma, some of which might partly explain these results. Analysis of data from the Interphone study identified twelve SNPs associated with development of meningioma[141] but the relationship between ethnicity and genetic risk factors is not yet clear. As with gliomas, ionising radiation is linked to meningioma development [142] but there is no evidence that this varies by ethnic group. Obesity might increase women's risk of developing meningioma [143] which is consistent with Bangladeshis having the lowest incidence of meningioma and the lowest prevalence of obesity in England. [81]

For cranial and paraspinal nerve cancers, there were no significant differences when comparing any two individual ethnic groups directly. SNPs have also been identified which are associated with both increased and reduced risk of acoustic neuroma[144] but it is unknown as to how these vary by ethnicity.

For pituitary cancers, there is significant heterogeneity between the individual South Asian ethnic groups, with only two cases in the Bangladeshi population, far fewer than in Indians or Pakistanis. This is a new finding which requires further investigation. Blacks have the highest incidence rate of pituitary cancers, nearly 3 times higher than Whites which is reflected by other published data in the US [133] showing that both African Blacks and American Blacks having a higher incidence than American Whites[145]. This higher incidence rate may be due to genetic factors because there are no known environmental risk factors [146] and the increased incidence was apparent in both Black Africana and Black Caribbeans.

4.8 Haematological Cancers

In general, compared to the non-White ethnic groups, Whites experienced the highest or similar incidence rates for most haematological Cancers. However, Blacks had the highest rates of plasma cell neoplasms and mature T-cell neoplasms while Pakistanis had higher incidence of Hodgkin lymphoma. In addition, there were significant differences in incidence between Indians, Pakistanis and Bangladeshis for Hodgkin lymphoma and mature B cell neoplasms, and between Black African and Black Caribbeans for mature B cell neoplasms and other lymphoid neoplasms.

The excess risk of Hodgkin lymphoma among South Asian males, in particular Pakistanis, is consistent with previous studies [13, 18, 32]. Low rates of Hodgkin lymphoma have also been found in South Asian countries[1] but this could be due to under-diagnosis and under-reporting in these countries. Hodgkin lymphoma is an Epstein Barr Virus (EBV)-associated malignancy and EBV-associated Hodgkin lymphoma is known to be more common in less-developed countries, particularly among young children [147]. However, the precise nature of this association is unclear and the ubiquity of EBV infection suggests that other co-factors are important in the ethnic and geographic variation in incidence observed[147].

The increased incidence of diffuse large B-cell lymphoma (DLBCL), an HIV-associated lymphoma [148], in Black Africans compared to both Whites and Black Caribbeans is likely to be due to their higher rates of HIV infection.[149] The much higher rates in Pakistanis, compared to Indians, Bangladeshis & Whites may be related to EBV infection as this is also a risk factor for DLBCL [147] but it is unclear as to why Pakistanis should have higher prevalence of EBV infection.

The lower risk of follicular lymphoma among all ethnic groups is consistent with data from the US [150]. This may be due, in part, to genetic factors as specific genetic polymorphisms associated with a higher risk of follicular lymphoma have been identified [151]. Other studies have found that incidence rates among Asians increase with generation of residence suggesting that environmental factors may also play an important role in follicular lymphoma aetiology. [150]. A number of Western lifestyle factors have been associated with a higher risk of follicular lymphoma including high-meat and high–fat diets [152] and heavy smoking [153] which may explain some of differences observed as smoking rates tend to be lower among several of the non-White ethnic groups compared to Whites [81]

The increased incidence of plasma cell neoplasms (previously mainly classified as multiple myeloma) among Blacks, has been consistently reported in the literature both in the UK and the US [32, 154] and high incidence rates have also been observed in the Caribbean [155]. However, rates recorded in Africa are much lower than both Blacks and Whites in England [1], suggesting the disease is being under-diagnosed or under-reported in African countries. Several studies have found an association between obesity and multiple myeloma [156]. However, although there is a higher prevalence of obesity among Black females compared to Whites [81], this is not seen among males so this is unlikely to explain the large differences observed. Genetic factors may also play an important role as the disease shows significant familial aggregation [157] and human leukocyte antigen (HLA) phenotypes have been associated with increased risk of the disease [157]. Indeed, this is consistent with the finding that, despite having different diets, habits and socio-cultural practices, Black Africans and Black Caribbeans experienced very similar rates of the disease (similar to the findings for prostate cancer). A previous study also showed higher mortality among both Black Africans and Black Caribbeans. [12]

The lower rates of chronic lymphocytic leukaemia found among South Asians are consistent with international comparisons which reveal much lower rates of the disease in South Asia compared to Western countries [158]. There are currently no lifestyle or environmental factors that have been consistently associated with chronic lymphocytic leukaemia and evidence suggests that this ethnic variation is more likely to be the result of genetic differences [158] with migrants from low incidence countries not adopting the rates of their host country [159].

The very high incidence of mature T-cell lymphomas seen in Blacks, and particularly Black Caribbeans, has not been shown in the UK before but a US study did find higher rates of T-cell lymphomas among Blacks compared to Whites [160]. In the subgroup analysis of T-cell malignancy type, rates of adult-T-cell lymphoma/leukaemia (ATLL) were almost 40 times higher in Black Caribbeans compared to Whites. ATLL is caused by the Human T-cell Lymphotropic Virus (HTLV) which is endemic in the Caribbean and the prevalence of HTLV are 200 times higher in Black Caribbeans than Whites in England and around 3 times higher in Black Africans [161].

The elevated incidence of ‘other lymphoid’ malignancies among Blacks, specifically Black Africans, may be due to higher rates of HIV infection in this group [162]. Indeed, some cases of malignant lymphoma, not otherwise specified, which makes up a large proportion of the other lymphoid group may be associated with HIV infection. [163].

4.9 Other (Thyroid & Malignant Melanoma)

Thyroid cancer

In contrast to most other cancers, the risk of thyroid cancer was higher in all the 'non-White' ethnic groups, and also higher in women than in men across all ethnicities. There were significant differences in the incidence of thyroid cancer amongst South Asians with the risk of both follicular and papillary cancer being higher in Pakistanis and Bangladeshis but not in Indians. The higher rate of thyroid cancer in Blacks was driven principally by increased risk of follicular cancer whereas in Chinese, the higher rate was due to an increased risk of papillary cancer.

The single previous report of thyroid cancer incidence by ethnicity in England also showed a higher thyroid cancer incidence in South Asians compared with non-South Asians (using name analysis) but only in females. [18] There are no previous reports for Indians, Pakistanis and Bangladeshis separately of for Blacks or Chinese in the UK. The US SEER dataset does report incidence by race and showed a higher incidence in Whites than African Americans [64]. However this may have been be due to decreased access to healthcare in African Americans. [164]. Other studies in the US have shown the highest rates in East Asian men and women, consistent with these results. [165]. Thyroid cancer is generally an indolent disease, which may not shorten life-span and is generally diagnosed more in those with better access to healthcare [166].

The environmental and genetic factors that lead to thyroid cancer are not fully known, but there are some established risk factors - pre-existing thyroid disease, iodine status and exposure to radiation.[166] Iodine deficiency is associated particularly with follicular thyroid cancer, while iodine sufficiency may have contributed to the worldwide increase in papillary thyroid cancer [167]. The increased incidence of papillary thyroid cancer in developed countries and of follicular thyroid cancer in developing countries is consistent with this being associated with iodine supplementation. In the UK, salt iodization [168] is long-standing and there is no evidence of difference in iodine status by ethnic group and this is therefore unlikely to explain the ethnic variation.

Thyroid cancer is likely to be under-diagnosed in less advanced health systems which could explain the reduced risk of thyroid cancer seen in countries of origin for each ethnic group. The findings for Chinese, where the incidence is higher compared to Whites, and higher than China as a whole, but lower than Hong-Kong Chinese may be due to Hong Kong having an advanced endocrine oncology clinical service community [169].

In conclusion, the higher rates of thyroid cancer in South Asians and Blacks is not explained by socioeconomic differences, differential access to health care or a higher incidence in their countries of origin and so further investigation is required.

Melanoma

As expected, the 'non-White' groups had a much lower incidence of melanoma compared to Whites with the lowest rates seen in South Asians. The very low risk was seen in both those aged greater than 50 and less than 50. These results are consistent with previous reports. [18, 32, 58, 59].

The lower overall risk in South Asians & Blacks is due mainly to their darker skin pigmentation which is known to be protective [57]. i.e. they are genetically protected from melanoma and they have moved to a country with less exposure to sunlight than their country of origin – hence the extremely low rates.

In South Asians, it is also likely to be due lower skin exposure to sunlight (UV radiation) due to dressing more conservatively. [170]

4.10 Childhood cancers

There was an overall increased risk of childhood cancers in Pakistani and Black African children relative to White children. The results confirm the increased risk of leukaemia and lymphoma seen in South Asian children in previous studies[61, 171] , but for leukaemia show that this is due to the greater risk in Pakistani children. An increased risk of 'other solid cancers' was also observed in Black African children, possibly driven by the previously described excess of renal cancers in this ethnic group in the US. [172].

The cause of most childhood cancers is unknown but high birthweight has been associated with an increased risk of leukaemia (and possibly non-leukaemia cancers in older children)[173]. Similarly, advancing maternal age has also been associated with a small increased risk in all groups of childhood cancer – leukaemia, lymphoma, CNS - analysed in this study. The above and other risk factors, such as maternal alcohol consumption in pregnancy[174], and maternal[175, 176] and paternal smoking[177], all of which been shown to be associated with an increased childhood cancer risk are all generally more prevalent in British Whites. This cannot therefore explain the increased cancer risk overall, and in leukaemias and lymphomas in particular, seen in this study in South Asian and the Black African ethnic minority groups.

A greater proportion of the groups who have a higher risk of leukaemias (Pakistanis) and lymphomas (South Asians and Black Africans) are from a lower income domain, but recent large representative population-based studies have not observed an association of deprivation with leukaemia or lymphoma subtypes[178].

HIV is known to be a risk factor for childhood lymphoma [179] and the greater prevalence of HIV in Black African women [149] likely explains the higher risk in Black African children.

The one group of cancers in which a reduced risk relative to British Whites was observed was in CNS cancers in South Asian children (driven mainly by reduced risk in Pakistani children). This finding is in keeping with previous UK studies, many of which were in communities where there are large Pakistani populations. [62, 180, 181] but in contrast to the findings of the study conducted in Indian children in Leicester [63], but this had a very small sample size. There are few well established risk factors for childhood CNS cancers – although Asthma, or atopy more generally, has been shown to be associated with a reduced risk [182, 183] its prevalence does not markedly differ across different ethnic groups in adolescents in the UK. [184].

4.11 **Strengths and limitations**

Strengths

As discussed above and in section 1.5, the results of most previous studies (where they have data on the cancers analysed) have been broadly similar to this one. However, this study has a number of advantages which have produced a more accurate estimation of cancer incidence rates for more ethnic groups and in more cancers. These are summarised below:

1. Self-assigned ethnicity was used which is more reliable than other measures of ethnicity (e.g. name analysis) as it uses the same measure of ethnicity in the numerator (Cancer Registry and HES) and denominator (Census).
2. Rates were adjusted for socioeconomic status, a potential confounder in studies of health and ethnicity, and particularly important in comparisons involving Pakistanis, Bangladeshis and Blacks due to their higher levels of deprivation. [35, 36, 88]
3. For many cancers, this study analysed incidence by individual ethnic group (Indians, Pakistani, Bangladeshis) as opposed to “South Asians” & Black Caribbean and Black Africans (instead of ‘Blacks’) for the first time. As shown repeatedly above, there were significant differences in cancer incidence between individual ethnic groups for many cancers and it is therefore vital to distinguish between them.
4. It has the largest sample size of any study looking at individual ethnic groups with the only similar previous analyses being done in the Thames region which were limited by small sample size (less than a third of the sample size in this study).
5. This large sample size also meant this study was able to correct some of the results from the smaller studies previously done in Indians in Leicester. (e.g. rectal cancer and childhood CNS cancers.)
6. It has the lowest missing values for ethnicity (21 % missing overall) which is the highest proportion of cases with ethnicity assigned of any study to date.
   The use of multiple imputation (as opposed to assuming that the ethnicity data are missing at random) to deal with missing ethnicity data in the sensitivity analyses.
   Doing the sensitivity analysis using multiple imputation allows us to test the assumption that data are MAR and based on the fact that the results were the same in the sensitivity analysis and the complete-case analysis, this can therefore be assumed to be valid.
7. For haematological cancers, this study used the current WHO classification scheme, which is widely used in clinical practice [178]. By analysing more specific subgroups

rather than the broader categories defined by the ICD-10 scheme, it was possible to identify subtype-specific incidence patterns for the first time.

8. For CNS cancers, this study used the ICD-O-3 classification of cancers which is more specific than the ICD-10 classification which is based on location without reference to histology and hence is less accurate. This again allowed identification of subtype-specific incidence patterns for the first time.

Limitations

The main limitations of this study are:

1. Individual level information on most exposures is not available although population level data was available for some risk factors as discussed above. This allowed ecological comparisons to be made and is a useful starting point for the generation of hypotheses.
2. Ethnicity information was also missing for 21% (range 7% (childhood leukaemia) – 30% (melanoma) of cancer registrations but this is lower than previous analyses (e.g. 24% for all cancers (13-37% for individual cancers) in the NCIN report.)[32]. The similar results found in all the sensitivity analyses using multiple imputation also suggest that this did not markedly affect the results. The age-standardised rates were therefore about 20% lower than their true values, assuming they were missing at random.
3. The quality of the ethnic coding in HES has also been assessed and no ethnic group is widely misrepresented in HES data for England with the ethnic data coding being consistent with that of their patient population.[25] Of course, the assumption made in this study is that the ethnic code was self-assigned and that patients use the same self-assigned ethnicity coding in HES as they did in the census although there is no evidence to suggest that either of these assumptions is not valid. A previous study also showed minimal effect of missing ethnicity data on estimates of breast cancer incidence [26]
4. Of course, if there is a systematic difference in the distribution of ethnicities in the missing versus non-missing, this would introduce a selection bias. However, an analysis done on the Million Women Study (MWS) data showed that the distribution of ethnicity as self- recorded by MWS was the same in those with ethnicity missing in HES as for those for whom it was recorded. [10] It is also theoretically possible that there could be a misclassification of ethnicity in the numerator and denominator but given that both are self-assigned this would be very unlikely.

5. However, despite the use of self-assigned ethnicity being the best measure of ethnicity, there remains some discordance – more so in ethnic minorities - between HES ethnicity recording and self-assigned ethnicity and there is an ongoing need to improve the accuracy of this data[185].
6. There was a change in ethnicity coding in 2001 but not for Indians, Pakistanis, Bangladeshis, Black Caribbean, Black Africans and Chinese who had their own separate codes from 1991 to 2001 as well. The classification for Whites changed from White to British White/Irish White/Other white in 2001 but this is unlikely to have a significant impact on these results as 96% of All Whites are British Whites. [78]
7. The group 'British White' included some 'Other (non-British) Whites' as the ethnic category 'Whites' included both British Whites and 'Other Whites' prior to 2003 although this was less than 5% of the 'total White' category based on the data post-2003 so would not materially affect the results for British Whites. This study was therefore also unable to compare British Whites to 'Other Whites', and given that the 'Other White' population has increased rapidly since 2004 (due to migration from the European Union), future studies should look at incidence in this group as well.
8. The comparison of rates between ethnic groups in England and their countries of origin is problematic for a number of reasons. Firstly, population-based cancer registries simply do not exist in many of these countries, particularly in the areas from where the majority of migrants originate e.g. Punjab & Gujarat in India, Kashmir & Punjab in Pakistan, Sylhet in Bangladesh, Jamaica in the Caribbean and Somalia, Nigeria & Ghana in Africa and even where registries exist the quality is very variable and there are differences in cancer registration practices.[1] Rates in these developing countries are also likely to be underestimated due to under-diagnosis and under-ascertainment, and in access to screening and early detection, particularly for breast, cervical, prostate and colorectal cancer.[186] Migrants are also a selective group and may not be representative of the population from which they arose and they may be more or less healthy than the population in their native country. [4]
9. Although this study was able to analyse incidence by smaller, more homogenous ethnic subgroups, there remain within these groups a degree of heterogeneity, e.g. with Black Africans having a number of countries of origin, and similarly with Indians and Pakistanis originating from a number of provinces and states, with their own socio-cultural and genetic diversity.
10. This study was unable to see how cancer incidence varies by duration of

residence, age at migration, and between first- and second-generation migrants. This would have been useful to see if rates were higher in those who had been here longer or were born here, but such information is not available in the UK.

5. Conclusions & Future Perspectives

1. There is strong evidence of differences in incidence by ethnic group for most cancers.
2. South Asians are not homogeneous with respect to their risk of most cancers with large differences in incidence between Indians, Pakistanis and Bangladeshis.
3. There are also significant differences in risk between Black Africans and Black Caribbeans for some cancers.
4. This highlights the importance of distinguishing between these different, though related, ethnic groups.
5. Whilst some of these differences can be accounted for through known risk factors, many of the large differences in the incidence of many cancers seen across the different ethnic groups are not explicable and suggest that important, potentially modifiable, causes of these cancers are still to be discovered.
6. The very low rates seen for some cancers (e.g. oesophageal cancer in British Pakistanis) may also indicate the potential for reducing incidence in other ethnic groups.
7. The changes in cancer risk seen in these migrant populations may also give an indication of what could happen in the future in their countries of origin as they undergo rapid epidemiological transitions with potentially major global health implications.
8. Initial descriptive studies like this one highlight differences by ethnic group and are important as they allow for better public health planning and targeted initiatives. The differential risk may also impact on the index of clinical suspicion for particular cancers in different ethnic groups.
9. However, in order to understand why these differences exist and the relative contribution of genetic and environmental factors, further research is required, including individual level risk-factor information.
10. A large, prospective cohort study of first and second generation non-White ethnic groups in the UK is therefore needed.

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Appendix: Additional information

i) The work was carried out at the Cancer Epidemiology Unit (CEU) at the University of Oxford. My main supervisor was Professor Dame Valerie Beral and I have also received valuable advice from Dr Max Parkin. The main collaborating partners (in terms of providing data) are the National Cancer Intelligence Network and the Office for National Statistics.

ii) I am the Principal Investigator on this study. It was designed by me; all research questions and analyses were my idea and I wrote the protocol. I obtained the ethical approval and acquired the data. I am the corresponding author on all the papers related to this work, and supervised all the research fellows on the papers where they are first author.

iii) The dissertation is my own work and it is not simply a compilation of the published papers but inevitably there are parts of it which overlap with the papers that were published, which of course included input from the first authors. Also, all the statistical analyses were done by my colleague from the CEU, Dr Isobel Barnes, who also produced all the figures. (Except for those for gastrointestinal cancers, which were done by Dr Benjamin Cairns, also from the CEU as Dr Barnes was on maternity leave at the time of its submission.)

iv) This is a list of the published papers from this MD topic:

1. **Ali, R.**, Barnes, I., Cairns, B. J., Finlayson, A. E., Bhala, N., Mallath, M., . . . Beral, V. (2013). Incidence of gastrointestinal cancers by ethnic group in England, 2001-2007. *Gut*, *62*(12), 1692-1703. doi:10.1136/gutjnl-2012-303000
2. Sayeed, S., Barnes, I., Cairns, B. J., Finlayson, A., & **Ali, R**. (2013). Childhood cancer incidence in British Indians & Whites in Leicester, 1996-2008. *PLoS One*, *8*(4), e61881. doi:10.1371/journal.pone.0061881
3. Shirley, M. H., Sayeed, S., Barnes, I., Finlayson, A., **Ali, R**. (2013). Incidence of haematological malignancies by ethnic group in England, 2001-7. *British Journal of Haematology*, *163*(4), 465-477. doi:10.1111/bjh.12562
4. Finlayson, A., Barnes, I., Sayeed, S., McIver, B., Beral, V., Ali, **Ali, R**. (2014). Incidence of thyroid cancer in England by ethnic group, 2001-2007. *British Journal of Cancer*, *110*(5), 1322-1327. doi:10.1038/bjc.2014.4

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6. Maruthappu, M., Barnes, I., Sayeed, S., **Ali, R.** (2015). Incidence of prostate and urological cancers in England by ethnic group, 2001-2007: A descriptive study. *BMC Cancer*, *15*(1). doi:10.1186/s12885-015-1771-2

7. Maile, E Barnes, I., Sayeed, S., Finlayson, A., & **Ali, R**. Nervous System and Intracranial Cancer Incidence by Ethnicity in England, 2001-2007: A Descriptive Epidemiological Study. PLoS One. 2016; 11(5): e0154347.
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8. Sayeed S, Barnes I, **Ali R.**
   Childhood cancer incidence by ethnic group in England, 2001-2007: a descriptive epidemiological study. BMC Cancer. 2017 Aug 25;17(1):570. doi: 10.1186/s12885-017-3551-7.

I am the corresponding author on all papers.

v) **Ethical Approval**

This study was approved by the Oxford Research Ethics Committee (this was a requirement for the data to be released by NCIN). Consent was not obtained because the data were analysed anonymously.
This study used routinely collected data from the National Cancer Intelligence Network and the Office of National Statistics. All data which I received from the registries was encrypted and password protected. The main ethical issue in these types of studies is to ensure the confidentiality of patients' data. In this study, only completely non-identifiable data was used with no information on the patients' name, address, NHS number, or date of birth and so there was no possibility of being able to identify any patients. No patients were contacted.

(ix) Any other information:

As indicated in my letter to the MD Committee in October 2016, there are some differences between what I submitted in my original proposal and what is in this dissertation:

i) Some of the objectives listed in the original proposal were not realised and others were added:

The primary objectives were to:

- Compare Bangladeshis, Indians and Pakistanis living in England with British Whites in terms of cancer incidence- **Black Africans, Black Caribbeans and Chinese were added and Childhood cancers were analysed as well.**
- Compare Bangladeshis, Indians and Pakistanis living in England with British Whites in terms of cancer survival – **not done**
- Compare Bangladeshis, Indians and Pakistanis living in England with British Whites in terms of stage at diagnosis – **not done**

The secondary objectives were to:

- Compare cancer incidence, survival and stage at diagnosis in Bangladeshis, Indians and Pakistanis living in England to each other and to the other major migrant groups in England. i.e. Black Africans, Black Caribbeans and Chinese **– survival and stage not done**
- Investigate time trends in cancer incidence among Bangladeshis, Indians and Pakistanis living in England and among British Whites and again compare to the other major migrant groups in England **– not done**

- Compare Bangladeshis, Indians and Pakistanis who migrated to England with their offspring in terms of cancer incidence - **Black Africans, Black Caribbeans and Chinese were added.**
- Compare Bangladeshis, Indians and Pakistanis living in England with inhabitants of South Asia in terms of cancer incidence - **Black Africans, Black Caribbeans and Chinese were added.**

These analyses (survival, stage, time trends) were not done following the advice of my supervisor, Professor Dame Valerie Beral, as the data quality was not good enough (especially prior to 2001) and so there was insufficient data.

ii) Analyses were done for the whole of England, not just areas with a high concentration of Ethnic minorities, in order to increase the sample size.

iii) The analyses were restricted to the years 2001-7 (instead of 1996-2007), due to poor quality data pre-2001.

These changes to the dissertation were approved by the MD Committee in November 2016.