Spatial analysis of food insecurity and obesity by area-level deprivation in children in early years settings in England

Benjamin Neelon SE, Burgoine T, Gallis JA, Monsivais P.

1　**ABSTRACT**

2　**Background:** We assessed manager perceptions of food security and obesity in young children

3　attending nurseries across England, assessing spatial differences by area-level deprivation.

4

5　**Methods:** We conducted an adjusted multinomial logistic regression and an adjusted

6　geographically weighted logistic regression examining the odds of a manager perceiving obesity,

7　food insecurity, or both as a problem among children in care measured via a mailed survey.

8

9　**Results:** 851 (54.3%) managers returned the survey. A nursery being in the highest tertile of

10　area-level deprivation was associated with a 1.89 (95% CI 1.00, 3.57) greater odds of perceiving

11　obesity as a problem, a 3.06 (95% CI 1.94, 4.84) greater odds of perceiving food insecurity as a

12　problem, and a 8.39 (95% CI 4.36, 16.15) greater odds of perceiving both as a problem,

13　compared with the lowest tertile.

14

15　**Conclusions:** We observed differences in manager perception by area-level deprivation, but the

16　relationship was especially pronounced for food insecurity.

17

18

1. INTRODUCTION

Obesity is associated with numerous adverse health and behavioral conditions—even in early

childhood [1-5]. Thus, the prevention of childhood obesity is a public health priority in the

United Kingdom (UK). Although rates of obesity in early childhood have shown some

improvement in recent years, over 20% of children ages two to four years are currently

overweight or obese [6]. Moreover, as in adults, there are persistent social inequalities in the

prevalence of obesity [7-9]. These inequalities have widened in recent years, with children from

the lowest socioeconomic groups showing the sharpest rises in obesity [6].

At the same time, food insecurity, also known as food poverty, has emerged as an important

social and public health concern in England [10]. Food insecurity, characterized as limited or

uncertain availability of (or access to) nutritionally-adequate, safe and socially-acceptable foods

[11], has been associated with increased hospitalization, anemia, anxiety and depression, and

lower academic performance [12-20]. A recent United Nations survey of European countries

estimated that in the UK over 10% of people ages 15 years and above experienced food

insecurity [10]. For just under 5% of people surveyed, food insecurity was severe, meaning they

sometimes went without eating for an entire day because they did not have enough money to

purchase food [10]. Paradoxically, food insecurity may be a determinant of obesity [21, 22].

The majority of evidence, largely from the United States (US) and Canada, has linked food

insecurity with obesity and weight gain in adults. But the experience of food insecurity by

children, particularly very young children, has also been associated with obesity in both cross-

sectional and longitudinal studies [21, 23-26]. A recent study of children ages two to five years

44   found that more than 25% of food insecure children were overweight or obese, which is higher

45   than the overall average proportion of overweight and obesity in children across the US [26].

46   Several explanations have been put forward to reconcile the apparent paradox of obesity existing

47   within food-insecure families, including psychosocial stress and the reliance on energy-dense,

48   nutrient poor foods, which are low-cost and affordable for those experiencing financial hardship

49   [27], and especially palatable and acceptable to children [28].

50

51   Taken together, child obesity and food insecurity constitute complex and interrelated challenges

52   to public health. While obesity in the population is closely tracked, the study of food insecurity

53   in the UK population has been largely neglected. Considering the social and health consequences

54   of food insecurity among children [16, 18-20, 29, 30], more information is urgently needed on

55   the scope and extent of the problem in the UK. Moreover, little to no information is available on

56   the association between food insecurity and obesity in the UK.

57

58   Nurseries may provide important insight into the state of food insecurity among children. The

59   majority of children under the age of five years spend time in out-of-home child care, and the

60   amount of time in care increases as children age [31, 32]. The number of children in early years

61   settings in England has more than doubled in the past decade, with 796,500 in care in 2013 [31].

62   The purpose of this study was to assess manager perceptions of both food security and obesity in

63   children attending early years settings, assessing differences by area socioeconomic status across

64   England. We hypothesized that perceptions of both food insecurity and obesity in children would

65   be highest in the most deprived areas of England.

66

2. METHODS

2.1 Sample

We administered a survey by post to a stratified random (cross-sectional) sample of 2000

nurseries (determined by available funds) in England from November 2012 to September 2013.

Details of the survey protocol are available elsewhere [33]. Briefly, we obtained the names of all

28,091 registered nurseries in England from Ofsted, the agency responsible for regulating early

years programs in England. Nurseries include any group or organization that provides care for

children more than six days a year, and for at least two hours a day on non-domestic premises.

To be included in the study, Ofsted regulated nurseries needed to provide at least one meal or

snack to children in care daily, and care for children under six years of age on a regular basis

(e.g., not simply during holidays or after school hours). Programs were excluded if they were a

sports club or camp for children, served children with special dietary needs only, or cared for

children over six years of age exclusively. We designed the survey to be completed by the

manager in about 20 minutes, without review of any nursery documents or input from parents.

We did ask managers to seek input from other child care providers in their nurseries as needed.

We provided nursery managers with a £15 voucher after they completed the survey. The survey

included a letter to the manager stating that completion of the survey constituted consent to

participate in the study. All study procedures were approved by the University of Cambridge

Psychology Research Ethics Committee.

Using the list provided by Ofsted, we geocoded all 28,091 nursery addresses at the postcode

level, using a geographic information system (GIS) (ArcGIS 10, ESRI Inc., Redlands, CA) and

used the geocoded addresses to classify nurseries within Lower Super Output Areas (LSOAs),

90 which are small administrative boundaries containing about 1500 individuals. Next, we stratified

91 nurseries based on LSOA tertile (low, middle, high) using the Index of Multiple Deprivation

92 (IMD) 2010 scores (The English Indices of Deprivation, 2011), the most recent scores available

93 at the time the nursery survey was administered. The IMD measures relative deprivation and is

94 published by the Department for Communities and Local Government in England. The IMD is

95 updated every three to four years, is a compound measure of material deprivation, and includes

96 aspects of unemployment, housing prices, income, crime, and education levels, within LSOAs.

97 As noted previously [33], we oversampled nurseries in the most deprived areas (the highest

98 tertile of IMD) to reduce selection bias, expecting a lower response rate from nurseries in these

99 areas, sending surveys to 500 in the low, 500 in the middle, and 1000 in the high IMD tertile.

100

101 **2.2 Survey**

102 The purpose of the survey was to assess current practices related to food access and availability,

103 behaviors related to feeding children in care, and activities to promote healthy eating among

104 children in a sample of nurseries across England. We developed the survey using previous

105 instruments designed to assess nutrition- and obesity-related practices within child care programs

106 in the US [34-36], modifying the questions and response options as needed for use in England.

107 To assess manager perceptions of obesity in children attending their nursery, the survey asked

108 "How much of a problem is obesity in your program among children", with five possible

109 responses: "not a problem", "small problem", "moderate problem", "large problem", and "very

110 large problem". For analyses, we dichotomized nurseries into managers who perceived obesity

111 among their children as "not a problem", relative to those who reported obesity among children

112 in their care in any other way.

113

Questions regarding food security were based on those used in a survey previously conducted to

assess Head Start program practices [36]; an early years program within the US Department of

Health and Human Services that provides care and education to low-income children and their

families. Managers were asked "Do you or your staff feel that some children in your program do

not get enough food to eat at home?", with response options including "never or rarely",

"sometimes", and "often". For analyses we dichotomized responses as "never or rarely" versus

"sometimes" and "often"; we interpreted the latter as evidence of food insecurity within the

nursery. While food security among children is typically measured by asking the parent or the

primary caregiver, we were interested in assessing the manager's perception of food insecurity

and how the nursery responded to their concern. The follow-up question asked "What do you do

when you or your staff are concerned that children are not getting enough food to eat at home".

Response options included "feed more on Mondays and Fridays to make up for weekends",

"keep additional food on hand to feed the child during the day", "give food to the family to take

home for the child to eat", "refer the family to Sure Start Children's Centers, social services, or a

charity", and "talk to parents", and managers were instructed to mark all that apply.

129

We also asked a number of questions about how the nursery was owned and operated (privately

owned versus part of a corporation or chain), the number of children within the nursery, and the

number of years the nursery has been in operation. Additionally, we asked nursery managers to

report their age, sex, highest education (GCSEs, A-levels, National Vocational Qualifications,

two-year diploma, degree, or higher degree), years employed by their current nursery, and years

of experience in child care.

136

2.3 Global statistical analysis

We conducted binary logistic regression analyses, examining the odds of a manager perceiving

only obesity as a problem among children, perceiving only food insecurity as a problem, or

perceiving both as a problem, for each tertile of deprivation relative to those least deprived.

Models were adjusted for the total number of children enrolled in each nursery, whether a

nursery was privately owned or part of a corporation or chain, and manager level of education

(dichotomized as less than a two-year diploma versus a two-year diploma or higher). After

adjustment, total number of children made no meaningful difference to the relationship between

deprivation tertile and the outcome, and was not significant it its own right, and so was removed

from the final model. Additionally, as a sensitivity analysis, we performed multiple imputation

with fully conditional specification, with 10 imputations, and which included the outcome and all

covariates. Regression results are presented as odds ratios (OR) with 95% confidence intervals

(CI), and two-sided p-values. Analyses were conducted using SAS version 9.4 (SAS Institute,

Cary, North Carolina, US).

2.4 Local statistical analysis

We conducted a logistic geographically weighted regression (GWR) analysis, examining the

odds of a manager perceiving both obesity and food insecurity as problems, for each tertile of

deprivation relative to those least deprived. Models were adjusted as per our global analyses.

GWR predicts nonstationarity in relationships by producing a 'local' parameter estimate for each

geographic location (in this case, each nursery) based on a proximal subset of the global data

[37]. The GWR equation is as follows:

159

$$\gamma_i(u) = \beta_1(u)x_1 + \beta_2(u)x_2 + \cdots + \beta_n(u)x_n$$

161

162 where y_i is the dependent variable at location u, $\beta_1(u)$ is an estimate of the regression co-

163 efficient for x_1 as the product of a distance decay function surrounding location u, and to which

164 this parameter is unique [38]. To model distance decay, our analyses used an adaptive bi-square

165 geographic kernel, with bandwidth determined by Akaike Information Criterion (AIC)

166 minimization to account for the sparseness of nursery locations in some parts of England.

167 Logistic GWR results are presented as mapped ORs with t-values ≥±1.96 indicating statistical

168 significance. Relationships were deemed to exhibit nonstationarity across the study area where

169 the interquartile range of the local estimates for deprivation was more than double the standard

170 error of the global estimate [39]. Goodness of model fit is compared between global and local

171 models using corrected AIC values, where a lower value by more than two points is indicative of

172 better model fit [40]. Analyses were conducted using GWR4.0 (National Centre for

173 Geocomputation, National University of Ireland Maynooth, Ireland), with ORs mapped using a

174 GIS (ArcGIS 10, ESRI Inc., Redlands, CA).

175

176 **3. RESULTS**

177 **3.1 Demographics**

178 Of the 2000 nurseries mailed a survey, 202 (10%) were no longer in operation. We excluded an

179 additional 230 (11%) because they were not an early years setting, did not care for children

180 regularly, or did not provide any food to children. Of the remaining 1568 nurseries, 851 (54%)

181 returned a survey. Of those nurseries, four were missing information on tertile of deprivation, 56

182   did not respond to the question on manager education level, and 96 did not respond to the

183   question on nursery ownership, leaving a final sample for the adjusted analysis of 707. Thus, we

184   included only nurseries with complete exposure, outcome, and covariate data in our final sample

185   for analysis.

186

187   Responding nurseries were located throughout England (Figure 1), and relatively equally

188   distributed across deprivation tertiles, with 56% in the least deprived, 56% in the middle

189   deprived, and 52% in the most deprived LSOAs [33]. Among the 707 nurseries in our analysis,

190   most nursery managers (96.6%) were women, and had a mean (SD) of 16.9 (9.2) years of

191   experience working in nurseries. The mean age of managers was 42.4 (11.0) years. Among

192   managers, 73 (10.3%) perceived only obesity as a problem among children, 188 (26.6%)

193   perceived only food insecurity as a problem, 121 (17.1%) perceived both as a problem, and 325

194   (46.0%) perceived neither as a problem. Perceptions of food security being a problem, and of

195   both food security and obesity being problems, were patterned by area-level deprivation. Nursery

196   managers in the most deprived areas were more likely to perceive problems with food insecurity

197   (31.7%) and food security and obesity (27.6%), than those in the least deprived areas (20.5% and

198   6.8%, respectively).
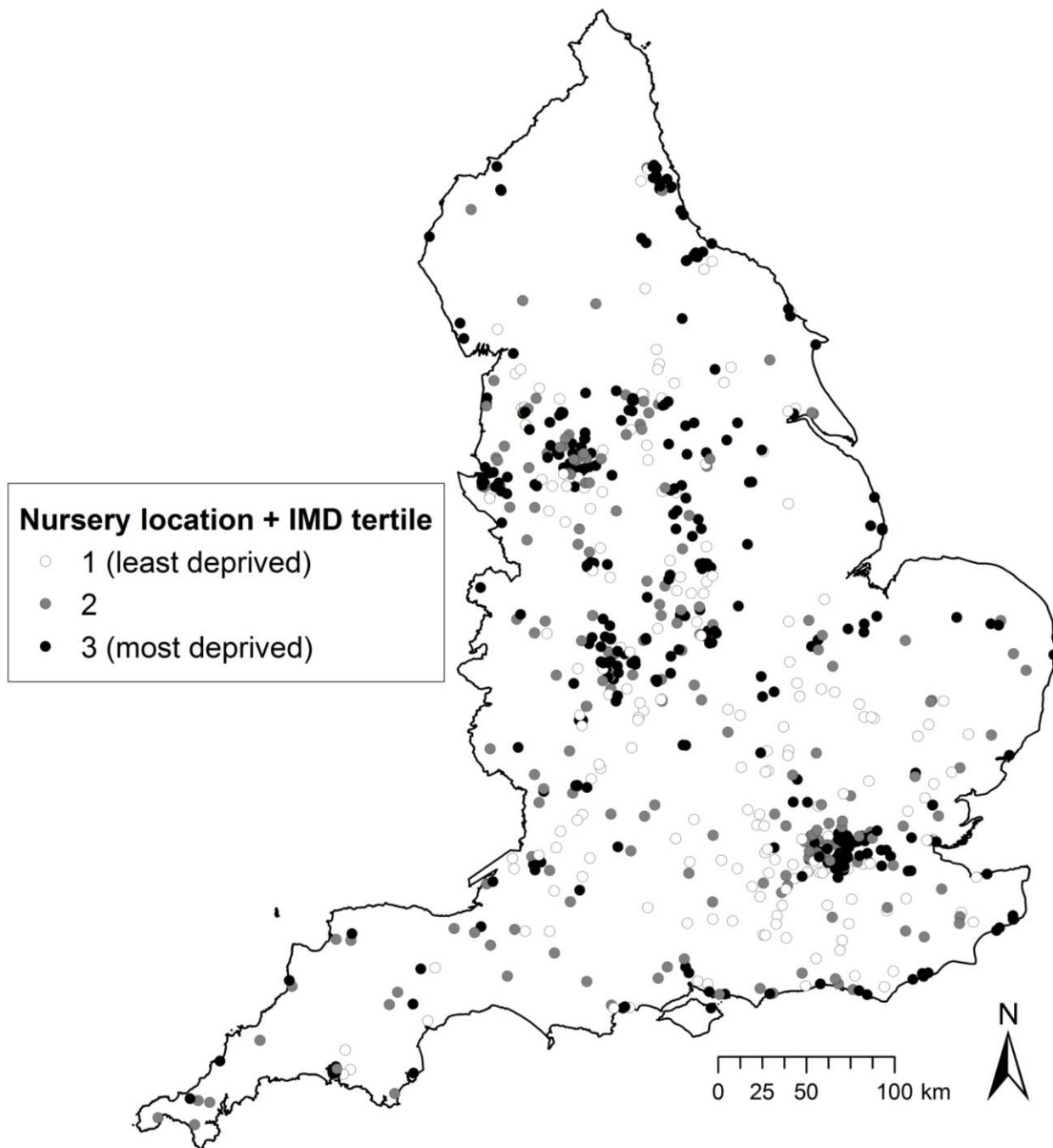
199   **Figure 1.** Locations of participating nurseries in the analytic sample throughout England

200   (n=707), and their distribution across Lower Super Output Area Index of Multiple Deprivation

201   2010 tertiles. © Crown Copyright/database right 2017, an Ordnance Survey/EDINA supplied

202   service.

203 **Table 1.** Demographic characteristics of nurseries and managers in the Nutrition in Nurseries

204 survey (n=707) by area-level deprivation.

	Total Sample (n=707)	Least Deprived (n=190)	Middle Deprived (n=195)	Most Deprived (n=322)
Nursery Characteristics	Number (Percent)			
Obesity and food security problems				
Neither problem	325 (46.0)	119 (62.6)	105 (53.8)	101 (31.4)
Obesity Problem only	73 (10.3)	19 (10.0)	24 (12.3)	30 (9.3)
Food security problem only	188 (26.6)	39 (20.5)	47 (24.1)	102 (31.7)
Obesity and food security problem	121 (17.1)	13 (6.8)	19 (9.7)	89 (27.6)
Nursery type				
Privately owner	169 (23.9)	37 (19.5)	42 (21.5)	90 (28.0)
Part of corporation or chain	538 (76.1)	153 (80.5)	153 (78.5)	232 (72.0)
	Mean (SD)			
Years in operation	16.5 (11.8)	18.6 (12.7)	18.0 (11.8)	14.5 (11.0)
Cost of care per month, £				
For infants	516.8 (356.6)	617.3 (356.0)	564.9 (410.4)	460.1 (321.7)
For toddlers	478.0 (341.8)	542.5 (355.7)	470.1 (377.6)	455.6 (314.2)
For preschoolers	392.9 (316.1)	438.8 (325.9)	374.1 (335.2)	382.1 (299.8)
Manager Characteristics	Number (Percent)			
Sex, female	673 (96.6)	184 (97.4)	184 (96.3)	305 (96.2)
Education				

Less than 2-year Degree	293 (41.4)	78 (41.1)	92 (47.2)	123 (38.2)
2-year Degree or higher	414 (58.6)	112 (58.9)	103 (52.8)	199 (61.8)
	Mean (SD)			
Age, years	42.4 (11.0)	42.9 (10.2)	42.2 (11.6)	42.3 (11.2)
Years worked in child care	16.9 (9.2)	16.5 (9.2)	17.0 (9.0)	17.1 (9.3)

205

206

3.2 Global associations between obesity and food insecurity as problems, and area deprivation

After adjusting for whether a nursery was privately owned and manager level of education, we found that a nursery being in the highest tertile of deprivation was associated with a 1.89 (95% CI 1.00, 3.57; p=0.049) times greater odds of perceiving only obesity as a problem; a 3.06 (95% CI 1.94, 4.84; p<0.001) times greater odds of perceiving only food insecurity as a problem; and a 8.39 (95% CI 4.36, 16.15; p<0.001) times greater odds of perceiving both as a problem, all relative to those in the lowest tertile of deprivation (Table 2). The overall F-test p-value for the tertile effect was <0.001. We did not observe a significant difference comparing the middle to the lowest tertile of deprivation for any of our outcomes. In the fully adjusted multiple imputation model, the estimates changed only slightly but did not change in terms of significance (data not shown).

219

Table 2. Associations of area-level deprivation and each of obesity, food insecurity, or both, estimated using individual binary logistic regression models.

	OR (95% CI)	P-value

Obesity problem only (n=398)		
Low deprivation	Ref	-
Middle deprivation	1.47 (0.76, 2.84)	0.26
High deprivation	1.89 (1.00, 3.57)	0.049
Food insecurity problem only (n=513)		
Low deprivation	Ref	-
Middle deprivation	1.40 (0.85, 2.32)	0.19
High deprivation	3.06 (1.94, 4.84)	<0.001
Both obesity and food security problems (n=446)		
Low deprivation	Ref	-
Middle deprivation	1.73 (0.81, 3.73)	0.16
High deprivation	8.39 (4.36, 16.15)	<0.001

222 **a** Adjusted for whether a nursery was privately owned or part of a corporation or chain and

223 manager level of education.

224

225 **3.3 Local associations between obesity and food insecurity as problems, and area**

226 **deprivation**

227 Our adjusted logistic GWR model revealed marked differences over space in the relationship

228 between area-level deprivation and nursery manager perception of both obesity and food

229 insecurity as problems. Figure 2 shows local ORs (quintiles) by nursery location, as well as an

230 inverse distance weighted surface representing these odds. All ORs demonstrated a positive

231 relationship between area-level deprivation and odds of perceiving both obesity and food

232 insecurity as a problem, and were significant (t-values ≥1.96). The observed relationship is

233   stronger in the North of England, and relatively less strong in the South, South-East, and in

234   Greater London. In one area of the North West, we found that a nursery being in the highest

235   tertile of deprivation was associated with 31.67 times greater odds of perceiving both obesity and

236   food insecurity as a problem, compared with a nursery being in the lowest tertile of deprivation.

237   The local model showed better fit than the global model, with marked differences in corrected

238   AIC values (global, 424.7; local, 421.9). These differences exhibited nonstationarity, with the

239   interquartile range for local model estimates (1.21) more than double the standard error of the
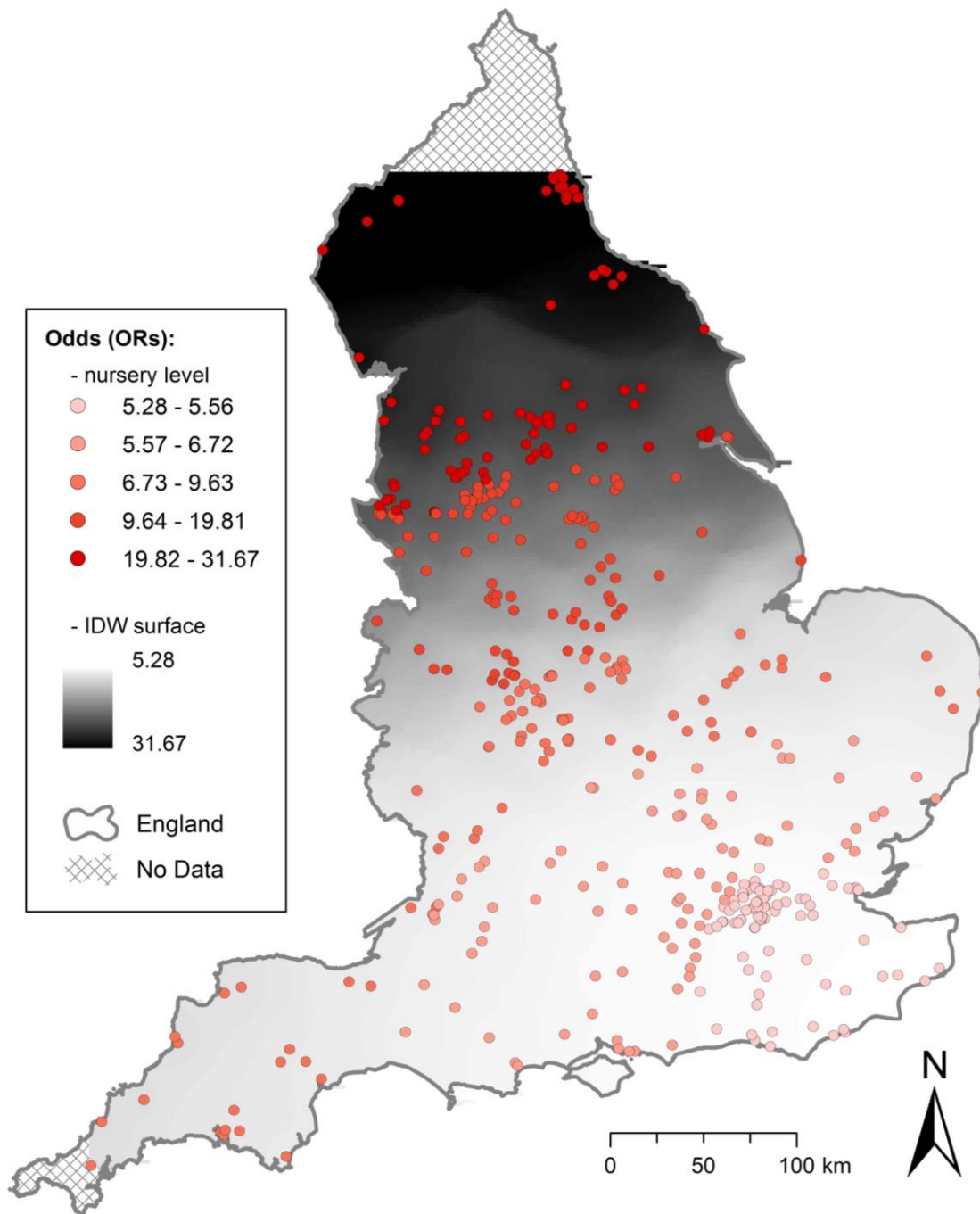
240   global model estimates (0.34).

Figure 2. Association of area-level deprivation (showing quintiles of local odds ratios for highest deprivation tertile only[a]) and both obesity and food insecurity reported as problems,[b] estimated using logistic geographically weighted regression, using data from the Nutrition in Nurseries

247 survey (n=446). Odds ratios attributed to each nursery location based on local analyses of a

248 proximal subset of the global data.

249 © Crown Copyright/database right 2017, an Ordnance Survey/EDINA supplied service.

250 [a] All odds ratios are significant, with t-values ≥1.96.

251 [b] Adjusted for whether a nursery was privately owned or part of a corporate chain and manager

252 level of education.

253

254 **4. DISCUSSION**

255 In this study of nurseries in England, we found that area deprivation was associated with

256 manager perceptions of obesity, food insecurity, and in particular of both obesity and food

257 insecurity combined. There is some evidence that food insecurity and obesity may co-exist

258 within communities, families, and even within individuals. The underlying mechanism linking

259 food insecurity with obesity include food consumption cycling—overconsumption in times of

260 food abundance to account for anticipated scarcity later [41, 42]—and intake of calorie-dense,

261 nutrient-poor foods, which are economical, palatable and filling but can promote passive

262 overconsumption [43, 44]. While the precise pathways linking food insecurity and obesity in

263 young children are not known, studies suggest that unhealthy dietary intake and inappropriate

264 feeding behaviors may play a role [45-49]. Bronte-Tinkew et al. [45] observed an indirect

265 association between household food insecurity during infancy and obesity at 2 years, working

266 primarily through parenting and feeding practices in a sample in the US. Feinberg et al [46],

267 studied 278 mothers and children living in urban US environments and found that food insecure

268 mothers were more likely to give their preschool- and school-age children high-energy

269 supplements and appetite stimulants. In our study, we found that over one fifth of managers

270   reported feeding children more on Mondays and Fridays or keeping additional food on hand at

271   the nursery for hungry children, and these practices were more prevalent in the most deprived

272   areas. These behaviors could in fact contribute to obesity, if managers are feeding children more

273   food whilst in care to compensate for inadequate calories at home.

274

275   We also showed geographic variation in the magnitude of the association between area

276   deprivation and manager perception of both obesity and food insecurity, using a GWR method.

277   There is some precedent for the use of GWR in recent obesity research [39, 50], however to our

278   knowledge, GWR has not yet been utilized to study the relationship between area deprivation

279   and nursery characteristics in any setting. While the relationships observed were aligned with

280   those from global models, perceptions of nursery managers of both obesity and food insecurity

281   being problems were more closely tied to area deprivation in particular hotspots, for example, in

282   the North of England. The spatial variation in this relationship was masked by the global models,

283   with GWR models exhibiting marked spatial nonstationarity and providing better overall model

284   fit. The diversity in magnitude of associations revealed should also help to drive the research

285   agenda in so far as they necessitate a deeper, region-specific understanding of other contributors

286   to nursery level obesity and food insecurity problems.

287

288   This study has some limitations. Our assessment of obesity was based on manager perception,

289   and not actual measures of children's obesity status. While measured height and weight would

290   have provided more precise information, the purpose of the study was to collect data on a large

291   sample of nurseries across England to inform and guide future research. Findings from this

292   survey will help identify geographic areas of focus for additional research that should include

293   more accurate measures of obesity in children. Similarly, our measure of food insecurity was not

294   based on parent report to reflect food insecurity within the household, which is the standard

295   approach used to identify food insecurity in children. Food security status may not be readily

296   identifiable in young children and manager perception may not reflect actual food insecurity.

297   However, this alleviates some of the social stigma and thus social desirability or response bias

298   associated with parent report of household food insecurity. However, it is possible that perceived

299   food insecurity may underestimate actual food insecurity, if outward signs are not readily

300   apparent in children.

301

302   Additionally, we asked managers to seek input from other child care providers in the nursery, as

303   needed, to complete the survey. Some managers may have sought assistance from child care

304   providers, but others may not have requested this input. While managers likely have a better

305   grasp of practices across the entire nursery, child care providers within the classroom may be

306   better positioned to assess food insecurity due to their proximity to and interactions with

307   children. Geographically weighted regression is also not without limitations, which include

308   issues related to multicollinearity, kernel bandwidth selection and study area edge effects. This

309   study is also limited in its generalizability and thus external validity by the 54% response rate.

310   However, the nursery managers who responded were distributed across England, and response

311   rates were largely similar by area deprivation. We anticipated a lower response rate from

312   nurseries in the most deprived areas, and to reduce potential selection bias we oversampled those

313   nurseries to ensure adequate representation. However, response rates across tertiles of

314   deprivation were similar, so this may not have been necessary.

315

316   Finally, our study reflects a snapshot of nursery conditions and practices in 2012-13 and did not

317   capture important trends in food insecurity occurring since this time. Although high food price

318   inflation in the UK since 2008 began to moderate in 2012 [51], household food insecurity is

319   likely to be a large and growing concern. The prevalence of food insecurity is not routinely

320   estimated in the UK, but a report using data from the United Nations estimated that 8.4 million

321   UK residents were food insecure in 2014 [52]. Moreover, the use of food banks in the UK, one

322   indicator of food insecurity, increased every year between 2008 and 2016-17, with more than a

323   three-fold increase between 2012-13 and 2016-17 [53]. More direct monitoring of food

324   insecurity is needed in England and throughout the UK, particularly for households that include

325   children.

326

327   At present, mandatory nutrition requirements for food in nurseries are minimal, stipulating only

328   that food and drink served should be 'healthy, balanced and nutritious' [57]. However, recent

329   national reports and papers have called for enhanced standards in nurseries and other child care

330   settings [54-56]. The most comprehensive nutrition standards for nurseries, developed in 2010,

331   are voluntary [58], but some have called for a clear and unambiguous definition of "healthy,

332   balanced and nutritious" in the mandatory regulations to help promote healthy eating and prevent

333   obesity [55].

334

335   **5. CONCLUSIONS**

336   In this study assessing food insecurity and obesity in young children, we found that area

337   deprivation was associated with manager perceptions of both obesity and food insecurity, but the

338   relationship was especially pronounced for food insecurity. Recent national efforts call for

339   improved nutrition in early years settings to help prevent obesity in young children [59]. It is also

340   important to consider issues of food insecurity, and the potential for food insecurity and obesity

341   to coexists in young children, when responding to these calls.

342

343

344 **List of abbreviations**

345 Akaike Information Criterion (AIC); Confidence Interval (CI); Geographic Information System

346 (GIS); Geographically Weighted Regression (GWR); Index of Multiple Deprivation (IMD);

347 Lower Super Output Areas (LSOAs); Odds Ratios (OR); United Kingdom (UK); United States

348 (US).

349

350 **Declarations**

351 **Ethics approval and consent to participate**

352 The Nutrition in Nurseries mailed survey included a letter to the manager stating that completion

353 of the survey constituted consent to participate in the study. All study and consent procedures

354 were approved by the University of Cambridge Psychology Research Ethics Committee.

355

356 **Consent for publication**

357 Not applicable.

358

359 **Availability of data and material**

360 The dataset used and analyzed during the current study are available from the corresponding

361 author on limited request with appropriate permissions. However, restrictions apply to the

362 availability of some aspects due to the identifiable information contained in the geocoded data.

363

364 **Competing interests**

365 The authors declare that they have no competing interests.

366

References

1. Simmonds M, Llewellyn A, Owen CG, Woolacott N: **Predicting adult obesity from childhood obesity: a systematic review and meta-analysis**. *Obesity reviews : an official journal of the International Association for the Study of Obesity* 2016, **17**(2):95-107.
2. Llewellyn A, Simmonds M, Owen CG, Woolacott N: **Childhood obesity as a predictor of morbidity in adulthood: a systematic review and meta-analysis**. *Obesity reviews : an official journal of the International Association for the Study of Obesity* 2016, **17**(1):56-67.
3. Juonala M, Magnussen CG, Berenson GS, Venn A, Burns TL, Sabin MA, Srinivasan SR, Daniels SR, Davis PH, Chen W *et al*: **Childhood adiposity, adult adiposity, and cardiovascular risk factors**. *The New England journal of medicine* 2011, **365**(20):1876-1885.
4. Puder JJ, Munsch S: **Psychological correlates of childhood obesity**. *International journal of obesity (2005)* 2010, **34 Suppl 2**:S37-43.
5. Kuhl ES, Clifford LM, Stark LJ: **Obesity in preschoolers: behavioral correlates and directions for treatment**. *Obesity (Silver Spring, Md)* 2012, **20**(1):3-29.
6. **National Child Measurement Programme England, 2015-2016 School Year, Health and Social Care Information Centre.** [http://content.digital.nhs.uk/catalogue/PUB22269/nati-chil-meas-prog-eng-2015-2016-rep.pdf]
7. Ogden CL, Carroll MD, Fryar CD, Flegal KM: **Prevalence of Obesity Among Adults and Youth: United States, 2011-2014**. *NCHS data brief* 2015(219):1-8.
8. Anderson SE, Whitaker RC: **Prevalence of obesity among US preschool children in different racial and ethnic groups**. *Archives of pediatrics & adolescent medicine* 2009, **163**(4):344-348.
9. Zilanawala A, Davis-Kean P, Nazroo J, Sacker A, Simonton S, Kelly Y: **Race/ethnic disparities in early childhood BMI, obesity and overweight in the United Kingdom and United States**. *International journal of obesity (2005)* 2015, **39**(3):520-529.
10. **Too poor to eat, Food insecurity in the UK** [http://foodfoundation.org.uk/wp-content/uploads/2016/07/FoodInsecurityBriefing-May-2016-FINAL.pdf]
11. **Core indicators of nutritional state for difficult-to-sample populations**. *The Journal of nutrition* 1990, **120 Suppl 11**:1559-1600.
12. Olson CM: **Nutrition and health outcomes associated with food insecurity and hunger**. *The Journal of nutrition* 1999, **129**(2S Suppl):521s-524s.
13. Ke J, Ford-Jones EL: **Food insecurity and hunger: A review of the effects on children's health and behaviour**. *Paediatrics & child health* 2015, **20**(2):89-91.
14. Bhattacharya J, Currie J, Haider S: **Poverty, food insecurity, and nutritional outcomes in children and adults**. *Journal of health economics* 2004, **23**(4):839-862.
15. Skalicky A, Meyers AF, Adams WG, Yang Z, Cook JT, Frank DA: **Child food insecurity and iron deficiency anemia in low-income infants and toddlers in the United States**. *Maternal and child health journal* 2006, **10**(2):177-185.
16. Cook JT, Black M, Chilton M, Cutts D, Ettinger de Cuba S, Heeren TC, Rose-Jacobs R, Sandel M, Casey PH, Coleman S *et al*: **Are food insecurity's health impacts underestimated in the U.S. population? Marginal food security also predicts adverse health outcomes in young U.S. children and mothers**. *Advances in nutrition (Bethesda, Md)* 2013, **4**(1):51-61.
17. Black MM, Quigg AM, Cook J, Casey PH, Cutts DB, Chilton M, Meyers A, Ettinger de Cuba S, Heeren T, Coleman S *et al*: **WIC participation and attenuation of stress-related child health risks of household food insecurity and caregiver depressive symptoms**. *Archives of pediatrics & adolescent medicine* 2012, **166**(5):444-451.

18. Hendrickson MA, O'Riordan MA, Arpilleda JC, Heneghan AM: **Effects of food insecurity on asthma outcomes in the pediatric emergency department**. *Pediatric emergency care* 2010, **26**(11):823-829.

19. Cook JT, Frank DA, Berkowitz C, Black MM, Casey PH, Cutts DB, Meyers AF, Zaldivar N, Skalicky A, Levenson S *et al*: **Food insecurity is associated with adverse health outcomes among human infants and toddlers**. *The Journal of nutrition* 2004, **134**(6):1432-1438.

20. Metallinos-Katsaras E, Colchamiro R, Edelstein S, Siu E: **Household Food Security Status Is Associated with Anemia Risk at Age 18 Months among Low-Income Infants in Massachusetts**. *Journal of the Academy of Nutrition and Dietetics* 2016, **116**(11):1760-1766.

21. Dinour LM, Bergen D, Yeh MC: **The food insecurity-obesity paradox: a review of the literature and the role food stamps may play**. *Journal of the American Dietetic Association* 2007, **107**(11):1952-1961.

22. Nackers LM, Appelhans BM: **Food insecurity is linked to a food environment promoting obesity in households with children**. *Journal of nutrition education and behavior* 2013, **45**(6):780-784.

23. Eisenmann JC, Gundersen C, Lohman BJ, Garasky S, Stewart SD: **Is food insecurity related to overweight and obesity in children and adolescents? A summary of studies, 1995-2009**. *Obesity reviews : an official journal of the International Association for the Study of Obesity* 2011, **12**(5):e73-83.

24. Metallinos-Katsaras E, Must A, Gorman K: **A longitudinal study of food insecurity on obesity in preschool children**. *Journal of the Academy of Nutrition and Dietetics* 2012, **112**(12):1949-1958.

25. Metallinos-Katsaras E, Sherry B, Kallio J: **Food insecurity is associated with overweight in children younger than 5 years of age**. *Journal of the American Dietetic Association* 2009, **109**(10):1790-1794.

26. Speirs KE, Fiese BH: **The Relationship Between Food Insecurity and BMI for Preschool Children**. *Maternal and child health journal* 2016, **20**(4):925-933.

27. Drewnowski A, Specter SE: **Poverty and obesity: the role of energy density and energy costs**. *The American journal of clinical nutrition* 2004, **79**(1):6-16.

28. Daniel C: **Economic constraints on taste formation and the true cost of healthy eating**. *Social science & medicine (1982)* 2016, **148**:34-41.

29. Pilgrim A, Barker M, Jackson A, Ntani G, Crozier S, Inskip H, Godfrey K, Cooper C, Robinson S: **Does living in a food insecure household impact on the diets and body composition of young children? Findings from the Southampton Women's Survey**. *Journal of epidemiology and community health* 2012, **66**(6):e6.

30. Fotso JC, Madise N, Baschieri A, Cleland J, Zulu E, Mutua MK, Essendi H: **Child growth in urban deprived settings: does household poverty status matter? At which stage of child development?** *Health & place* 2012, **18**(2):375-384.

31. **Childcare and early years providers survey 2013** [https://www.gov.uk/government/statistics/childcare-and-early-years-providers-survey-2013]

32. Kamerman SB: **Early childhood education and care: an overview of developments in the OECD countries**. *International Journal of Educational Research* 2000, **33**(1):7-29.

33. Neelon SE, Burgoine T, Hesketh KR, Monsivais P: **Nutrition practices of nurseries in England. Comparison with national guidelines**. *Appetite* 2015, **85**:22-29.

34. Benjamin SE, Neelon B, Ball SC, Bangdiwala SI, Ammerman AS, Ward DS: **Reliability and validity of a nutrition and physical activity environmental self-assessment for child care**. *The international journal of behavioral nutrition and physical activity* 2007, **4**:29.

35.   Ward D, Hales D, Haverly K, Marks J, Benjamin S, Ball S, Trost S: **An instrument to assess the obesogenic environment of child care centers**. *American journal of health behavior* 2008, **32**(4):380-386.

36.   Whitaker RC, Gooze RA, Hughes CC, Finkelstein DM: **A national survey of obesity prevention practices in Head Start**. *Archives of pediatrics & adolescent medicine* 2009, **163**(12):1144-1150.

37.   Matthews SA, Yang TC: **Mapping the results of local statistics: Using geographically weighted regression**. *Demographic research* 2012, **26**:151-166.

38.   **Geographically weighted regression: white paper** [http://gwr.nuim.ie/downloads/GWR_WhitePaper.pdf]

39.   Fraser LK, Clarke GP, Cade JE, Edwards KL: **Fast food and obesity: a spatial analysis in a large United Kingdom population of children aged 13-15**. *American journal of preventive medicine* 2012, **42**(5):e77-85.

40.   **GWR4.09 User Manual** [https://raw.githubusercontent.com/gwrtools/gwr4/master/GWR4manual_409.pdf]

41.   Heitmann BL, Westerterp KR, Loos RJ, Sorensen TI, O'Dea K, McLean P, Jensen TK, Eisenmann J, Speakman JR, Simpson SJ *et al*: **Obesity: lessons from evolution and the environment**. *Obesity reviews : an official journal of the International Association for the Study of Obesity* 2012, **13**(10):910-922.

42.   Wells JC: **The evolution of human fatness and susceptibility to obesity: an ethological approach**. *Biological reviews of the Cambridge Philosophical Society* 2006, **81**(2):183-205.

43.   Cornell CE, Rodin J, Weingarten H: **Stimulus-induced eating when satiated**. *Physiology & behavior* 1989, **45**(4):695-704.

44.   Erlanson-Albertsson C: **How palatable food disrupts appetite regulation**. *Basic & clinical pharmacology & toxicology* 2005, **97**(2):61-73.

45.   Bronte-Tinkew J, Zaslow M, Capps R, Horowitz A, McNamara M: **Food insecurity works through depression, parenting, and infant feeding to influence overweight and health in toddlers**. *The Journal of nutrition* 2007, **137**(9):2160-2165.

46.   Feinberg E, Kavanagh PL, Young RL, Prudent N: **Food insecurity and compensatory feeding practices among urban black families**. *Pediatrics* 2008, **122**(4):e854-860.

47.   Gross RS, Mendelsohn AL, Fierman AH, Hauser NR, Messito MJ: **Maternal infant feeding behaviors and disparities in early child obesity**. *Childhood obesity (Print)* 2014, **10**(2):145-152.

48.   Gross RS, Mendelsohn AL, Fierman AH, Racine AD, Messito MJ: **Food insecurity and obesogenic maternal infant feeding styles and practices in low-income families**. *Pediatrics* 2012, **130**(2):254-261.

49.   Kaiser LL, Melgar-Quinonez HR, Lamp CL, Johns MC, Sutherlin JM, Harwood JO: **Food security and nutritional outcomes of preschool-age Mexican-American children**. *Journal of the American Dietetic Association* 2002, **102**(7):924-929.

50.   Black NC: **An Ecological Approach to Understanding Adult Obesity Prevalence in the United States: A County-level Analysis using Geographically Weighted Regression**. *Applied Spatial Analysis and Policy* 2014, **7**(3):283-299.

51.   Department for Environment FaRA: **Family Food 2015**. In*.* London, England; 2017.

52.   Taylor AL, R.: **Too Poor to Eat Food insecurity in the UK**. In*.* Edited by Nations. U; 2016.

53.   Butler P: **Food banks report record demand amid universal credit chaos**. In: *The guardian.* London, England; 2017.

54.   Buttivant H, Knai C: **Improving food provision in child care in England: a stakeholder analysis**. *Public health nutrition* 2012, **15**(3):554-560.

55.   Trust CsF: **Voluntary Food and Drink Guidelines in Early Years Settings**. In. Edited by http://www.childrensfoodtrust.org.uk/assets/eat-better-start-better/CFT Early Years Guide_Interactive_Sept 12.pdf; 2012.

56.   **Department for Education. Statutory Framework for the Early Years Foundation Stage. Setting the standards for learning, development and care for children from birth to five**. In. Edited by http://media.education.gov.uk/assets/files/pdf/e/eyfs statutory framework march 2012.pdf; 2012.

57.   **Office for Standards in Education Children's Services and Skills. Framework for the Regulation of Those on the Early Years and Childcare Registers**. In. Manchester, England; 2013.

58.   Department for Children SaFSFT: **Laying the Table: Recommendations for National Food and Drink Guidance for Early Years Settings in England**. In. London, England; 2010.

59.   **Childhood Obesity: A Plan for Action** [https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/546588/Childhood_obesity_2016__2__acc.pdf]