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The impact of greenspace and condition of the neighbourhood on child overweight

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1 **The impact of greenspace and condition of the neighborhood on child overweight**

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27 **Abstract**

28 **Background**

29   Childhood overweight/obesity has been associated with environmental, parenting and

30   socioeconomic status (SES) factors. This paper assesses the influence of the amount of

31   green space, accessibility to a garden and neighbourhood condition on being

32   overweight/obese. It investigates whether parental behaviours moderate or mediate this

33   influence and evaluates the interaction of SES with environmental context.

34   **Methods**

35   6467 children from the UK Millennium Cohort Study living in England were analysed. We

36   estimated logistic regressions to examine the initial association between environment and

37   overweight. Subsequently, parenting determinants comprising: food consumption, physical

38   activity, rules and regularity were evaluated as moderators or mediators. Lastly SES related

39   variables were tested as moderators or mediators of the associations.

40   **Results**

41   Statistically significant associations were found between low levels of green space, no

42   access to a garden, run down area and childhood overweight/obesity (odds ratio (OR) (95%

43   confidence interval (CI)) respectively: 1,14 (1,02-1,27), 1,35 (1,16-1,58), 1,22 (1,05-1,42)).

44   None of the parental constructs mediated or moderated the relationships between

45   environment and childhood overweight/obesity. Including SES, parental education

46   moderated the effect of environmental context. Specifically, among lower educated

47   households lack of garden access and less green space was associated with

48   overweight/obesity; and among higher educated households poor neighborhood condition

49   influenced the probability of overweight/obesity respectively: 1,38 (1,12-1,70) OR 1.38, 95%

50   CI 1.21-1.70).

51   **Conclusions**

52   This study suggests that limits on access to outdoor space are associated with future

53   childhood overweight/obesity although the ways in which this occurs are moderated by

54   parental education level.

55   Keywords: Environment, Socioeconomic Status, Green space, Childhood Obesity, Education

56   parenting

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Introduction

The prevalence of overweight and obesity in children has increased dramatically over the last two decades.[1] In England 9.9% of boys and 9.0% of girls aged 4-5 years and 20.8% of boys and 17.3% of girls aged 10-11 years were classified as obese in 2013 according to the British 1990 population monitoring definition of obesity (≥95th centile) (NCMP 2013/14). This has been considered as a major public health challenge, as overweight and obesity at a young age have important short- and long-term health and social consequences.[1-6]

The neighbourhoods in which children live, play and eat provide an important environmental context that may influence obesity risk.[7;8] Research has shown that publicly provided recreational infrastructure is positively associated with children's physical activity.[9] It indicates that children and their parents tend to be more physically active in a conducive environment.[10;11] Other studies have found that a child's risk of being overweight or obese was related to socioeconomic status (SES), as measured by household income and parents' educational attainment.[12-14] Many studies suggest that there is in fact a growing socioeconomic status disparity of overweight and obesity prevalence in children. That is, overweight in children is increasing faster in lower socioeconomic groups.[15] Since children with the lowest levels of health inequality were exposed to the greenest environment,[16] this may suggest an interaction between socioeconomic class and physical environment, although this has not previously been researched in relation to child overweight. Besides physical environment, other factors influencing child overweight or obesity include parenting behaviours.[17-20]

We hypothesize that environmental context influences the prevalence of overweight or obesity in children and that environmental context and parenting behaviour are intimately linked. Since more affluent parents tend to live in more salubrious areas, the effect of environment may in part be driven by parental SES. At the same time, environmental context may matter more for those otherwise able to take advantage of it. We therefore also

87   hypothesize that there might be an interaction between socioeconomic status and the

88   influence of environmental context on the prevalence of overweight or obesity in children.

89   Therefore the first aim of this study is to assess the influence of green space, access to a

90   garden and condition of the neighbourhood measured at ages 3-5 years on being

91   overweight/ obese at age 7. Second, we investigate whether parenting behaviours moderate

92   or mediate this influence . Lastly, we evaluate the interaction of socioeconomic status with

93   environmental context.

94

95   **Methods**

96   *Data Millennium Cohort Study*

97   We used the nationally representative UK Millennium Cohort Study (MCS)

98   (www.cls.ioe.ac.uk/mcs). The MCS is a prospective cohort of around 19,000 children born in

99   2000/2001 across the UK and first surveyed at the age of 9 months (sweep 1), with follow-

100   ups at ages 3, 5 and 7 years old (sweeps 2-4).[21-24] The MCS provides an opportunity to

101   simultaneously assess environmental and family factors for childhood obesity using an

102   ecological systems approach.[25]

103   The MCS children were sampled from families eligible for (universal) Child Benefit. The MCS

104   employed a stratified clustered sample design to over-represent children living in

105   disadvantaged areas and from ethnic minority groups.[26] At all sweeps information was

106   collected through interviews with main respondents in the home (over 99% were natural

107   mothers), as well as their co-resident partners (mostly the children's father). A range of

108   health-related data have also been collected, including direct measures of height and weight.

109   The data include a wealth of information describing the social, economic and demographic

110   characteristics of the cohort members and their families. Data were accessed through the UK

111   Data Archive, University of Essex.[27] The MCS received ethical approval from the NHS Multi-

112   Centre Research Ethics Committees for all the sweeps.[25;28]

113

114   In this study we restrict our sample to those children living in England at the time child weight

115   and the predictors were measured. We excluded families who had more than one child in the

116   cohort (n=186), where information was missing on whether the family moved between

117   contacts (n=980), where the level of green space changed between sweeps (1-3) (n=679), or

118   where the child had a missing height or weight (n=230). Some participants met more than

119   one exclusion criterion. Among the 8239 singleton infants who were living in England at the

120   first survey a total of 6467 (78%) children remained in England for the subsequent surveys

121   and participated at all subsequent survey sweeps up to the age 7 survey and provided full

122   data on the relevant variables. These children form our analytic sample.

123

124   *Outcome variables*

125   Figure 1 presents the research questions driving this study. The main outcome was

126   dichotomous: childhood overweight/obesity at age seven with normal weight as the reference

127   category. Children were weighed and measured, without shoes or outdoor clothing, by

128   trained interviewers. Weight was collected using Tanita HD-305 scales (Tanita UK Ltd.,

129   Middlesex, UK), and recorded in kilograms to one decimal place. Heights were measured

130   with the Leicester Height Measure Stadiometer (Seca Ltd., Birmingham, UK) and recorded to

131   the nearest millimetre.[29] Cole's international age and sex specific cut-offs for body mass

132   index (BMI, weight/height^2) were used to classify children as overweight or obese.[30]

133

134   *Neighbourhood determinants*

135   Three environmental variables (Figure 1: base model; RQ1) were measured at either the age

136   three or age five survey periods and used as proxies for environmental context; green space,

137   access to a garden and neighbourhood condition. We used "green space" as defined by the

138   Office for National Statistics and measured using the 2001 Generalized Land Use Database

139   (GLUD).[31] The data are presented in thousands of square metres (1000 m^2), to 2 decimal

140   places. Hence, the statistics are accurate to the nearest 10 m^2. GLUD defined

141   neighbourhood green space as the percentage of space within each Lower Level Super

6

142   Output Areas (LSOA: a small area geography defined by the Office for National Statistics),

143   which was green. LSOAs were then ranked from 1 (low)-10 (high) according to their

144   concentration of green space across the tenths of the distribution. The respective rank was

145   then linked to the LSOA where the children were living at age 5, based on their postcodes.

146   We further collapsed these tenths of green space into 3 levels: low 30%, middle 40% and

147   high 30% green space.

148   Second, at the age three survey (sweep 2), mothers were asked whether they had access to

149   a garden.

150   Third, also at the age three survey (sweep 2), prior to conducting the interview, the

151   interviewer carried out an observational assessment of the local neighbourhood. Interviewers

152   were asked to report on a number of features of the MCS child's street or immediate

153   neighbourhood comprising i) the general condition of buildings in the street, ii) whether there

154   were security blinds, iii) traffic calming measures, iv) the volume of traffic, v) whether there

155   were burnt-out cars on the street, vi) litter on the street or pavement, vii) dog mess on the

156   pavement, viii) graffiti on walls or public spaces, ix) evidence of vandalism, and x) arguing or

157   fighting in the street. The condition of the neighbourhood was measured as the sum scores

158   of these 10 questions. The range of total scores was then divided in four groups. The

159   complete description of the items, the response options and the scoring per answer are given

160   in Appendix 1.

161

162   *Parenting measures*

163   For research question 2 (Figure 1, RQ2a and b): do parenting behaviours mediate or

164   moderate the relationship between the environmental variables and childhood

165   overweight/obesity?, we used the interviews with the main carer conducted when the child

166   was around 5 years old. Standardised questions were asked about the choices parents

167   made in the upbringing of the child (and their siblings, if any). In total 13 questions were

168   judged to be potentially related to child BMI. These included behaviours such as physical

169   activity with the child, eating habits, rules and discipline. An overview of the items, the

170 response options and the scoring per answer are presented in Appendix 1. We initially tested

171 the contribution of each of the items individually before performing an exploratory factor

172 analysis on all the items to assess which items were correlated. Next the items that grouped

173 on a factor were tested with principle component analysis, with varimax rotation and

174 eigenvalue -1 cut off. Four parental constructs were identified: food construct (4 items),

175 physical activity construct (4 items), rules construct (2 items) and regularity construct (2

176 items). Note that, as Appendix 1 shows, the physical activity construct was not based on

177 direct but on reported measures of physical activity, which do not necessarily reflect intensity

178 of activity. After the principal component analysis it became evident that one item did not

179 correlate with any of the other questions: self-assessment of the level of competence as a

180 parent. We actually found it to be inversely correlated to questions of a more objective

181 nature. For this reason we chose to exclude this item.

182

183 *Socio economic status measures*

184 Research question 3 (Figure 1; RQ3) evaluates the interaction of SES with environmental

185 context and childhood overweight/obesity. The SES variables selected were, first,

186 educational qualifications as measured by the National Vocational Qualification (NVQ)

187 framework. The original NVQ had five levels but due to the limited number of postgraduate-

188 level educated parents we recoded it into four levels: Secondary school low grades;

189 secondary school high grades; vocational training, and undergraduate or postgraduate level

190 education. The highest NVQ level of the mother or father was used. Second, low income was

191 added as a dichotomous variable (measured as <60% median or >60% median).

192

193 *Statistical analysis*

194 Due to the design of the study, in which children living in disadvantaged areas and from

195 ethnic minority groups are over sampled, not all participants had an equal selection

196 probability.[26] To correct for this complex survey design, all analyses were performed using

197 Complex Sample Analysis.[32] For the basic model (that is, evaluating the influence of

198   environmental variables on childhood overweight and obesity) logistic regression models

199   were estimated, with a minimum threshold for statistical significance of p≤0.05. To test if

200   parental choices moderate the raw model (figure 1; RQ 2a), interactions between the

201   environmental variables and each of the four parental constructs were tested. Moderation

202   was judged to be present if at least two of the three interaction variables had a p value ≤0.1.

203   If moderation was identified the model would be adjusted accordingly. Mediation of the

204   parental influence on the model (figure 1; RQ 2b) was tested in two steps. The relationship

205   between the environmental variables and the possible mediator (i.e. parental construct) was

206   first tested using ordinal regression models. Then the parental construct was added to the

207   logistic regression model. If step 1 was significant (p≤0.05) and step 2 changed the original

208   odds ratio by 10% or more, then the parental construct would be considered to be a

209   mediating variable. The model would be adjusted accordingly.

210

211   The model derived from these sequential steps was then tested for moderation or mediation

212   of both SES related variables (family poverty and parental education) (figure 1; RQ 3) using

213   the same approach as for the parental constructs. All analyses were performed using SPSS

214   (Version 22, IBM Corp, Armonk, NY).

215

216   **Results**

217   According to the unweighted statistics, about half of the children were female (49.7%), nearly

218   one in five was overweight or obese (19.9%), and almost 90% had access to a garden. Due

219   to oversampling of deprived areas, about 40% of parents had finished secondary school

220   (Table 1).

221   The raw relationship between the environment factors and childhood overweight/obesity is

222   depicted in Table 2. Living in an area where the amount of green space was in the lowest

223   30%, a child had a higher chance of being overweight or obese at age seven (Odds Ratio

224   [OR] 1.14, 95% confidence Interval [CI] 1.02-1.27). This was also the case for children

225   without access to a garden (OR 1.35 95% CI 1.16-1.58) and living in surroundings that were

226   more rundown (worst surroundings: OR 1.22, 95% CI 1.05-1.42, second worst surroundings:

227   (OR 1.27, 95% CI 1.11-1.47)). Parenting constructs relating to physical activity and regularity

228   were significantly related to childhood overweight/obesity in the expected directions.

229   The food and rules constructs were not associated with overweight/obesity, even when we

230   tested the individual indicators for the constructs separately. Moreover, none of the parental

231   constructs mediated or moderated the relationships between the environment and childhood

232   overweight/obesity.

233

234   Children of higher educated parents tend to live in greener areas, have greater access to a

235   garden and better surroundings (Table 3). The highest level of education (NVQ) was found

236   not to mediate but to moderate the relationship between environmental factors and child

237   overweight/obesity. Therefore, the relationship between environmental variables and

238   childhood overweight / obesity was analysed separately for each NVQ-level (Table 4). This

239   showed that children in households where one or both parents had an undergraduate degree

240   (or equivalent) or higher had an increased probability of being overweight or obese when the

241   environment was more rundown of 4.4 percentage points (probability best

242   surroundings:16.2%, more run down: 20.6%). By contrast, for children in households with

243   secondary school as their highest level of education, the absence of a garden and less green

244   space in the surrounding area increased the probability of being overweight or obese by

245   respectively 3.8 and 2.9 percentage points (probability: garden access: 20.9%, no garden

246   access: 25.7%; high green surroundings: 21.1%, low green surroundings: 24.0%).

247

248   **Discussion**

249   More green space in the local neighbourhood may be important for children having the

250   opportunity to engage in physical activities and thereby attain a healthier weight status.[2;5;6;12]

251   This study contributes to the understanding of the relationship between the level of green

252   space, accessibility to a garden and the degree of dilapidation of an area and children's risks

253   of being overweight or obese. We found that children living in an area with less green space,

10

254   or which was less hospitable and children without access to a garden had a higher chance of

255   being overweight or obese. Therefore, improving the neighbourhoods they live in may

256   contribute to healthier behaviours and less overweight.

257

258   Our findings are consistent with other studies demonstrating a relationship between the level

259   of green space and the chance of being overweight or obese.[33-35] The influence of having

260   access to a garden has thus far not been studied but can be compared to the effects of

261   having a higher level of green space. In addition, access to a garden can be viewed as a

262   simpler and safer way for children to access green spaces.

263

264   Our finding that a more rundown neighbourhood is related to a higher chance of childhood

265   overweight/obesity is also consistent with other studies.[34;36-38] In these studies environment

266   was based on the perception of the care givers whereas in our study the interviewer scored

267   the individual items that were combined into the variable depicting the quality of the

268   environment. This is important as it means that parental choices that may relate to children's

269   risks of obesity are not confounded with their perceptions of the neighbourhood. Unlike these

270   other studies, therefore we can treat the quality of the neighbourhood as exogenous to

271   parenting decisions.

272

273   Both our results and those of other studies show a relationship between child overweight

274   /obesity and the choices made by parents regarding physical activity and having rules and

275   family discipline.[18-20;39] Our study is the first, however, to test whether parenting mediates or

276   moderates the relationship between environmental factors and childhood overweight/obesity.

277   Against our expectations we found that none of the parental constructs either mediated or

278   moderated this relationship. This implies that parenting and the environment exert

279   independent influences on child overweight/obesity.

280

281   Many studies have shown that SES is associated with children's risks of being overweight or

282   obese.[10;12;13] We were able to demonstrate that the associations between the environment

283   and childhood overweight/obesity were dependent on the educational level of the parents.

284   Children growing up in lower educated families (parents with secondary school qualifications

285   only) had a higher chance of overweight in a less green environment or if there was no

286   access to a garden. This is congruent with the findings of Lovasi et al. who found that

287   children in lower income families had a lower chance of obesity if they lived in an area with a

288   higher density of trees.[40]However, the focus on low income families in that study meant they

289   were unable to assess how the relationship varied with SES. In our study, we did not find this

290   relationship for families with post-compulsory educational qualifications. Instead, for those

291   with more highly qualified parents, living in a more rundown area was linked to overweight

292   and obesity suggesting that such parents may be more sensitive to their children playing

293   outside in such contexts. To our knowledge, this is the first study to report associations for

294   specific SES (educational- level) groups and show that they differ The cause and

295   mechanisms of these differences are areas for further research.

296

297   **Strengths and limitations**

298   The study has certain limitations. We cannot claim causality for our findings only

299   associations. Nevertheless, one of the strengths of this study is that children and their

300   caregivers were followed over time and that variables measured earlier in life (at age 3 and

301   5) were associated with being overweight or obese at age 7, reducing the problem of

302   potential reverse causality. We addressed problems of selection by only including families

303   who continued living in an environment that did not change its level of green space (i.e. they

304   either didn't move or moved to an area with similar level of green space). It would be

305   interesting, however, to assess what happens to the BMI of the child when a family moves to

306   an area with more or less green space.

307

308   **Conclusions**

309 Associations are found between environmental variables at ages 3 and 5 with children being

310 overweight and obese at age 7. But these associations are moderated by the education level

311 in the household. The influence of level of green space and having garden access on child

312 weight is only identified for lower educated families whereas more rundown areas are more

313 relevant for child overweight among more highly educated families. Both findings, however,

314 emphasise the relevance of safe, congenial outdoor spaces for children to play in if their

315 rates of overweight are to be tackled.

316

Conflicts of interest

The authors declare that they have no competing interests.

Key points:

- Children living in an area with less green space or that is more run down or who are without access to a garden have a higher chance of being overweight or obese;
- The education level of the child's parents moderates the relationship between environment and the chance of overweight or obesity;
- Children from lower educated parents have a lower risk of being overweight or obese when they have access to a garden or green space, those from higher educated parents have a higher risk of overweight or obesity when they live in a more run down area.

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450   children from low-income families in New York City. Preventive medicine
451   2013;57(3):189-93.
452
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454　**Table 1 Participant characteristics**

Variable		N (6467 total)	% of total
Gender	Female	3212	(49.7%)
Weight	Overweight or obese	1290	(19.9%)
Environmental variables			
Green space[1]	Top 3 deciles	1807	(27.9%)
	Middle 4 deciles	2386	(36.9%)
	Bottom 3 deciles	2274	(35.2%)
Access to garden	Yes	5806	(89.8%)
Condition of the neighborhood	Best	2114	(32.7%)
	Good	1552	(24.0%)
	Not too good	1056	(16.3%)
	Worst	1562	(24.2%)
Parenting related variables			
Food construct			
Eats breakfast	7 days/week	5934	(91.8%)
	≥6 days/week	508	(7.9%)
Snacks between meals	No or only healthy	446	(7.2%)
	Unhealthy	5956	(92.1%)

Importance of having meals together with at least one adult	Very	4623	(71.5%)
	Fairly	1654	(25.6%)
	Not really or not at all	157	(2.4%)
Pieces of fruit per day	≥3	3349	(51.8%)
	2	1758	(27.2%)
	1	1086	(16.8%)
	None	246	(3.4%)

Physical activity (PA) construct

PA child	≥3 times/week	565	(8.7%)
	1-2 times/week	2782	(43.0%)
	None	3120	(48.2%)
PA parent and child	≥3 times/week	1674	(25.9%)
	1-2 times/week	2527	(39.1%)
	≤1/month	1306	(20.2%)
	≤1/year	960	(14.8%)
Park visits	≥3 times/week	1079	(16.7%)
	1-2 times/week	2726	(42.2%)
	1-2/month	1854	(28.7%)
	<1/month	785	(12.1%)

Television viewing	<1 hour/day	1340 (20.7%)	
	1-2 hours/day	4139 (64.0%)	
	≥3 hours/day	967 (15.0%)	

Rules construct

Having rules	Lots of rules	1926	(29.8%)
	Not many	2853	(44.3%)
	It varies	1655	(25.6%)
Importance of having rules	Strictly enforced	3110	(48.1%)
	Not very strictly enforced	1668	(25.8%)
	It varies	1656	(25.6%)

Regularity construct

Regular bedtimes	Always	2627	(40.6%)
	Usually	2436	(37.7%)
	Sometimes	912	(14.1%)
	Never or almost never	460	(7.1%)
Regular mealtimes	Always	2955	(45.7%)
	Usually	2858	(44.3%)
	Sometimes	498	(7.7%)
	Never or almost never	132 (2.0%)	

Socio-economic Status related variables (household highest)

National Vocational	Under graduate or higher	2963	(45.8%)
Qualification (NVQ)	Vocational training	973	(15.0%)
	Secondary school higher grades	1545	(23.9%)
	Secondary school lower grades	338	(5.2%)
	Other	648	(10.0%)
Poverty[3]	No poverty	5322	(82.3%)
	Poverty	1145	(17.7%)

455 [1]Based on Deciles of % green space Layer Super Output Areas (LSOA) Level.

456 [2]Addition of variables scored by interviewer (general condition buildings, presence of security

457 blinds, traffic calming, traffic volume, burnt out cars on the street, litter on street, dog mess

458 on pavement, graffiti on walls, evidence of vandalism, arguing/fighting on street).

459 [3]Poverty is when the household income is below 60% of the median of MCS-families

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463 **Table 2 Basic model.** Relationship between overweight/obese and environmental variables.

Independent variables		OR	(95% CI)	
Greenspace[1]	lowest 30%	1,139*	(1,023-	1,267)
(reference =	middle 40%	1,023	(0,914	1,146)
Highest 30%)				
Access to garden	no	1,352*	(1,156	1,582)
(reference = yes)				
Condition of the neighbourhood[2]	worst surroundings	1,221*	(1,050 -	1,420)
	surroundings not too	1,274*		
(reference = best	good		(1,108 -	1,466)
surroundings)	good surroundings	1,090	(0,977-	1,216)

464 [1]Based on Deciles of % green space Layer Super Output Areas (LSOA) Level.

465 [2]Sum score of variables scored by interviewer (general condition buildings, presence of

466 security blinds, traffic calming, traffic volume, burnt out cars on the street, litter on street, dog

467 mess on pavement, graffiti on walls, evidence of vandalism, arguing/fighting on street).

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Table 4 Relationship between environmental variables and overweight/obese by level of education.

Independent variables		NVQ level 1[3] OR	95% CI	NVQ level 2 OR	95% CI	NVQ level 3 OR	95% CI	NVQ level 4 OR	95% CI
Greenspace[1]	Lowest 30%	1,089	(0,592-2,002)	1,246	(1,020-1,523)*	1,262	(0,938-1,697)	0,982	(0,831-1,162)
(reference = Highest 30%)	Middle 40%	0,977	(0,593-1,607)	0,824	(0,661-1,026)	1,334	(0,970-1,834)	0,998	(0,854-1,165)
Access to garden	No	0,645	(0,255-1,632)	1,413	(1,087-1,837)*	1,134	(0,970-1.834)	1,288	(0,989-1,677)
(reference = Yes)									
Condition of the neighborhood[2]	Worst surroundings	0,903	(0,508-1,605)	0,837	(0,663-1,056)	1,219	(0,903-1,646)	1,382	(1,121-1,704)*
(reference = Best surroundings)	Surroundings not too good	0,537	(0,336-1,227)	1,258	(0,977-1,620)	1,141	(0,865-1,505)	1,272	(1,047-1,546)*

	0,868	(0,515-1,461)	1,215	(0,945-1,561)	1,220	(0,938-1,586)	1,035	(0,897-1,193)
Good surroundings								

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478   **Figure 1 Construct of the research questions (RQ) driving this study**

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