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Integrating environmental justice and socioecological models of health to understand population-level physical activity

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Abstract. The uneven geographical distribution of environmental pathogens and salutogens, as well as the political, social, and cultural antecedents leading to this sociospatial arrangement, have been posited as a partial explanation for the stark inequalities in health across many high-income nations. Whilst there is significant international evidence for the maldistribution of health-related environmental features, few studies have examined the material outcomes (including health) of this unequal environmental 'exposure'. In this paper we utilise the theoretical stances offered by work in the fields of environmental justice and socioecological models of health to consider the pathway between physical environmental deprivation and health. We consider the influence of multiple aspects of the 'natural' physical environment on individual-level levels of physical activity—both utilitarian and physical activity for leisure. We found that, for physical activity conducted for recreational purposes, there is a strong relationship with the natural physical environment: those living in the least deprived physical environments are most likely to engage in physical activity. However, for utilitarian physical activity, physical activity whose primary purpose is not the activity itself, we observed increased levels in the most environmentally deprived areas. Finally, the important role that the environment may play in shaping capabilities, particularly during the current economic and political climate, is recognised. Our results show that the environment matters and that rhetoric regarding 'lifestyle choice' needs to be viewed in a broader environmental context.

Keywords: environmental justice, physical activity, health behaviours, socio-ecological model, capabilities

Background

The notion that aspects of the physical environment may mediate and shape health inequalities is supported by a growing evidence base demonstrating that socially disadvantaged groups often reside in areas of poorer environmental quality. Using a framework of environmental justice, researchers have noted that low-income communities suffer the burden of environmental disamenities such as poor air quality, noise pollution, and exposure to toxic facilities (Evans and Kantrowitz 2002; Jerrett et al, 2001; Walker et al, 2005). It is likely that the unequal access to a high-quality environment, and the political, social, and cultural factors underpinning this arrangement, may partly account for the variations in health outcomes across areas differentiated by social disadvantage. Whilst recognising this, research has rarely bridged the divide between environmental justice and health-related outcomes (Pearce et al, 2010). Evidence is lacking on the specific causal pathways by which the physical environment might influence health, with the available evidence suggesting that health-related behaviours may be a pathway through which the environment impacts upon health outcomes (Diehr et al, 1993; Ellaway and Macintyre, 1996). In this paper we develop one such pathway. We explore the influence of the 'natural' physical environment on individual-level levels of physical activity and determine whether the environment has a differing influence on utilitarian physical activity (or active transportation) and physical activity for leisure. We define the 'natural' physical environment as consisting of external physical, chemical, and biological dimensions, and exclude social and cultural dimensions.

Critiques of environmental justice research focus on the traditional emphasis placed on descriptive accounts of the associations between environmental 'risks' and population factors. To this end the first wave of environmental justice research is characterised by a plethora of research demonstrating an unequivocal relationship between risky environments and populations of low socioeconomic status or racial minorities. More recently, researchers have called for a new environmental justice paradigm that explores the material effects of environmental (in)justice, with risky environments seen as fundamental structural barriers in a person's ability to lead a healthful life (Taylor et al, 2007). Recast in this way, research begins to query the health consequences of *experiencing* different environments—thus moving from description to outcomes.

Whilst emerging research in this field has sought to understand if and how features of the local environment are related to area-level health inequalities (Pearce et al, 2010), few have considered how the distribution of either pathogenic or salutogenic environments may influence health-related behaviours. Such behaviours have been firmly established as proximate risk factors for poor health (World Health Organisation, 2002) and their higher prevalence rates in lower socioeconomic groups may be contributing to the growing inequalities both in mortality and in morbidity (van Lenthe et al, 2009). Whilst explorations of such contextual effects on behaviours are not new, few have considered the natural physical environment and the ways in which issues of justice may be considered as a result of differential population exposure, related behaviours, and health outcomes.

Understanding the disparate health behaviour related opportunities afforded to the population contributes towards the second wave of the environmental justice movement (Taylor et al, 2007). Developing upon the first wave, concerned with the uneven distribution of polluting facilities, this second wave is concerned more with health outcomes and the availability of health-promoting environments (Taylor et al, 2007). Such uneven distributions, and the resulting related behaviours, raise questions of justice and accountability. Within a health capabilities framework, it has been argued that the ability to choose a healthier lifestyle is influenced by these external environments, formed by political and economic processes, which in turn shape an individual's ability to exercise their agency (Sen, 1993). Such a capabilities perspective rejects the distributive approach and recognises different needs and outcomes.

There is an abundance of research demonstrating an association between the environment and health behaviours. Developing from a historical environmental deterministic perspective, researchers have moved beyond such theories towards a socioecological view, exploring the *aggregation* of individuals and investigating the ways in which the environment may modify, but not determine, an individual's health and well-being. Such a model recognises the relationships between people and their environments, with the environment seen as a consequence of social processes shaped both by individual-level and by group-level interactions (Stokols, 1992). As such, we see clear linkages with environmental justice and the cultural, economic, and political antecedents of environmental inequality.

A socioecological perspective, framed within the processes of environmental justice, helps us to reject environmental determinism and embrace a model in which the individual interacts with their environment to influence health behaviours and health outcomes. Within such a model, *place* is critical in any analysis of health-related behaviours and environment: seen both as a facilitator and as a container of 'choice'. Emerging from this discourse recent work in health geography has looked towards socioecological theories, rejecting both environmental determinism and a lifestyle hypothesis, whilst recognising 'reciprocal causation' such that "individuals and environments jointly contribute to behaviour" (McLeroy et al, 1988, page …). This approach acknowledges the differing layers of influence related to Bronfenbrenner's (1979) micro, meso, and exo environments but in particular develops Stokols's (1992) social ecology model for health promotion. This model is based on four assumptions: that health behaviour and 'healthfulness' are influenced by personal attributes and features of the physical and social environments; that these environments are multidimensional and complex, recognising their objective and subjective characteristics; that interactions occur at a variety of scales and a socioecological analysis must incorporate multiple levels and ideas from systems theory; and that not only do environments influence people, but people in turn influence their environments in a series of people–environment transactions. These transactions "modify the healthfulness of their surroundings through their individual and collective actions" (Stokols, 1992, page 8).

The interaction between the individual and the various environmental layers reflects the multidimensionality which could not be captured through a reductionist approach that ignores contextual influences on behaviour. When focusing on health-related behaviours the approach allows one to incorporate issues of accountability and agency and, when considering the environments to which populations are exposed, we are forced to reflect on how these environments are "born of egregious social policies, past and present" (Krieger 2001, page 8). A socioecological approach, as suggested by Stokols, is therefore concerned with more than distributive justice: rather, it is concerned with how the unequal distributions of health-promoting environments relate to inequalities in outcomes, echoing current concerns held by scholars of environmental justice (Taylor et al, 2007).

In previous research, exploring inequalities in outcomes, we found an ecological association between multiple physical environmental deprivation and health (Pearce et al, 2010). We created a measure of the physical environment that included multiple exposures. Like the socioeconomic environment, the physical environment is multifactorial. Populations are not exposed to single environmental factors in isolation: they simultaneously experience multiple exposures. Different environmental exposures may have additive, synergistic, or antagonistic effects on health outcomes and behaviours when experienced in combination (Sterner, 1999). Thus, identifying areas experiencing multiple environmental deprivation may assist in clarifying environment–health relationships.

Our measurement of the environment included physical environmental factors with health relevance that are both pathogenic (ie, with potential to damage health—air pollution, proximity to industry, and cold climate) and salutogenic (ie, with potential to enhance or maintain health which—access to green spaces and UVB levels). Like area-level socioeconomic indices, we amalgamated the data to create an area-level index—the multiple environmental deprivation index (MEDIx)—which measured area-level multiple *physical* environmental deprivation. Analysis showed that higher levels of multiple physical environmental deprivation were significantly associated with a greater risk of all-cause mortality, mortality from certain specific causes, and with self-reported morbidity, independently of the level of socioeconomic deprivation (Pearce et al, 2010). Whilst this study has made important methodological and empirical contributions to the literature on multiple environmental deprivation and health, the conclusions are based on ecological associations, and the pathways linking multiple environmental deprivation to health outcomes, such as mortality, require further investigation.

In this paper we develop our earlier work to explore one particular pathway and consider the influence of the physical environment on individual-level levels of physical activity, both utilitarian (active transportation) and physical activity for leisure. We have chosen physical activity as increasing rates of obesity, coupled with increased levels of sedentary behaviours, have meant that physical activity has gained greater prominence within both public health and health geography. It is well established that physical activity is important for health and well-being and that low levels of physical activity are of increasing concern (Surgeon General, 1996). Physical inactivity is known to increase the risk of coronary heart disease, stroke, type-2 diabetes, and certain cancers (Wen and Wu, 2012). It is estimated that physical inactivity is responsible for 6–10% of deaths from major noncommunicable diseases and 9% of all premature mortality (Lee et al, 2012). Despite this evidence base, physical activity levels remain low and the current recommendation of 30 minutes of physical activity on most days is not met by 60% of men or 70% of women in the UK (NHS Information Centre, 2008).

The focus of the current study is England, where research has reported regional differences in physical activity and associations with socioeconomic status (Gidlow et al, 2006). Less well known is why these associations exist. The relationship between social class and physical activity is complex and patterned by structural, social, cultural, and psychological environments. Various suggestions have been made to explain lower levels of leisure time physical activity amongst the most deprived populations, including: lack of knowledge of the health benefits of physical activity (Wardle and Steptoe 2003), cultural capital (Bourdieu, 1985); lack of financial capital (Withall et al, 2011); time constraints (Withall et al, 2011); social norms (Mansfield et al, 2012); and lack of facilities in deprived areas (Estabrooks et al, 2003). Reflecting on the socioeconomic divide in sports participation, Eitzen (1996) comments that “sport, just as other institutions of society, reflects the inequalities and injustices found in society” (page 103).

Using physical activity as an example, we are therefore interested not only in the spatial and social inequalities of individual-level physical activity engagement, but also the drivers of these within the broader environment. Such an approach recognises that individual-level attributes only explain between 20 and 40% of the variance in physical activity (Spence and Lee, 2003) prompting exploration into how the local environment can provide opportunities for promoting or hindering engagement in physical activity. Building on such socioecological theories, researchers have begun to contribute to this knowledge base, dividing the physical activity environment into two distinct areas: the built environment and the natural environment (Sallis, 2009). A plethora of recent research has explored the association between physical activity levels and the built environment. Street connectivity, aesthetics, lower crime rates, mixed land use, street lighting, and public open space have all been found to have a positive influence on physical activity levels, although most of these studies have been confined to the United States (Owen et al, 2004; Saelens et al, 2003).

Whilst the relationship between physical activity and the environment is clearly a burgeoning field, relatively few have considered the ‘*natural*’ physical environment (Brownson et al, 2001; Humpel et al, 2002; Tu et al, 2004) understood as “aspects of nature that could alter physical activity patterns, such as climate, weather” (Sallis, 2009). Research in this area has found negative associations between physical activity levels and air pollutant emissions (Zahran et al, 2008), rainfall (Winters et al, 2007), cold temperatures (Winters et al, 2007) and inclement weather (Nankervis, 1999). Positive associations have been found with green space (Wendel-Vos et al, 2004) and moderate weather (Zahran et al, 2008). Proposing physical ecology as a layer within their ecological model of physical activity, Spence and Lee (2003) recognise the possible influence that the *natural* physical environment may have on an individual's ability to engage in physical activity. Whilst policy options to change such environments are limited, an understanding of the effects of the physical environment on physical activity may be equally important in generating our understanding of the correlates of such behaviours in order to support a shift in policy away from individual behavioural change towards environmental mitigation.

In this paper we extend previous research on physical activity and the environment in three ways. Firstly, we focus exclusively on the 'natural' physical environment, building an evidence base alongside research on features of the built environment. Secondly, we extend previous analysis in this area that has focused on a single environmental variable. We would argue that the confluence of multiple environmental exposures is important as individuals are not exposed to single environmental attributes in isolation. Thirdly, our index includes aspects of the environment that may promote *and* hinder physical activity, thus reflecting everyday experience. Our aim is to explore the influence of multiple natural physical environmental features, *in combination*, on individual levels of physical activity. To explore this we join a multiple measure of the physical environment (MEDIx) to individual-level responses from the Active People Survey to investigate the importance of broader structures for health behaviours and the implications of this for equity within a discourse of lifestyles and personal responsibility.

Methodology

Environmental variables

To capture the multidimensional features of the physical environment we created MEDIx—an index including both pathogenic and salutogenic features akin to socioeconomic measures of deprivation, such as that of Carstairs, that summarises factors that individuals may be exposed to at an area level. The pathogenic features of MEDIx are proximity to industrial facilities, cold climate, and outdoor ambient air pollution. Salutogenic features are access to green space and levels of UV. Data collected for each of the eight variables (listed in table 1) were used to construct MEDIx and these data were rendered to CAS (Census Area Statistics) ward level. Ward level was chosen as the appropriate geography as such areas are large enough to preserve anonymity of the individuals in our survey analysis yet small enough to allow for sufficient environmental variability between areas ($n = 7969$, average population = 6166). The data were then transformed into exposure quintiles, with those in the highest exposure quintile for pathogenic factor scoring +1 and those in the highest exposure quintile for salutogenic factors scoring −1. Scores were then summed to create an exposure index which ranged from −2 (theoretically, the least environmentally deprived wards) to +3 (theoretically, the most environmentally deprived wards). More detail regarding the choice of environmental factors and how MEDIx was constructed is available elsewhere (Pearce et al, 2010; Richardson et al, 2009; 2010).

Individual-level measure of physical activity

Covering the whole of England, the Active People Survey (APS) is the largest annual (telephone) survey series of self-reported recreational physical activity in Europe. It is commissioned by Sport England and includes key indicators on physical activity (PA) which are comparable across all survey years as well as a range of sociodemographic characteristics of the participants. Adults, aged over 16 years, are randomly selected using random digit dialling (RDD) and the Rizzo method. The full methodology is described elsewhere (IPSOS MORI, 2011). To increase the sample size for this analysis, we used pooled data from three surveys including the waves 2007–08, 2008–09, and 2009–10, with a final sample of 573 626. A ward-level identifier was obtained for each of the APS respondents which made it possible to link information on individual-level PA to MEDIx.

Table 1. Data used to construct MEDIx

Dimension	Subdimension	Data source
Air pollution	Air pollution particular matter (PM_{10}) Nitrogen dioxide (NO_2) Sulphur dioxide (SO_2) Carbon monoxide (CO)	AEA Technology [1 km grids, annual average concentrations, modelled from National Atmospheric Emissions Inventory (NAEI) data, 1999–2006]
Climate	Average temperature	Met Office UK Climate Impact Programme data (5 km grids, 1996–2003)
UV radiation		UVB index calculated using Met Office UK monthly cloud cover data (1 km grid, 1991–2000) and latitude
Industrial facilities	Locations of waste management and metal production/processing sites	European Pollutant Emission Register (EPER) (grid references, 2001–02)
Green space		Generalised Land Use Database and CORINE land cover data (UK, 2000)

Individual-level physical activity outcomes

All PA outcomes were based on the number of days the activity was undertaken in the last 28 days preceding the interview, the usual amount of time spent doing the activity, and the average perceived effort level. For example, a 30-minute walk was classified as ‘moderate activity’ if the participants reported raised breathing rate; whereas ‘vigorous activities’ make participants sweat and/or out of breath.

Based on the government’s recommendation for PA (30 minutes of moderate PA on at least five days/week) (Department of Health, 2011), four binary PA outcomes were derived for this analysis. Respondents were identified who achieved the recommended physical activity level (RPAL) through overall recreational PA including all activities reported. Furthermore, participants were identified who achieved RPAL through walking alone. As respondents were asked whether they undertook their walks particularly for the purpose of health or recreation, it was also possible to identify respondents who achieved RPAL through recreational or nonrecreational walking (including walking to and from work or for the purpose of shopping). We chose walking as this was the most common form of physical activity undertaken by survey respondents. We decided to subdivide walking according to recreational and nonrecreational modes to determine whether the relationship differed for exercise which could be seen as voluntary and that which is carried out not for the primary purpose of exercise.

Individual-level and area-level covariates

The APS also includes a variety of covariates that may be associated with PA. Those included were age group (16–24, 25–44, 45–64, and 65 years and above), gender, ethnicity (White/non-White), presence of long-term limiting illness (yes/no), social class (6 categories), and household income (7 categories) (Gidlow et al, 2006; Trost et al, 2002). Univariate analysis confirmed associations between physical activity and each of these covariates in our sample. Furthermore, we controlled for interview season (Summer: 14 April to 14 October versus Winter: 15 October to 13 April) in our models because, although the survey took place throughout the year, respondents were more likely to be physically active in the summer months.

To adjust for area-level socioeconomic deprivation we included the ward-level Carstairs Deprivation Index in our models. The Carstairs index includes measures of overcrowding, unemployment among men, low social class, and not owning a car (Carstairs and Morris, 1991).

We have used the Carstairs index as a measure of area-level socioeconomic deprivation in previous environment and health research (Shortt et al, 2011). We did not include a further measure of rurality due to a high degree of multicollinearity between rurality, Carstairs index, and MEDIx.

Assessing the implications of missing data

We observed a high number of missing values both for household income (22%) and for social class (8%); for all other variables the number of missing values was <2%. To explore the implication of this for our analysis we ran three types of models. In the first, we excluded respondents with missing data; in the second we ran models which included the missing data added as an extra category (Vogl et al, 2012) and in the final model we imputed the missing data using Stata/IC 12.1 according to Lunt's (2011) guide to imputing missing data. Since the results did not vary either in direction of association or in statistical significance, we report results from our original models which exclude the respondents with missing data. Furthermore, Vogl et al (2012) emphasise that imputation would induce additional bias in the analysis.

Statistical analysis

Our final dataset comprised of 496 582 individual respondents with ward-level quintiles of MEDIx and Carstairs Deprivation Index attached. We had four outcomes of interest: (1) whether the respondent met RPAL through total physical activity; (2) whether the respondent met RPAL through total walking; (3) whether the respondent met RPAL through recreational walking; and (4) whether the respondent met RPAL through nonrecreational walking. As the outcome variables were binary, we fitted logistic random effects regression models with maximum-likelihood estimation, reporting odds ratios (ORs) and confidence intervals (CIs). Random-effect models are used analysing clustered data where the usual assumption of independence of the responses is not appropriate (Rabe-Hesketh et al, 2005). The data used in this analysis have a two-level hierarchical structure, with respondents achieving the recommended levels of physical activity through total physical activity or walking at level 1, nested within Caswards at level 2. All models were fitted in Stata/IC 12.0 using the xtlogit command. Models were built in three stages. In the first model we added MEDIx to explore whether there was an association between the physical environment and physical activity before adjusting for confounders. In the second model we added individual and household variables (age, sex, ethnicity, limiting long-term illness, social class, household income). We also included our measure of seasonality in this model. In the third model we added the Carstairs index to explore whether area-level socioeconomic deprivation attenuated the relationship between physical activity and environmental deprivation after controlling for individual-level variables. To explore the influence of individual car ownership on the results, particularly walking, we further added this to models 2 and 3. As the Carstairs index also includes an area-level measure of car ownership we report this only when there were significant changes to the results: on the whole, the addition of car ownership did little to change the odds or the confidence intervals.

Due to the small numbers in MEDIx category +3 (the most deprived environments), we collapsed this category with MEDIx +2. In our models we used MEDIx 0—areas experiencing environments with an equal number of measured salutogens and pathogens—as our reference category. Testing for interaction between physical activity and confounding variables confirmed significant interaction with gender. Hence, we ran further models stratified by gender to explore the associations for males and females separately.

Results

In the total sample just 10.7% of respondents met the recommended levels of weekly physical activity, the numbers were slightly higher for males (11.8%) than for females (9.9%) (table 2). Of all the survey respondents, 9.2% met the recommendations through walking alone, although this was slightly higher for females (9.5%) than for males (8.8%), demonstrating the importance of walking as a form of physical activity. For those for whom we could distinguish nonrecreational from recreational walking, just 2.3% met the recommendations through nonrecreational walking—slightly more males (2.6%) than females (2.1%).

Table 2. Descriptive statistics of the physical activity outcomes, Active People Survey 2007–10.

Physical activity (PA) outcomes (30 minutes of moderate intensity activities at least five days/week)		Total n = 496 582		Male n = 204 023		Female n = 292 559	
		frequency	valid %	frequency	valid %	frequency	valid %
Total recreational PA	no	439 387	89.3	178 427	88.2	260 960	90.1
	yes	52 562	10.7	23 759	11.8	28 803	9.9
	missing	4 633	0.9	1 837	0.9	2 796	1.0
Total walking	no	450 997	90.8	186 107	91.2	264 890	90.5
	yes	45 585	9.2	17 916	8.8	27 669	9.5
Recreational walking	no	471 332	94.9	194 893	95.5	276 439	94.5
	yes	25 250	5.1	9 130	4.5	16 120	5.5
Nonrecreational walking	no	485 218	97.7	198 797	97.4	286 421	97.9
	yes	11 364	2.3	5 226	2.6	6 138	2.1

Overall levels of physical activity

Before controlling for any individual-level or area-level variables, those living in the least environmentally deprived areas had a 40% increased odds (OR 1.40, CI: 1.32–1.48) of meeting RPAL compared with those in MEDIx 0; Furthermore those in the most deprived environments had a 17% reduced odds (OR 0.83, CI: 0.80–0.87) (table 3). These odds ratios changed little and remained significant in model 2 after controlling for individual-level demographic factors (age, sex, ethnicity, limiting long-term illness, social class, household income, and seasonality). In the final model, which included MEDIx, individual-level demographic factors, seasonality, and area-level socioeconomic deprivation (Carstairs index), the relationship was attenuated but remained significant, with an odds ratio of 1.36 (CI: 1.28–1.45) in the least environmentally deprived environments and 0.92 (CI: 0.88–0.95) in the most deprived environments (table 3). The environmental gradient remained in all models with those in the least deprived areas more likely to achieve recommended levels of physical activity with the odds of this diminishing with greater exposure to worsening physical environments.

A significant gender interaction was found in the relationship between physical activity and MEDIx. To explore this we ran stratified models for males and females. After controlling for our independent individual-level and area-level variables, females in the least environmentally deprived areas have 52% greater odds (OR 1.52, CI: 1.40–1.65) of achieving RPAL than those in MEDIx 0, whilst with those in the most environmentally deprived areas were less likely to (OR 0.88, CI: 0.83–0.94). The relationship between the physical environment and male levels of physical activity is in the same direction, with those in the least environmentally deprived areas having greater odds of achieving RPAL (OR 1.16, CI: 1.06–1.28) compared with those in the least environmentally deprived areas

Table 3. Multilevel logistic regression models of total physical activity (including walking).

	Model 1			Model 2			Model 3		
	OR	95% CI		OR	95% CI		OR	95% CI	
		upper	lower		upper	lower		upper	lower
Number of observations (individuals)	491 949			357 712			357 712		
Number of groups (wards)	7 932			7 931			7 931		
MEDix									
−2 (least deprived)	**1.40**	1.32	1.48	**1.40**	1.32	1.50	**1.36**	1.28	1.45
−1	**1.11**	1.08	1.14	**1.11**	1.07	1.14	**1.09**	1.06	1.13
0	1.00			1.00			1.00		
+1	**0.88**	0.86	0.90	**0.90**	0.88	0.93	**0.94**	0.92	0.97
+2/+3 (most deprived)	**0.83**	0.80	0.87	**0.87**	0.83	0.91	**0.92**	0.88	0.96
Age group									
65+				1.00			1.00		
45–64				**1.62**	1.56	1.68	**1.64**	1.58	1.70
25–44				**2.01**	1.93	2.09	**2.04**	1.97	2.12
16–24				**2.79**	2.64	2.95	**2.84**	2.68	3.01
Gender									
Female				1.00			1.00		
Male				**1.04**	1.02	1.06	**1.04**	1.02	1.06
Ethnicity									
Non-White				1.00			1.00		
White				**1.50**	1.42	1.59	**1.47**	1.39	1.55
Long-term limiting illness									
Yes				1.00			1.00		
No				**2.02**	1.94	2.10	**2.01**	1.93	2.09
Social class									
V: unskilled occupations				1.00			1.00		
IV: partly skilled				**1.19**	1.09	1.31	**1.19**	1.09	1.30
IIIM: skilled manual				**1.30**	1.19	1.41	**1.29**	1.18	1.40
IIIN: skilled, nonmanual				**1.24**	1.14	1.35	**1.22**	1.12	1.33
II: managerial				**1.43**	1.31	1.55	**1.41**	1.29	1.53
I: professional				**1.41**	1.29	1.55	**1.39**	1.27	1.53
Household income (£ per annum)									
0–15 599				1.00			1.00		
15 600–20 799				**1.14**	1.09	1.19	**1.13**	1.08	1.18
20 800–25 999				**1.19**	1.14	1.25	**1.18**	1.13	1.24
26 000–31 199				**1.28**	1.23	1.34	**1.27**	1.21	1.32
31 200–36 399				**1.32**	1.26	1.39	**1.30**	1.24	1.37
36 400–51 999				**1.47**	1.41	1.52	**1.44**	1.38	1.49
52 000				**1.82**	1.75	1.89	**1.76**	1.69	1.83
Seasonality									
Winter—15 October to 13 April				1.00			1.00		
Summer—14 April to 14 October				**1.13**	1.11	1.16	**1.13**	1.11	1.16
Carstairs index quintile									
1 (highest deprivation)							1.00		
2							**1.08**	1.04	1.12
3							**1.14**	1.10	1.19
4							**1.19**	1.15	1.24
5 (lowest deprivation)							**1.19**	1.14	1.24

Note. OR—odds ratio, CI—confidence interval. OR significant $p < 0.01$ shown in boldface.

Table 4. Multilevel logistic regression models of total physical activity (including walking) by sex.

	Model 3 females			Model 3 males		
	OR	95% CI		OR	95% CI	
		upper	lower		upper	lower
Number of observations (individuals)	200 796			156 916		
Number of groups (wards)	7928			7927		
MEDix						
−2 (least deprived)	**1.52**	1.40	1.65	**1.16**	1.06	1.28
−1	**1.15**	1.10	1.20	1.03	0.98	1.07
0	1.00			1.00		
+1	**0.93**	*0.90*	*0.97*	***0.95***	0.92	0.99
+2/+3 (most deprived)	**0.88**	0.83	0.94	0.96	0.90	1.02

Note. Model 3: MEDIx, age, ethnicity, long-term limiting illness, social class, household income, seasonality and Carstairs Deprivation Index. OR—odds ratio, CI—confidence interval. OR significant $p<0.01$ shown in boldface, $p<0.05$ shown in italic boldface.

(OR 0.96, CI: 0.90–1.02), though marginally insignificant (table 4). Whilst these are separate models, and the results are therefore not comparable, this could suggest that the environment has a stronger influence on female levels of physical activity than on male levels.

Walking

Following preliminary analysis of the data we chose to focus more closely on walking as a form of physical activity; Our reasons for this were twofold. First, walking is largely an outdoor activity and MEDIx was a measure of outdoor environments; hence, if we expected to see a relationship between the physical environment and physical activity then we would expect to see this most strongly in outdoor activities. Second, our preliminary analysis of the data confirmed the importance of walking as a form of physical activity.

Before controlling for individual-level and area-level confounders, there were a significant odds of respondents meeting RPAL through total walking in the least environmentally deprived areas (OR 1.39, CI: 1.31–1.48), with the relationship changing little after controlling for individual-level and area-level independence (OR 1.40 CI, 1.31–1.50) (table 5). As with total physical activity, there was a reduced odds ratio in the most environmentally deprived areas before (OR 0.87, CI: 0.83–0.90) and after (OR 0.90, CI: 0.86–0.94) confounding. Again, an environmental gradient across all MEDIx categories was evident. As with total physical activity, the models were stratified by gender with, again, the strongest effect sizes for females (table 6). Females in the least environmentally deprived areas have 44% greater odds of meeting RPAL through walking (OR 1.44, CI: 1.32–1.57), and those in the most environmentally deprived areas have odds reduced by 11%(OR 0.89, CI: 0.83–0.94). For men, the effect was lower with an increased odds of 36% (OR 1.36, CI: 1.23–1.50) in the least environmentally deprived areas and a reduced odds of 8% (OR 0.92, CI: 0.85–0.98) in the most environmentally deprived areas.

Recreational and nonrecreational walking

Dividing walking into recreational and nonrecreational activities, we find conflicting results (table 7). For recreational walking, once again before adjusting for any confounders, those in the least environmentally deprived areas have a greater odds of achieving RPAL (OR 1.72, CI: 1.60–1.85) with those in the most deprived areas having reduced odds (OR 0.75, CI: 0.71–0.80). After controlling for individual-level and area-level confounders, this was attenuated slightly (least deprived OR 1.59, CI: 1.46–1.72 and most deprived OR 0.86, CI: 0.81–0.92).

Table 5. Multilevel logistic regression models of total walking.

	Model 1			Model 2			Model 3		
	OR	95% CI		OR	95% CI		OR	95% CI	
		upper	lower		upper	lower		upper	lower
Number of observations (individuals)	496 582			360 289			360 289		
Number of groups (wards)	7 932			7 931			7 931		
MEDIx									
−2 (least deprived)	**1.39**	1.31	1.48	**1.40**	1.31	1.50	**1.40**	1.31	1.50
−1	**1.10**	1.07	1.13	**1.12**	1.08	1.16	**1.13**	1.09	1.17
0	1.00			1.00			1.00		
+1	**0.93**	0.91	0.96	***0.96***	0.93	0.99	***0.96***	0.93	0.99
+2/+3 (most deprived)	**0.87**	0.83	0.90	***0.90***	0.86	0.94	***0.90***	0.85	0.94

Note. Model 1: MEDIx. model 2: model 1 plus gender, age, ethnicity, long-term limiting illness, social class, household income, seasonality. Model 3: model 2 plus Carstairs Deprivation Index. OR—odds ratio, CI—confidence interval. OR significant $p<0.01$ shown in boldface, $p<0.05$ shown in italic boldface.

Table 6. Multilevel logistic regression models of total walking by sex.

	Model 3 females			Model 3 males		
	OR	95% CI		OR	95% CI	
		upper	lower		upper	lower
Number of observations (individuals)	292 559			202 333		
Number of groups (wards)	7 929			7 928		
MEDIx						
−2 (least deprived)	**1.44**	1.32	1.57	**1.36**	1.23	1.50
−1	**1.15**	1.10	1.20	**1.09**	1.03	1.15
0	1.00			1.00		
+1	***0.96***	0.92	1.00	0.96	0.92	1.01
+2/+3 (most deprived)	***0.89***	0.83	0.94	***0.92***	0.85	0.98

Note. Model 3: MEDIx, age, ethnicity, long-term limiting illness, social class, household income, seasonality and Carstairs Deprivation Index. OR—odds ratio, CI—confidence interval. OR significant $p<0.01$ shown in boldface, $p<0.05$ shown in italic boldface.

The relationship between the physical environment and recreational walking (controlling for individual-level and area-level confounders) was particularly strong for females, with women 67% (OR 1.67, CI 1.51–1.85) greater odds of achieving recommended levels in the least environmentally deprived areas to (males in the same category OR 1.45, CI: 1.28–1.65). As with overall physical activity, we see an environmental gradient with the odds of meeting the RPAL through walking diminishing with increasing physical environmental deprivation.

The relationship between nonrecreational walking and physical environmental deprivation ran in the opposite direction. Before adjustment those in the *most* environmentally

Table 7. Multilevel logistic regression models of recreational and non-recreational walking.

	Model 1			Model 2			Model 3		
	OR	95% CI		OR	95% CI		OR	95% CI	
		upper	lower		upper	lower		upper	lower
Number of observations (individuals)	496 582			360 289			360 289		
Number of groups (wards)	7932			7931			7931		
Recreational walking									
MEDIx									
−2 (least deprived)	**1.72**	1.60	1.85	**1.66**	1.53	1.80	**1.59**	1.46	1.72
−1	**1.19**	1.14	1.23	**1.18**	1.13	1.23	**1.16**	1.11	1.21
0	1.00			1.00			1.00		
+1	**0.78**	0.75	0.81	**0.83**	0.79	0.86	**0.88**	0.84	0.92
+2/+3 (most deprived)	**0.75**	0.71	0.80	**0.80**	0.75	0.85	**0.86**	0.81	0.92
Nonrecreational walking									
MEDIx									
−2 (least deprived)	**0.76**	0.66	0.88	***0.84***	0.70	0.99	0.92	0.78	1.10
−1	**0.90**	0.84	0.96	0.98	0.91	1.06	1.03	0.95	1.11
0	1.00			1.00			1.00		
+1	**1.24**	1.18	1.30	**1.23**	1.16	1.31	**1.10**	1.03	1.16
+2/+3 (most deprived)	***1.10***	1.02	1.19	1.08	0.99	1.18	0.94	0.86	1.03

Note. Model 1: MEDIx. Model 2: model 1 plus gender, age, ethnicity, long-term limiting illness, social class, household income, seasonality. Model 3: model 2 plus Carstairs Deprivation Index. OR—odds ratio, CI—confidence interval. OR significant $p<0.01$ shown in boldface, $p<0.05$ shown in italic boldface.

deprived wards had greater odds of achieving RPAL through nonrecreational walking (OR 1.10, CI: 1.02–1.19) compared with those in the average environments, and those in the least environmentally deprived groups had reduced odds (OR 0.76, CI: 0.66–0.88). Controlling for individual-level factors attenuated this gradient (most deprived OR 1.08, CI: 0.99–1.18; least deprived OR 0.84, CI: 0.70–0.99). In an additional model we further controlled for individual-level car ownership and saw the odds reduce further, with only the areas in the second-most deprived category—MEDIx +1 (OR 1.11, CI: 1.05–1.18) demonstrating a significant result. All of these results were largely reduced to insignificance once we controlled for area-level socioeconomic deprivation (most deprived OR 0.94, CI: 0.86–1.03; least deprived OR 0.92, CI, 0.78–1.10). A significant relationship did, however, remain between residence in the second-most environmentally deprived group of wards and an increased likelihood of achieving their RPAL through nonrecreational walking (OR 1.10, CI: 1.03–1.16) and, whilst increased odds remained after controlling for car ownership, the result was no longer significant (OR 1.04, CI: 0.98–1.10).

There was again a gender difference in the relationship, however: whilst the association between achieving RPAL through nonrecreational walking and physical environment deprivation for women adhered to the overall pattern just described, we found no significance for men.

Discussion

In this paper we have explored the associations between the physical environment and physical activity. Our results demonstrate that the physical environment is related to overall levels of physical activity, total walking, and recreational walking. Populations in the least deprived physical environments are more likely to achieve recommended physical activity levels through these activities, compared with those in the most deprived physical environments. These results persist after controlling for individual-level and area-level confounders. Associations between non-recreational walking and physical environmental deprivation, however, are in the opposite direction: those in the *most* environmentally deprived wards have a greater likelihood of achieving recommended physical activity levels through nonrecreational walking.

The distinction between recreational and nonrecreational modes of activity is supportive of research elsewhere which suggests that the relationship between the environment and physical activity is complex (Giles-Corti and Donovan 2002). For physical activity that is seen as voluntary, conducted for recreational purposes with enjoyment and health benefits in mind, there is a strong relationship with the physical environment: those living in the least deprived physical environments are most likely to engage in physical activity and, more particularly, in recreational walking. This demonstrates the importance of the environment in supporting individual-level capabilities. However, for utilitarian physical activity—physical activity whose primary purpose is not the activity itself, in this case nonrecreational walking—we observe increased odds in the most environmentally deprived areas.

The association between the environment, both social and physical, and physical activity reported here suggests that the environment could be seen as a mediator between socioeconomic position and health-related outcomes (Ferrer and Carrasco, 2010). The capability framework offered by Sen (1993) recognises individual choice and motivation as determinants of behaviour; however, such choice and motivation is coupled with opportunity, or capability (Sen, 1993). In a health context, such capability can be defined "as the extent to which people have the opportunity to live the kind of life they value" (Ferrer and Carasco, 2010, page 455). When considering the results within this context it could be hypothesised that the lack of environmental opportunity, coupled with other area-level and individual-level motivators, merge to result in reduced likelihood of 'voluntary' recreational physical activity in more deprived physical environments. On the other hand, whilst those in the most deprived areas have greater odds of nonrecreational walking, such an activity may not be chosen with health benefits in mind: rather, walking in such environments may be seen as a means to an end. Research has reported perceptions of walking as not being 'proper' exercise: rather, it is understood as functional and not undertaken for health benefits (Darker, et al, 2007).

Supporting our findings of this inverse relationship, previous research has found higher levels of active travel in more socioeconomically deprived areas (van Lenthe et al, 2005). Our results also lend weight to existing suggestions that there may be different environmental correlates for recreational and nonrecreational physical activity (Owen et al, 2004) and for different population groups. Whilst active travel may be promoted as a cost-effective and sustainable way of encouraging more deprived individuals to engage in physical activity, we must also consider the possible negative effects of exercising in deprived physical environments. Whilst it may be the case that these individuals will be exposed to higher levels of air pollution, and perhaps increased risk of accidents, research has demonstrated that, overall, the benefits of active travel by far outweigh any negative risks (Rojas-Rueda et al, 2011).

Recognising the important role that the environment may play in shaping our capabilities and 'choices' is important, particularly in the current economic and political climate. A narrow focus on changing behaviours dominates despite evidence demonstrating that policies focused on individuals, rather than at the population level, have had limited success (Mutrie and Woods, 2003). Reflecting this, many governments in developed nations have embraced a policy mandate that focuses largely on the individual; in the UK this is reflected in such publications as the Government's White Paper *Choosing Health: Making Healthy Choices Easier* (Department of Health, 2004). This publication highlights the emphasis placed on choice rather than government-led intervention aimed at improving population levels of physical activity. This is then mirrored in the general population's stigmatisation of obese and inactive individuals who are seen as "architects of their own ill-health, personally responsible for their weight problems because of laziness and overeating" (Puhl and Heuer 2010, page 1020). Such stigma threatens the health of obese individuals, reinforces unhealthy behaviours, and increases health disparities within the population (Puhl and Heuer, 2010). Querying blame and individual responsibility, geographers can move the debate towards a consideration of place and, in particular, environmental and social justice.

There are limitations to our study. We could not determine whether the environment has a direct or indirect influence on physical activity. Whilst we have explored possible direct influences, we cannot rule out psychosocial indirect influences of the environment on behaviours. The fact that fewer people in the most environmentally deprived environments are physically active at recommended levels may suggest competing demands and the need to prioritise other goals over physical activity, rather than a direct influence of the environment itself (Powers and Faden, 2006). Environmental and social deprivation combined may mean that opportunities to engage in recreational physical activity are greatly reduced for individuals disproportionately exposed to both. Previous research has highlighted the importance of perceived behavioural control, social and familial support, social norms, lack of time, and competing demands (Giles-Corti and Donovan, 2002; Spence and Lee, 2003).

The survey we have used is cross-sectional and, whilst we have pooled together data from several years to boost our sample, it remains cross-sectional. As a result, we cannot infer causality and in this paper we report associations. In order to develop this work further we would require a longitudinal approach that explores the association between the physical environment and physical activity over time. Linked to this is the changing nature of the environment through time, both physical and social (Mitchell and Norman, 2012). In our modelling approach we explored interactions by stratifying our models by gender; we do, however, recognise that there are other ways in which such interactions could be assessed. There are further limitations with the survey—specifically, related to recall bias and self-report. The APS asks respondents to recall their physical activity over the previous 28 days and, as such, all of our results are subject to recall bias. Furthermore, our measure of physical activity is self-reported with—the possibility that some respondents may inflate their levels of physical activity whilst others may not report activities such as walking, perhaps not seeing this as physical activity. Finally, our measure of the physical environment was an objective one and we have no indication of the perception of these environments by residents. Further research could explore whether the ways in which the population perceive their environment is related to levels of physical activity.

Acknowledging the limitations of this study, our results show that environment matters, even after controlling for individual-level confounders, demonstrating that rhetoric regarding 'lifestyle choice' needs to be viewed in a broader environmental context. We have demonstrated that the physical environment is only significant to a point: the environment mattered differently for different types of people in different circumstances. Whilst less deprived physical environments may support leisure time physical activity and, in particular recreational walking, more deprived physical environments may be a barrier to such recreational physical activity but not for nonrecreational physical activity. This research demonstrates that a single policy approach is unsuitable: we cannot see physical activity as one single issue; rather, different population groups in different areas will engage with different forms of physical activity for different reasons. Furthermore, we would support Krieger (1994) in calling for a reformulation of terms such as 'lifestyle', "so as to end the practice of obscuring or misclassifying agency" (page 899). This raises issues of social justice and calls into question the level of freedom an individual may have to choose healthy behaviours. This reframing of choice and responsibility relates to growing inequalities in health and acknowledges that individual-level physical activity interventions will not be felt evenly across all sectors of society, and the extent to which they are successful will be dependent upon both the physical and the social environments in which people live. Evidence elsewhere on individual-level 'soft' initiatives would suggest that the complexity of health-related behavioural issues requires coordinated effort at various levels to support individual capabilities without resulting in an 'inequality paradox' (Frolich and Potvin, 2008).

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