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Land use planning and health and well-being☆

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ABSTRACT

This paper is concerned with the relationship between the planning of settlements and health. It gives a brief introduction to the issues before summarising the evidence in relation to a range of topics, concluding with some more speculative thoughts on likely future findings.

Modern planning was invented in response to inhumane living conditions in 19th century cities. But in the last century the connection was lost. Only now, with concerns over climate change and obesity, is there beginning to be the realisation that the physical environment is an important determinant of health.

The paper uses a particular model of this relationship based on eco-system and health determinants theories to structure the review of evidence. The review covers: lifestyle choices in relation to physical activity and diet, mental well-being and community, the local economy and income, health inequalities and strategic land use transport planning, pollution and urban form, and finally impacts on global ecology.

There is now a growing consensus that while personal factors are critical in determining health, the urban environment exacerbates or mitigates health and well-being outcomes.

The level of active travel (walking and cycling) and outdoor recreational activity is strongly affected by accessibility to local facilities. Access to green, natural environments, and to local social networks, are factors in mental well-being. The wider sub-regional pattern of housing, economic development, land use and transport is a determinant of social exclusion and therefore health inequalities. It also affects health-damaging pollution, adaptability in the face of climate change and the level of carbon dioxide emissions.

We have literally been building unhealthy conditions into many of our towns and cities. But comparisons with the best cities in Europe indicate that it is possible to reverse the less desirable trends. Success depends, however, on more radical policies of local authority control over land and finance than any political party has yet advocated. It also requires collaboration between the full range of powerful public and private organizations that influence the built environment.

Future research is likely to further strengthen these conclusions. It will become much more obvious that planning for health and well-being is not only the NHS, but about creating a health-promoting physical, social and economic environment.

Introduction

Purpose and definitions

The focus of this paper is on land use planning for healthy human settlements. It is widely recognised that the spatial planning of human urban activity is affecting quality of life, health and well-being (EEA, 2009; WHO, 2009; RTPI, 2009; NICE, 2008). The paper gives a brief introduction to the issue and provides a framework for analysis, before summarising the evidence in relation to a wide range of topics. It concentrates in particular on the crucial relationship between spatial variables and physical activity, mental well-being and inequality.

First to give some definitions: settlements in this context include cities, towns and villages. The tentacles of large settlements spread out far beyond urban areas, into hinterlands and networks, linking places together through commuter residence and work, retail, educational and leisure activities. So there is no clear functional distinction between urban and rural settlements within a town or city region.

Land use planning is conventionally called 'town and country planning' in Britain, following the 1947 Act, but since 2004

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is officially termed 'spatial planning', implying a more integrated, inter-agency process. In literature the term 'built environment' is often used to mean the human-made environment that may be subject to planning. It does not refer only to buildings and hard infrastructure but to all the physical elements that go to make up settlements, including greenspace.

Health is defined broadly, in line with the World Health Organization (WHO), as 'not only the absence of disease but a state of complete physical, mental and social well-being. The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being, without distinction of race, religion, political belief or economic or social condition' (WHO, 1946). Health in this sense is linked to every aspect of life – the social, the economic and the environmental – and can be seen as consonant with the anthropogenic version of sustainable development evident in the UN Brundtland definition. Just as equity (intra-generational as well as inter-generational) is a key aspect of sustainable development, so concern for health inequalities is central to public health policy.

Health and land use planning

Health and land use planning are historically linked. Modern planning originated in the nineteenth century expressly in order to combat unhealthy conditions—the unsanitary, over-crowded and inhumane conditions of the burgeoning industrial cities. It was recognised then, and still is, that there is an umbilical link between environmental conditions and human health. This link has been articulated in the modern era as permeating the human condition. The environment is seen as one of the key determinants of health, alongside inherited characteristics, lifestyles, and social and economic variables (Lalonde, 1974; Whitehead and Dahlgren, 1991). It is not only a matter of the direct physical impacts on health – for example of foul air or contaminated water – but also of indirect social and behavioural effects, on the exercise we take, the people we meet, and the degree of inequality in access to housing, employment opportunities, health services and other facilities.

According to VicHealth (the Victorian Health Promotion Foundation in Australia) there are four key reasons why planning health into the environment is positive for population health. Good planning can:

- reduce the inequalities that exist in access to housing, facilities and transport for different socioeconomic groups and vulnerable groups in the population, such as the elderly or children;
- increase the amount of incidental physical activity necessary to reduce the burden of disease, disability and mortality due to sedentary life styles, by improving access and providing walkable, mixed use communities;
- contribute to the improved health of the population by the reduction of air and water pollution and greenhouse emissions, combating the threat of climate change;
- contribute to a changed social environment by improving the liveability of streets, making them safer, improving communication between people and therefore improving community cohesion (Butterworth, 2000).

All this reflects the broad WHO view of health as a positive experience of well-being and not merely the absence of disease. Yet despite the symbiotic relationship between land use planning and health, these connections have in practice been forgotten until recently. This is in part because of departmental silos. Health authorities have been charged with providing services for those who are ill. Public health programmes have concentrated on infectious diseases and addiction (to tobacco, alcohol and drugs) rather than on healthy environments. Health and safety and environmental protection agencies have been given narrow, functional remits. Planning authorities have often been equally blinkered (see a survey reported in Barton and Tsourou, 2000). Local councils, guided by national governments and local politics, have taken the view that the purposes of town planning are economic development and environmental protection rather than health promotion. Each sphere of public policy has been pursued independently, with agencies adopting specific targets in order to deliver on their mission, failing to grasp, or at least failing to deal with, the interdependence of the issues.

Partly as a result we have been quite literally building unhealthy conditions into the fabric of our cities, towns and villages. All levels and types of planning are implicated. The report *Building Health* (National Heart Foundation et al., 2007) provides an accessible overview, showing how broad strategy, urban and transport policies, urban design and greenspace management are all important, and sometimes at present counterproductive.

We are discovering that the diseases of advanced civilisations – such as cardio-vascular disease, diabetes, asthma and chronic depression – are associated with particular social and environmental conditions. The overriding impression from recent research is that we ignore environmental factors at our peril. Attitudes are changing fast in response, and the WHO has played a role in this. The WHO Healthy cities programme has been acting as a catalyst for 'healthy urban planning' in municipalities across Europe since 1998 (Barton, forthcoming). There is now growing recognition amongst professional planners that the health-environment link is important, and that some current development trends compromise health (see RTPI, 2009). But while many planners recognise that urban planning influences health, they do not normally perceive it as their job to worry about it or study it. Their priorities are elsewhere.

At the same time the public health professionals are suddenly taking a real interest in spatial planning. They have become conscious that advocacy and specific population programmes are not enough to change behaviour (e.g. to persuade people to take more exercise) when structural limits, the very forms of towns and cities, are working against them. In 2008, and even more in 2009, there has been an explosion of demands from public health authorities for knowledge exchange and for effective contact between the health and planning sectors. The National Institute for Health and Clinical Excellence has issued guidelines on physical activity and the environment (NICE, 2008).

Framing the debate

The diagram below (Fig. 1) offers a way of conceptualising both the way settlements work and the way the way they affect health. It is based on two interlocking sets of theories: about urban eco-systems and about the determinants of health (Barton, 2005; Whitehead and Dahlgren, 1991).

Each of the layers of the model impacts on health and well-being. Equivalently each layer is influenced by land use change. The built environment layer is the sphere where land use planning has a direct impact. A change in the structure of the built environment alters the natural environment and the social and economic environment.

The overview in this paper draws on a wide range of evidence, including a number of broad ranging literature reviews (NICE, 2008; Croucher et al., 2007; Jones et al., 2007; Davis et al., 2007; National Heart Foundation et al., 2007; Institute of Public Health in Ireland, 2006; Transportation Research Board, 2005; Cave et al., 2004). Taking each sphere in turn, the summary first highlights its

Fig. 1. The settlement health map.
Source: Barton and Grant (2006).

health significance and then identifies the main ways in which land use planning influences the relevant factors. The sequence works from the inmost ring (lifestyle) to the outer ring (the earth):

- Lifestyle: physical activity – active travel and recreation, with an emphasis on the neighbourhood planning level.
- Lifestyle: diet – retailing and local food production.
- Community: mental well-being – local social networks and neighbourhood planning.
- Local economy and income – the general influence of planning.
- Activities, space and networks (linking two spheres of the health map) – social inclusion and health inequalities, with a strategic planning emphasis.
- The natural environment: air pollution – transport and urban form.
- Global eco-system: climate change – mitigation and adaptation.

Lifestyle: physical activity

The critical issue of physical activity is given most space. The level of physical activity, particularly 'active travel', in the population is important not only in relation to the obesity epidemic, as highlighted by the Foresight Obesity Report (2007), but also to social capital, mental well-being, equity, pollution and climate change. It is central to the UK Government programme promoting 'sustainable communities' that are socially inclusive, low carbon and safe.

Physical activity is defined as 'any bodily movement produced by the contraction of skeletal muscles that increases energy expenditure above a basal level' (CDC, 2008). This definition includes:

- everyday home or work activity: walking, carrying, cleaning, climbing stairs;
- children's active play, running, gambolling, skipping, skateboarding;
- activities in specific places: gardening, dancing, gym exercise, swimming;
- sports such as football, rugby, tennis, hockey – also in specific places;
- 'active travel' to get to places: walking and cycling.

The significance of physical activity for health and well-being is profound and need not be rehearsed in detail here. It is related to the so-called 'epidemic of obesity' (Jones et al., 2007). If present trends continue half the UK's adult population will be clinically obese by 2050. Excess weight and lack of exercise are associated with increased risk of diabetes, stroke, heart disease, osteoarthritis, and some forms of cancer. Physical activity can also reduce feelings of depression, anxiety and promote physiological and psychological well-being. The evidence of inadequate exercise gets more alarming by the day: UK cases of type 2 diabetes – the form linked to obesity – rose by 69% between 1996 and 2005 – the fastest rate of increase in the world (Newsflash 24/02/09). The positive physiological and psychological benefits of regular exercise encouraged the Chief Medical Officer to give a target of 30 min of moderate intensity activity at least 5 days a week. For many people this is only practicable if they engage in daily active travel.

The degree to which physical activity is affected by the built environment rather than being determined by social, economic and cultural factors is contested. Levels of physical activity vary between different types of people, places and culture. Public health professionals use the phrase 'obesogenic environments' to highlight the links between land use and obesity. On the basis of its review of the evidence, NICE public health guidance 8 encompasses almost every aspect of the built environment, from strategic plans and major developments through to the detailed design and management of streets, schools, buildings and public open spaces (NICE, 2008). The main focus is on walking and cycling as active travel, and on play. Active travel to get to work, school, friends, shops, etc. is highlighted as the most critical issue because it is about daily physical activity and is the main way in which groups at risk of poorer health gain their exercise. The existence of good pedestrian networks and accessible local facilities is a good predictor of physical activity amongst older people (Patterson and Chapman, 2004).

Active travel

However, the significance of active travel (walking and cycling to get somewhere) for a healthy lifestyle and for combating obesity, is still much debated. We are not dealing here with simple cause and effect. People may get their exercise by sport, cycling or walking for pleasure, gardening, swimming or workouts at the gym. The ownership and use of cars is for many people associated with status and self-respect, and that in itself has health benefits. Conversely, walking and cycling also confer physiological benefits and create opportunities for informal meetings which build social networks and help give a sense of a supportive environment, which is good for mental well-being.

There is consensus in the literature that urban environments influence levels of active travel and thereby levels of physical activity (Handy et al., 2005; Anand, 2006; Lee and Moudon, 2008; Brown et al., 2008). The degree of influence, though, has been the subject of much debate, with some studies suggesting that land use patterns have only a slight impact on travel choice by comparison with social variables (e.g. Boarnet and Sarmiento, 1998). Establishing a clear relationship between particular land use variables – such as density or 'mixed use' – has been particularly problematic (Handy, 2005). However, many studies show an unequivocal relationship between accessibility (in terms of time and distance) to local facilities and the propensity to walk (Hanson and Schwab, 1987; ECOTEC, 1993; Farthing et al., 1996; Lee and Moudon, 2008; Horswell et al., 2009). The significance of local non-motorised trips for health was supported by Brown et al. (2008), who found that neighbourhood, utilitarian walking and cycling trips were associated with lower body mass index.

The importance of local or neighbourhood trips is evident. Neighbourhoods in this context may be defined simply as local service catchments areas, based on walking distance (Barton and Hills, 2005). Yet neighbourhoods have often been perceived as dying or even dead, as mobility and virtual communication increase (Webber, 1964; Dennis, 1968; Giddens, 1990). And indeed, the characteristics that go to make a viable neighbourhood – such as a certain level of density, local shops, services and schools, the presence of pavements and footpaths, an attractive and safe environment – are not present in many modern suburban estates.

Where facilities are not conveniently located, the propensity for active travel reduces markedly (Lee and Moudon, 2008). One US study which systematically compared the 'walkability' of localities found that only 18% of those living in the lowest quartile of walkability recorded 30 min or more of physical activity on at least 1 day, compared with 37.5% of those in the highest quartile (Frank et al., 2005). In England a recent survey of 12 suburban and exurban neighbourhoods found that the proportion of 'local' trips by foot and pedal varied between 18% and 62%. Some of the difference was accounted for by car ownership levels and local culture, but the biggest factor was distance: there was some consistency across neighbourhoods in terms of how *far* people would walk, but some places had far fewer facilities accessible (Horswell et al., 2009). The implication is that the structure of localities – specifically the location and accessibility of facilities and the quality of the route network – is a critical determinant of the amount of active travel.

There is more to accessibility than simple distance. The quality and safety of the pedestrian and cycling environment is important—particularly the perception of these things (Pikora et al., 2003). Parental consent for children to walk or cycle to school, friends or playground is notoriously low in the UK by comparison with much of Europe, due to real or perceived traffic and stranger danger. Children's freedom to roam has been curtailed. Physical improvement to route continuity, directness, safety, informal surveillance and aesthetic quality is a part of any strategy to change perceptions and culture. Once there are some more people on the streets, perceptions begin to change and we have a virtuous circle (Hume et al., 2005).

There remain questions about particular built environment and behavioural variables. Density, for example, may not be as key a factor as it is often portrayed, while households' choice of dwelling location to suit their lifestyle could be significant. The huge variation in behaviour between people in different countries (e.g. the US, Britain and the Netherlands – the latter with 70% of all trips by active travel modes in some towns) has not been adequately addressed. The degree to which people change behaviour, or more precisely the conditions which foster change when accessibility is improved, also needs more investigation.

Despite the research uncertainties, official policy for sustainable development has for some while laid great stress on the need to revive neighbourhoods and enhance the availability of facilities within walking distance of people's homes (DETR, 1998; Urban Task Force, 1999; Social Exclusion Unit, 2000). The benefits would (it is hoped) be better accessibility for the transport-disadvantaged, improved social capital and health, and reduced transport emissions. Particular models of neighbourhood design have been advocated as likely to promote the use of local facilities as well as walking and cycling (Urban Villages Group, 1992; Calthorpe, 1993; Urban Task Force, 1999; Barton et al., 2003).

Local authorities are employing specific accessibility criteria in policy. Some such standards are very widely used across Western Europe, such as the criterion that dwellings should be within 400 m of a bus stop. Others have rapidly gained currency in recent years, such as the principle of an 800 m 'ped-shed' around local shopping centres (Llewelyn Davies, 1998). The research underpinning these standards from the physical activity viewpoint is weak, but current research at UWE is beginning to provide evidence (Horswell et al., 2009).

Recreational activity

Recreational physical activity comes in many forms, from children's play to gardening, from organized sports, swimming or gym activity to walking or cycling for pleasure. It therefore relies on many different kinds of spatial provision. Some aspects of provision – notably the availability of greenspace – have been studied in greater depth than others, but before turning to them it is important to note the spatial planning significance of

- private gardens for both gardening and young children's play;
- allotments and community gardens (more on this under 'food');
- tennis courts, squash courts, swimming pools, leisure centres and gyms;
- hard surface provision for team sports or youth games.

All these require land, careful planning and appropriate mechanisms for implementation and management, and have importance for levels of physical activity. For some activities people may be willing to travel a considerable distance to reach the club or activity of their choice, but the participation of the less mobile is important in order to combat health inequalities. Accessibility from home is therefore critical.

Apart from provision for specific activities, the natural environment itself plays a significant part in facilitating physical activity: 'evidence consistently shows that accessible and safe urban greenspaces have a positive influence on levels of physical activity' (Croucher et al., 2007). Evaluation of programmes for encouraging exercise indicates that attractive, green environments close to the home or work provide the best opportunities to encourage daily exercise, walking or cycling. People also keep exercising longer in natural surroundings (Bird, 2004). The effect on children seems particularly marked. Children who have easy access to safe greenspaces (parks, playgrounds, kick-about areas) are more likely to be physically active than those who are not so close, and this has a positive effect on health, particularly for those from low income families (Mitchell and Popham, 2008). One analysis of a European cross-sectional survey suggests that the likelihood of being physically active is three times greater, and the prevalence of obesity 40% less, in neighbourhoods with high levels of greenspace as opposed to those with low levels (Ellaway et al., 2005).

Greenspace Scotland has undertaken a comprehensive literature review (Croucher et al., 2008), selecting 87 studies from 550 identified across the world (a third from the UK), and advises that physical activity (which can sometimes be an incidental benefit from other priorities, such as relief from stress) is influenced by these attributes:

- distance of residence from greenspace;
- ease of access in terms of routes and entry points;
- size of greenspace in relation to levels of population use;
- connectivity to residential and commercial areas (allowing through routes);
- the range of amenities for formal and informal activities;
- perceived safety of the greenspace;
- the quality of maintenance.

Lifestyle: diet

The relationship of spatial planning to diet is less clear. There has been much speculation in the past about food deserts (places, normally outlying estates, with relatively low car ownership and lacking local access to fresh food). But empirical evidence so far does not lend credence to this theory. One longitudinal study of the effect of a supermarket opening in a poor outer estate found that the impact on fresh food purchase was negligible – the local residents changed their diet at the same rate as the city as a whole. However, the study did find a marked affect on active travel. Many more people walked to the superstore because it was now close (Cummins et al., 2005). Studies of the location of fast food outlets affecting diet are also inconclusive. It seems that eating habits are largely a cultural, habitual matter, and are not heavily influenced by spatial planning.

However, household choice on whether to grow fruit and vegetables is itself affected by the options presented by the built environment. Many places, including most modern housing estates, have been built at relatively high densities with small gardens or none at all for flats. This militates against home food production. Allotments are often at an inconvenient distance from home, and many cities now have waiting lists for them. Few recent housing developments have provided accessible allotments, and over the past few decades some allotments have been sold off for housing. There is clearly a need for new research and policy which will enhance local food production.

Community and mental well-being

Community is defined here in terms of social networks of mutual support. Social networks are critical to mental and emotional well-being (Halpern, 1995). Many people have social networks which are numerous, varied and geographically widespread, with a basis in a range of shared interests. Some are virtual. But the networks of vulnerable groups are often very local. These groups include elderly people, infirm or disabled people, young parents (especially single parents) and their children, some teenagers, and unemployed and unskilled people. For them the local social networks in their own neighbourhood are particularly critical.

The quality of social networks is affected by people's perception of the safety of their locality and their sense of belonging. One study of an inner London suburb found that residents experienced 'time-space inequality' as a consequence of crime and fear of crime, resulting in feelings of isolation and low self esteem (Whitley and Prince, 2005).

Research is unequivocal in relating people's perception of their neighbourhood both to objective indicators of its physical and social quality and to health and well-being (Truong and Ma, 2006; Croucher et al., 2007). It is less clear exactly what physical features or characteristics have particular significance. Causality is also difficult to establish. But one study pursued a rare quasi-experimental approach by placing difficult families randomly into affluent localities. It found that their mental well-being improved by comparison to those placed in poor communities (Levanthal and Brooks-Gunn, 2003).

Supportive social networks are also affected by traffic levels and by access to local facilities. Addenbrooke's classic research in the US has been reproduced in this country with similar findings: that levels of social interaction and the extent of the perceived home territory vary inversely to traffic levels (Hart, 2008). Lack of availability of local schools, health facilities and libraries can also have negative social impacts and affect both physical and mental well-being (Lavin et al., 2006). A current study is finding a strong positive relationship between the local availability of shops and services, the density of social networks, the perceptions of social capital and mental well-being. The fact of being able to walk easily to facilities, meeting people either by accident or arrangement, appears to be key to these relationships (Calve-Blanco, 2009).

Greenspaces facilitate physical activity, and can also promote social interaction and social cohesion (Croucher et al., 2008). Close access to greenspace promotes the sense of well-being, stress relief and speed of recovery from illness. Residents of urban social housing who can see trees or open space from their homes demonstrate greater ability to deal with stress than those who have no such views (Kuo, 2001). People who are more locally based – older residents, the unemployed and single parents – benefit especially from such access (Orsega-Smith et al., 2004; De Vries et al., 2003). However, the quality and safety of open space is important. If the community perceives the risk of assault or intimidation to be high, the benefits of greenspace largely evaporate (Croucher et al., 2007). Social problems are compounded if park maintenance is poor. In 2000 only 44% of local greenspace managers considered the quality of their parks to be stable or improving. However, the positive news is that by 2005 this had risen to 84% (National Audit Office, 2006).

Overall, then, and contrary to earlier social science assumptions (Giddens, 1990; Dennis, 1968; Webber, 1964) it seems that spatial planning is important for social networks and for mental well-being. This is particularly so for poorer and less mobile groups, who are more likely to be to be locally based. The structure of the housing market and the allocation of affordable housing mean that vulnerable households tend to be clustered in less desirable locations, reinforcing patterns of deprivation. The significance for health inequalities and social exclusion is clear.

Local economy and income issues

Employment and income are clearly related. Both are determinants of health and both impact on social status, which is also a key determinant of wellness (Marmot, 2004). It is generally accepted that mortality and mental illness increase when unemployment rises (Cave et al., 2004). Individuals who are long-term unemployed are much more likely to suffer depression and physical illness than those in satisfying work, because of both relative poverty and lack of purpose in life. Poverty itself (whether due to unemployment or not) is associated with poor housing, limited mobility, reduced life chances and increased stress, all of which are likely to impact on health and well-being.

Spatial planning effects the local economy broadly, through its effects on the dynamics and growth patterns of regions and settlements, and more specifically through land availability, planning permission for commercial and retail land and buildings, retraining programmes, regeneration strategies and infrastructure provision (improved roads, new stations) that can encourage enterprise. Planning may also affect the economy indirectly through the housing market and the general quality of the environment. For example Welsh valley towns, suffering from terminal decline of traditional industries and poor population health, find it difficult to attract entrepreneurs because of the limitations of the housing stock and facilities available.

Governments attach high value to a successful economy, while health professionals recognise the importance of income and the status that work gives. But research linking health and economic development policy is not evident in the broad reviews of evidence.

Activities, space and networks

Spatial planning influences activities through decisions on infrastructure, land and buildings (the 'built environment'), while

the activities themselves are pursued by individuals, households, firms and institutions. The focus here is on equity and social inclusion.

Spatial planning is deeply implicated in social exclusion and health inequalities. Land use decisions, particularly in relation to housing, transport and economic development, are key determinants of where people live, and therefore of the population profile in any particular area. For example, the distribution of social housing determines where low income groups in housing need tend to live. The most important variables apart from income are probably household status and culture or ethnicity. The social segregation that can occur as a result of the housing market can lead to geographical health inequalities to a sometimes alarming degree. Glasgow provides an extreme example, with life expectancy in one deprived suburb being 54 years, while in an affluent suburb not far away it is 82 years. These figures can be compared with the all-India life expectancy of 61 (Hanlon et al., 2006). The concentration of poverty and unemployment in ghettos causes individual misfortune to be magnified and reinforced.

The strategic planning of housing numbers and land requirements – a cause of continuing political conflict – have profound implications for health. If supply is unduly constrained and prices are high in relation to incomes, social exclusion in the housing market increases (Barker, 2004; Bramley, 2009). Health inequalities are exacerbated as poorer households have difficulty in finding adequate accommodation at a price they can afford in a convenient location. The recent report by Knight Frank (2009) cites evidence from Oxford to show how green belt and housing policies are compromising the options for poorer households, and notes the increasing backlog of affordable units.

The situation of poorer households is also worsened by the prevailing fashion for low density, edge-of-city commercial development, in the form of business parks, retail and leisure parks (National Heart Foundation et al., 2007). This pattern of development increases dependency on the car, and disenfranchises households which do not have access to a car (or two). Conversely, it can force them to buy and run a vehicle they can ill afford.

These edge city locational patterns relate to overall land use and transport strategies. Despite many brave words from local planning authorities, the reality is that new suburban development is proceeding in a way which does not support viable public transport services and which discourages walking and cycling. The public and private sectors are both implicated in this trend, including hospital trusts which close inner city facilities in favour of edge-of-town facilities.

We now appreciate that if households find themselves having to live in over-crowded conditions far from their main social connections, they will be more prone to stress and ill-health. A particular problem, currently becoming more common in both urban and rural areas as energy costs rise, is fuel poverty. Houses which are poorly insulated, draughty, and with inadequate or expensive heating systems, are frequently occupied by those least able to cope with these conditions. The result is 'spatial shrink' (when old people live in their one heated room), vulnerability to illness, and hypothermia. Rehabilitation and renewal programmes, aimed at bringing all houses up to standard, are therefore important from the health perspective (DETR, 2001).

The local bioregion

The relationship between environmental pollution and health was, as noted earlier, one original reason for developing a land use planning system. Basic life support depends on the quality of the air, the availability and quality of water, and lack of contamination of soils when they are used to grow food. This section focuses on air pollution as the most significant environmental health risk in the UK.

The risks associated with poor air quality come mainly from transport and to a lesser extent industry and energy use. Environmental pollutants including particulate matter, ozone, carbon monoxide, nitrogen oxides, sulphur dioxide and benzene cause lung and heart disease, while fresh air contributes to a sense of well-being. In the UK these concerns are institutionalised and are generally effectively managed through the Environment Agency and Environmental Health departments. The Royal Commission on Environmental Pollution has spelt out all the aspects of pollution, including its relationship to health and to the natural and built environments (RCEP, 2007).

In terms of land use, the health impacts of air pollution are greater in urban areas with high traffic levels and high built densities, more people and lower air dispersal characteristics (RCEP, 2007). Here there is a complicated balance of conflicting parameters: more compact urban centres reduce the amount of per capita travel but at the same time, greater density results in increased vehicle trips in any given area, with higher congestion which itself increases pollution (Frank et al., 2005). With regard to health inequality, a study reporting on England found that the most deprived wards were those with highest pollutant concentrations. "The number of people in wards above pollution thresholds increases progressively with increasing deprivation" (Walker et al., 2003). However, this pattern is not universal, and in Wales for instance, both the least and the most deprived areas on average experience similar levels because of their particular spatial distribution (Pye et al., 2006). The key point is that there are large clusters of wards experiencing pollution above health thresholds in larger cities.

Pollution can be tackled at source (through better vehicles, changed power sources, improved industrial processes and heating systems, more efficient buildings, etc.), but can also be managed by good urban form and the management of the urban environment. In terms of urban form, concentrations of pollution can be moderated and pollutants absorbed by linear parkways and green lungs that break up the urban area and almost literally let it breathe (Hough, 1995). Urban heat domes (associated with excess summer deaths as the climate warms) can be effectively managed by greening the city – not just by open spaces but also by tree planting and having living green surfaces as widespread as possible.

All this points to the critical importance of seeing settlements not simply as human artifacts but also as part of the natural world, affecting it and dependent on it. The phrase 'green infrastructure' hints at this relationship. It is vital to see the planning of green infrastructure in the broadest sense, embracing the management of key environmental assets (air quality, water, energy, biodiversity) as well as providing for physical activity, community activities and psychological well-being.

Global ecology

The interdependence of humans and nature becomes obvious when we consider climate change. Global warming and sea level rise are the biggest risks to health in the world – and possibly to the UK specifically, as the Inter-Governmental Panel on Climate Change (2007), the World Health Assembly (WHA, 2008) and Costelloe et al. (2009) have shown. The main threats to health come from regional weather changes, which affect heat stress, flooding, water security and food production, and from sea level rise, with huge implications for coastal settlements, economic dislocation, forced migration and disease.

Settlements, both rural and urban, are profoundly implicated in the causes of climate change. Land transport accounts for 28% of end

user carbon dioxide emissions, and is tending to rise (DEFRA, 2008). Spatial policy to combat climate change touches every element: of the energy efficiency of new and existing buildings, carbon-neutral energy generation, a progressive and massive reduction of reliance on carbon-fuelled transport, and the planning of town and country for easy accessibility and active travel. While certain aspects of this agenda are being actively pursued in the UK, the current plans for future of cities and regions involve growing transport energy consumption (and carbon emissions) over the next 20 years at least (Echenique et al., 2009). Much more radical measures are needed if the UK is to achieve its targets.

Urban and rural areas will have to adapt to some level of climate change, whether mitigation is effective or not. This includes the proper planning of the water cycle, including flood risk management and sustainable urban drainage, reducing the urban heat island effect by greening the city, constructing buildings that maintain a comfortable temperature without energy use, and coping with the broad social and economic changes caused by climate change. It is salutary to note that many of the measures needed to combat global warming are similar to those needed to cope with it.

Overview: a wicked problem

This brief review points up a vital realisation: the relationship between health and land use, especially urban land use, is hugely complex. The various aspects of human social and economic activity, development patterns, planning and environmental policy and health and well-being interact in a myriad ways. Inevitably, many different agencies need to be involved in cooperating to create a healthy environment. This highlights the desperate need for a coherent, shared philosophy. Health (which we all believe in) draws together all the main policy themes: it is closely tied to economic health because of the importance of jobs and income; it relies on the reduction of inequality, building inclusive and supportive communities, and it helps drive the need for environmental sustainability.

While the UK is spending more on the National Health Service, it should also aim to reduce illness through investing in healthy environments. In many towns and cities in Western Europe, priority has been given to the quality of the environment and to inclusive accessibility, and the culture allows children to play in and roam their public realm.

The UK community of planning practitioners is beginning to be influenced by continental European experience. Comparative studies of UK experience with specific cities and neighbourhoods in Germany, France, the Netherlands and Scandinavia are startling. In terms of equity, active travel, accessibility, environmental quality and robustness in the face of the climate change threat, the best UK cities are far behind their continental equivalents (Falk and Hall, 2009). Our UK research, and other English language research, mainly from the US, seem sometimes to miss the point. In some places in Europe we see experimental evidence of behaviour which is very different from that which prevails in the UK, amongst populations that are in other ways quite similar. There is also general evidence that this different behaviour is affecting health and well-being. The comparative study of child health and well-being in OECD countries puts British children as amongst the least healthy and least happy (UNICEF, 2007). Spatial planning in its broad sense, and the character of settlements, are part of the UK problem, and need to become part of the solution.

Future directions and expected findings of future research

Below are some of the expected insights which research will be able to afford us in the future, chosen from instances where already one can see clear trends in findings and the conviction with which researchers are able and willing to put them across. It is interesting to note the relative speed with which the research community acts once a new agenda – such as climate change or the obesity epidemic – takes hold. In the field of physical activity and urban form, for example, the main research effort (following the work of some early pioneers) has occurred this decade. For a while much of the research used methods which searched for aggregate average patterns and which were often not very revealing. It used spatial variables, such as density, which proved not to be so critical as many had believed. But just in the last few years, we have found more crucial variables and the weight of evidence is becoming impressive, allowing more discriminating judgements to be made.

My belief is that the inter-linkage of health and spatial planning research literature will continue apace, and progressively leave little excuse for inaction. A major shift in political priorities, however, will be necessary if action is to be effective. Part of that shift will be increased autonomy and financial muscle for local authorities, so that they can innovate and shape the future of their communities to a much greater degree, as we see in continental European examples. Also necessary is a shift in the control of land for development, so that vested interests do not dominate over the common good. At present, the main political parties show little sign of shifts in such a direction. We await a crisis (possibly due to climate change) to galvanise the political classes and public opinion.

The research areas in which we might expect interesting results in this area include:

- *Integrated settlement theory*: current research is hampered by the inadequacy of human settlement theory. Each discipline provides its own perspective but they are not integrated. Various attempts have been made to integrate them, none yet fully convincing. The next 40 years will see the development of an integrated theory of settlement function, form and evolution. It will be based in eco-system theory, linking human activity and well-being with development processes, the structure of the built environment and the natural bioregion.
- *Normative planning strategies*: partly as result of the integrated theory, and partly as a result of gathering comparative evidence from around the globe, clear normative principles will be identified in relation to the processes of urban governance and decision-making and the spatial structures that are successful at delivering healthy, sustainable human settlements. These principles are already being articulated but not are widely accepted.
- *Health well-being and spatial planning*: much more research will be undertaken to help us understand the links between health and urban land use, including strategic policies for housing, commerce and transport. This is still a new research arena. The areas of uncertainty will be progressively reduced, and the more significant determinants of health will be separated from less critical factors. The relative significance of, and dynamic relationship between, social, cultural, environmental and economic drivers of personal behaviour will be much better understood.
- *Population, social mix and health inequalities*: the evidence will become compelling that if long-term productivity, health and quality of life for all (avoiding the crippling societal costs of poor health) are priorities, then the social structure of population within a neighbourhood or town is a matter of central policy concern. The socially polarised geographies in the UK which result from current housing mechanisms and urban forms will be condemned as exacerbating social and health inequalities and for their high cost to society.
- *Lifestyle: physical activity and the built environment*: the growing but still contended evidence that urban form, settlement patterns and local environments have a major impact on behaviour,

especially the levels of physical activity and therefore obesity, will be full and clear. The significance and dangers of obesogenic environments – again with a cost tag which will influence the Treasury – will be accepted. Local greenspace, retail, social and educational facilities, and the cycling routes and walkways which give access to them, will become recognised as important for public health and well-being.

- *Community networks, mental well-being*: The still uncertain relationship between community networks, the physical environment and mental well-being will have been sorted. There will be a recognition that it is impossible to generalise about this topic, because of the increasingly diverse patterns of social connection which people have. Nevertheless, for those who are obliged, or choose, to live locally, the importance of local facilities and casual pedestrian meetings will be established. In an aging population, with more retired people, this will be especially important.
- *Children, education and locality*: the crisis brought on by a generation of obese children becoming adults, with consequent health problems, will focus the minds of politicians and academics. There will be research showing that it is vital for children to experience their environment, engage in active play and free socialising, and learn about the world, in the context of a more holistic educational approach, if they are to be happy and healthy. The dangers of exaggerated fear of strangers, fortress schools and car-dependence will be accepted – though the aftermath of the current situation will still impede progress.

Given the strong direction of research, and the urgent necessity of planning the human habitat so that it promotes health and sustainability, a maxim of Goethe's is apposite:

> Whatever you can do, or dream you can, begin it. Boldness has genius, power and magic in it.

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B

Fair Society, Healthy Lives

The Marmot Review

Strategic Review of Health Inequalities in England post-2010

Fair Society, Healthy Lives

The Marmot Review

Strategic Review of Health Inequalities
in England post-2010

in these determinants. The London Congestion Charge is applied across central London only, but it has reduced the gradient in air pollution proportionately across the social gradient, with increasing impact in the more deprived areas – Figure 4.8.

Improving the food environment in local areas across the social gradient

Dietary change can also play a key role not only in mitigating climate change and adaptation strategies, but also in promoting health by reducing the consumption of saturated fat from meat and dairy sources. Food preparation and production contributes around 19 per cent of the UK's greenhouse gas emissions; half of these emissions are attributable to the agricultural stage.

Food systems have the potential to provide direct health benefits through the nutritional quality of the foods they supply.[439] Improving the food environment involves addressing issues concerning the accessibility of affordable and nutritious food that is sustainably produced, processed and delivered. Internationally, studies show that among low-income groups price is the greatest motivating factor in food choice. In the US, price reductions have seen positive increases in the sales of low-fat foods and fruit and vegetables.[440] The era of cheap food may be approaching its end, but consumer expectations are still of low prices, which fail to include the full environmental costs.[441]

There are studies that show association between proximity, or lack of, to healthy food, and health outcomes such as obesity or malnutrition, but these studies should be approached with caution. They are most often observational and so do not show *causality* between inadequate access and health outcomes.[442] One study in the UK on the greater access to unhealthy food has shown this *may* disproportionately affect those in more deprived areas.[443] Data from the US shows more substantial links between schools and proximity to fast food outlets, as well as proximity to fast food outlets and obesity but the food environment in the US is very different to the UK's.[444]

Case Study Working in partnership to reduce fuel poverty

The UK Public Health Association (UKPHA) brings together individuals and organisations from all sectors who share a common commitment to promoting the public's health and it is leading the delivery of an innovative and integrated fuel poverty programme. Starting with understanding the current evidence, engaging with key partners then implementing a pilot, the project is a good example of the delivery of integrated and evidence-based interventions to reduce health inequalities.

The programme originates from the UKPHA's Health Housing and Fuel Poverty Forum, funded by DEfRA. The forum, made up national figures from the health, housing and energy sectors, and practitioners from across England, developed the 'Central Clearing House' model. Their research concluded that a model of local area partnerships that linked health, housing and fuel poverty services was the most effective approach for directing services to the vulnerable. The CCH model identified the key systems and processes necessary to access the vulnerable fuel poor, identify high risk groups, streamline referral and delivery systems and implement monitoring and evaluation processes.

The CCH model was first piloted in Manchester, with the implementation of the Affordable Warmth Access Referral Mechanism (AWARM). Funded by the Department of Health, the pilot was a partnership with Salford City Council and Primary Care Trust. Manchester Business School is evaluating the programme for the mismatch between theory and practice and an assessment of what 'fit for purpose' should look like.

Greater Manchester invested approximately £100,000 each year into AWARM. Since April 2008 AWARM activity resulted in over £600,000 of investment and majority of cases are still open so many households will receive further investment. AWARM resulted in a dramatic increase in referrals from across the social and care sectors, but the number of referrals from health professionals (mainly GPs) remains low. In 12 months the programme trained 1,359 professionals, a third in health, with the remainder in social services, voluntary/community services, local government and housing.

The lessons learned from the pilot include:

— There are numerous opportunities to share data between local authorities, GPs and PCTs to improve how referrals are targeted
— A pop-up system on GP patient electronic records would help to immediately direct referral to a one-stop-shop
— Involving energy companies as active project partners can help identify novel ways to target vulnerable individuals and neighbourhoods.

The funding received ends in 2010, yet the project is improving local delivery systems, increasing the numbers receiving funding to reduce fuel poverty. Like many other ill health prevention projects, funding only invests in a pilot, regardless of the outcomes. In this case, this means a project showing successful short-term outcomes may not be rolled out.

For more information see
www.ukpha.org.uk/fuel-poverty.aspx

Availability of healthy food, and in particular fresh produce, is often worse in deprived areas due to the mix of shops that tend to locate in these neighbourhoods.[445] A study of the location of McDonald's outlets in England and Scotland showed per capita outlet provision was four times higher in the most deprived census output areas than in the least deprived areas.[446] Low-income groups are more likely to consume fat spreads, non-diet soft drinks, meat dishes, pizzas, processed meats, whole milk and table sugar than the better-off.[447]

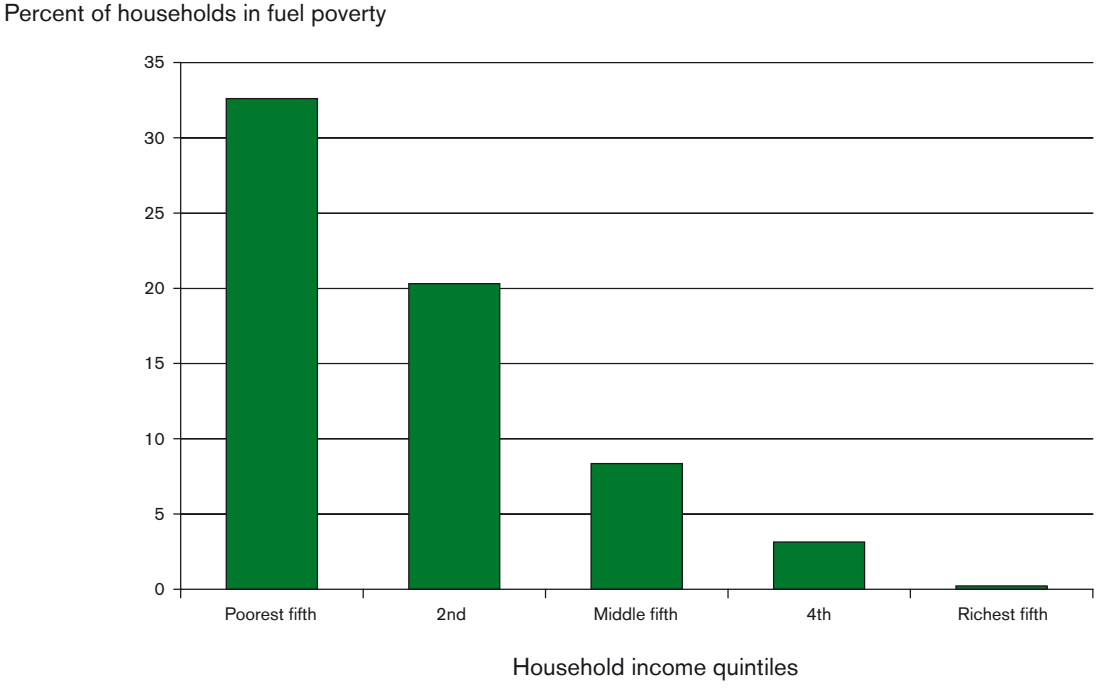
The creation of food deserts is likely to be a by-product of a complex interaction between local planning, regulatory and economic factors and the national location policies of large supermarket companies.[448] In a controlled 'before/after' study following the opening of a new supermarket in Scotland, there were no differences between the control and experimental groups: both increased their daily intake of fruit and vegetable portions.[449] However, there is still a suggestion that residents of deprived areas could benefit from policies aimed at low-mobility groups, increasing their access to better shopping facilities and healthier food alternatives.[450]

Improving energy efficiency of housing across the social gradient

The existing housing stock emits 13 per cent of our carbon dioxide and as such, there is a compelling case for improving the environmental standards of housing across all sectors. Poor housing conditions and design have substantial impacts on health inequalities. It is estimated that reducing household energy emissions but examining the effects of fabric, ventilation, fuel switching, and behavioural changes, could lead, in one year, to 850 fewer disability-adjusted life-years (DALYs – a method of estimating the negative lifetime impact of premature mortality and disability) and a saving of 0.6 megatonnes of CO_2 per million population.[451] The annual cost to the NHS of both cold homes and falls is estimated to be over £1 billion. The ageing housing stock requires consistent reinvestment, particularly to reduce the carbon emissions from older homes.[452]

Living in cold conditions is a health risk. A household is in fuel poverty if it needs to spend more than 10 per cent of its income on fuel to sustain satisfactory heating. In 2006, 11.5 per cent of households in England were fuel poor, either spending more than this 10 per cent or under-consuming energy to save money; over half of these households were single persons. The Government set statutory targets to eradicate fuel poverty among vulnerable households in England by 2010 and all households in England by 2016 as far as is reasonably practicable. It is estimated that these targets will not be met and the most recent figures state that 2.8 million households in England are in fuel poverty.[453] The risks of fuel poverty are higher in rural areas – in 2006, 21 per cent in rural areas were in fuel poverty compared with 11 per cent in suburban and 10 per cent in urban areas.[454] The risk of fuel poverty rises sharply as household income

Figure 4.9 The risk of fuel poverty according to household income, 2009



Source: English House Conditions Survey, Department of Communities and Local Government [455]

Note: Percent in fuel poverty relates to households in fuel poverty after deducting housing costs

falls. Very few households with above-average incomes are in fuel poverty – see Figure 4.9.

Other factors besides household income affect whether a household is in fuel poverty or not, such as housing costs and type of ownership. As a proportion of the total number of households for a given tenure, for example private rented, owner occupier or social housing, households living in private rented accommodation have higher likelihood of living in fuel poverty – 16 per cent of which were in fuel poverty compared with 11 per cent in other tenures.[456] However, more of the fuel poor live in owner-occupied properties, with over two thirds of fuel poor household living in that sector.

The government programme Warm Front, which provides a package of insulation and heating improvements to qualifying households, has been shown to have a positive impact on mental health, alleviating respiratory problems in children and reducing deaths among older people.[457] Despite this policy and others such as the Winter Fuel Payment, the number of fuel poor households in England dramatically increased between 2004 and 2008. The cold winter of 2008/9 saw the highest number of extra deaths in England and Wales since 1999/2000, with 36,700 excess deaths. Much of the increase in fuel poverty in 2008/9 was due to the increased costs of energy and it is estimated that in the long term, energy costs will increase.[458]

Improvements in housing conditions have been shown to have a number of positive impacts on health, including lower rates of mortality, improved mental health and lower rates of contact with GPs. Significant improvements in health-related quality of life were found in a randomised controlled trial of home insulation, which concluded that targeting home improvements at low-income households significantly improved social functioning and both physical and emotional well-being (including respiratory symptoms).[459] Adequate heating systems improve asthma symptoms and reduce the number of days off school.[460]

Following the introduction of the Housing Health and Safety Rating System by the Department for Communities and Local Government (CLG) a number of the initiatives addressing the problems of cold homes and the impacts of housing on health. Many of the difficulties in addressing the issue of cold homes is that the *effects* of the problem are the responsibility of one government department, the Department of Health, but the responsibility for *solutions* lies with the CLG and with the Department of Energy and Climate Change (DECC).

The 2004 Housing Act gave local authorities the powers to tackle poor housing, setting out statutory minimum standards. The Housing Health and Safety Rating System evaluates the potential risks to health and safety from any deficiencies identified in dwellings. The introduction of the Housing Health and Safety Rating System, together with other developments in calculating the cost of the impact of poor housing on health, has led to increased activity between local housing authorities and health partners in reducing health inequalities. This work is at a relatively early stage but it has the potential to help reduce the numbers of people in fuel poverty, to help maintain independence and lead to improvements in health and well-being.

Health inequalities also relate to the shortage of new homes. It is estimated that three million new homes are needed by 2020 to meet the rate of new household formation. Many are waiting for new homes. Close to two million are on council waiting lists, with 500,000 in overcrowded conditions and 70,000 in temporary accommodation.

The Decent Homes programme sought to improve the quality of homes and by 2010, 95 per cent of social housing will reach the Decent Homes Standard. The programme had invested over £40 billion by 2010 and work has been completed on 3.6 million social homes, with improvements for 8 million people in total, including 2.5 million children. Continued investment is needed to maintain this standard; housing associations will need funding to continue to invest in the ageing housing stock. The impact of this investment on health needs to be better understood; it is important that these policies and investments are assessed for their impact on health inequalities.

Summary

- There are co-benefits to addressing both health inequalities and climate change.
- The NHS has implemented some strategies to reduce carbon emissions and improve environmental sustainability but can go further.
- Strategies are needed to enable access to good quality, active transport across the social gradient.
- Good quality green and open spaces improve physical and mental health.
- Green and open spaces have more of an impact if they are close to where people live.
- Fuel poverty is a significant problem and likely to grow as the cost of fuel increases.
- Investments to improve housing need to be sustained.

E.2.2 Integrate planning, transport, housing, environmental and health policies to address the social determinants of health

Recommendation: Fully integrate the planning, transport, housing, environmental and health systems to address the social determinants of health in each locality.

An important step in tackling the social determinants of health at a local level would be greater integration of health, planning, transport, environment and housing departments and personnel.

At present, the planning process at local and national levels is not systematically concerned with impact on health and health equity.[461] Currently, Policy Planning Statement (PPS) 17 deals with health issues, 'Planning for open space, sport and recreation'. However, the lack of attention paid to

health and health inequalities in the planning process can lead to unintended and negative consequences. A policy planning statement on health would help incorporate health equity into planners' roles.[462]

The Healthy Urban Development Unit and CABE demonstrate in numerous reports how good planning can have a positive impact on public health and that designers can influence people's well-being and design neighbourhoods in a manner that promotes health and well-being.[463] A new Planning Policy Statement on health could ensure that new developments are assessed for their impact on health inequalities, for example limiting the number of fast food outlets in a Super Output Area. This tool could help to provide a lever for local authorities to change the way neighbourhoods are designed.

Existing tools such as the Joint Strategic Needs Assessments are another lever to facilitate integrated approaches at a local level. However, as CABE reports, 'producing needs analysis data does not in itself lead to change'.[464] Integrated working, such as making PCTs statutory partners in local planning decisions, should be decided at local levels.

Training local authority managers and officers in planning, housing, environment and transport in health equity issues could improve commitments to local development frameworks.[465] Related professional bodies can make health equity mandatory in professional development.

Equally, local planning should ensure services are easier to access and more joined up locally. The design of neighbourhoods can have an impact on community participation – good neighbourhood design can avoid putting up barriers to participation, and actively encourage it, for example through ensuring accessible transport, well-located services and amenities, and the provision of facilities and activities which encourage integration.

Case Study Improving private rented housing in Liverpool

Liverpool City Council's Healthy Homes Programme (HHP) seeks to prevent premature death and ill health caused by poor housing conditions and accidents in the home. It is aimed at the rented sector and seeks to help the most vulnerable residents in Liverpool. Based on national estimates, poor housing conditions are a significant contributor in up to 500 deaths and around 5,000 illnesses needing medical attention in Liverpool each year. The city has one of the highest rates of excess winter deaths in the UK; between 2004 and 2007, there were 242 excess winter deaths per year.

Liverpool PCT commissioned the City Council to assist in the reduction of health inequalities and improve morbidity and mortality statistics through the HHP. The HHP proactively targets and surveys a large number of the worst properties that house the most vulnerable occupants. In tackling sub-standard housing conditions and knitting together the wide range of health-related services the city has to offer, the hardest to reach and most vulnerable residents are actively engaged and encouraged to take advantage of available health services from a single point of contact. This partnership confronts head-on health inequalities in a city that has some of the worst levels of deprivation and health disparity in the country.

The programme will identify approximately 15,000 properties for an initial survey, and prioritise 2,750 for full health and safety inspection to develop a personalised home improvement plan. Following the inspections of the properties, the necessary improvements are secured by the team's Environmental Health Officers through advice and enforcement. This programme is delivered initially over three years and is controlling the most significant and life threatening hazards in these homes, including: poor heating and insulation; bad internal arrangements (to prevent accidents); dampness and mould (combating respiratory illness).

In addition to inspecting housing conditions, the health and well-being needs of all occupants are investigated and advice on accident prevention and health promotion provided. Referrals to relevant agencies are also made where specific health and well-being problems are identified.

The programme works in partnership with a number of related agencies such as Merseyside Fire and Rescue Service and initiatives such as energy efficiency and making neighbourhoods cleaner and healthier. HHP also works with primary care by increasing awareness of the programme in neighbourhood General Practices and creates referral systems for clinicians. Health professionals can then actively address the causes of some respiratory complaints and other chronic diseases.

Advice and education on health promotion and home accident prevention are also integral to the programme. Vulnerable households such as those housing black and minority ethnic groups, the elderly and young are being specifically targeted.

The programme is designed to:

— Prevent up to 100 premature deaths when fully implemented
— Reduce the number of GP consultations and hospital admissions by an estimated 1000 cases
— Improve clinical understanding of poor housing on local health via communication with GPs and other clinical services
— Reduce reliance on secondary and tertiary treatment
— Increase community capacity to support housing improvements.

For more information see
www.liverpool.gov.uk/healthyhomes

Summary

— Integrated planning, transport, housing, environmental and health systems are needed.
— Training in health for planning, transport, housing and environmental professionals should be implemented.
— A Policy Planning Statement on health is needed.

E.2.3 Create and develop communities

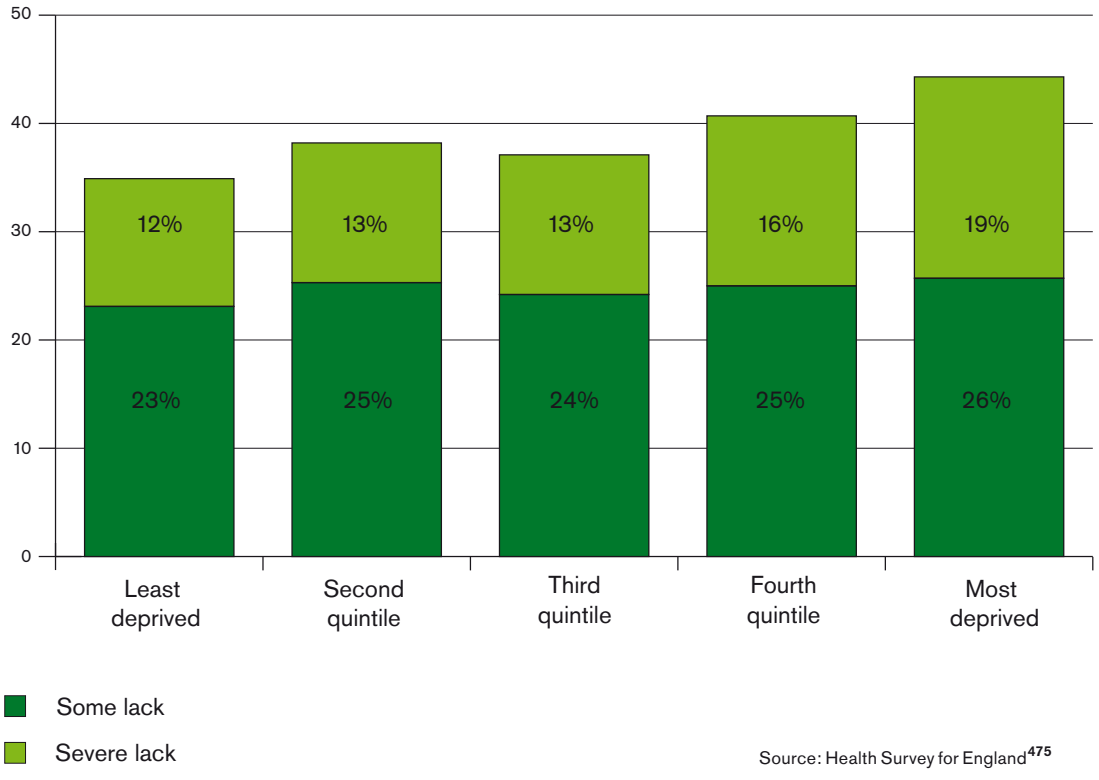
Recommendation: Support locally developed and evidence-based community regeneration programmes that:
— Remove barriers to community participation and action
— Reduce social isolation.

Community or social capital is shaped both by the ability of communities to define and organise themselves, and by the extent to which national and local organisations seek to involve and enagage with communities. It is comprised of different factors in different communities, and can include community networks, civic engagement, a sense of belonging and equality, cooperation with others and trust in the community. Community capital needs to be built at a local level to ensure that policies are drawn on and owned by those most affected and are shaped by their experiences.

Communities with less community capital differ from stronger communities in many ways. For example, there is less volunteering/unpaid work in neighbourhoods that are perceived to be less safe, and less socialising and less trust in others.[466] In the last decade, the level of volunteering/unpaid work has remained fairly constant. According to the Joseph Rowntree Foundation, '[b]etween 35 per cent and 40 per cent engaged in some form of civic participation, around 20 per cent in civic consultation and 10 per cent in civic activism. Around 35 per cent volunteered informally, and 25 per cent formally over the period.'[467]

Evidence for causal associations between social capital and health is improving. In many communities facing multiple deprivation, stress, isolation and depression are all too common.[468] Residents of busy streets have less than one quarter the number of local friends than those living on similar streets with little traffic.[469] The most powerful sources of stress are low status and lacking social networks, particularly for parents with young children.[470] Low levels of social integration, and loneliness, significantly increase mortality.[471] Several longitudinal studies have shown that social networks and social participation appear to act as a protective factor against dementia or cognitive decline over the age of 65 and social networks are consistently and positively associated with reduced morbidity and mortality.[472] There is strong evidence that social relationships can also reduce the risk of depression.[473] People with stronger networks are

Figure 4.10 Percentage of those lacking social support, by deprivation of residential area, 2005



Source: Health Survey for England[475]

healthier and happier. Making resources available to address the association between poor health and poor social networks and break the cycle of deprivation can also decrease costs of health care.[474]

Remove barriers to community participation and action

Addressing the psychosocial effects of neighbourhood deprivation is a difficult task as identifying methods to improve community capital can be difficult. Those living in deprived areas often find their communities lack social support (Figure 4.10) and, according to the Joseph Rowntree Foundation, 'people in more deprived areas [are] more likely than others to think that certain issues [represent] a serious problem in their area. For example, over half of people in the most deprived areas [feel] that drug use or dealing, litter and vandalism [are] serious problems where they [live]. This compare[s] to between one-quarter and one-third in other areas.'[476]

In the UK, neighbourhood regeneration programmes have demonstrated improvements in average employment rates, educational achievements, household income and housing quality, all of which may contribute to a reduction in inequalities in health, but they can also increase housing costs, rendering residents poorer, as regeneration displaces the original residents.[477]

Numerous policies across government departments have sought to improve community capital and to tackle concentrated deprivation in deprived neighbourhood, such as Communities for Health (Department of Health) and the National Strategy for Neighbourhood Renewal (CLG). The latter was underpinned by investment in area-based regeneration and community renewal, primarily through the Neighbourhood Renewal Fund (NRF – refocused since 2008/9 on employment as the 'Working Neighbourhoods Fund'), but also through the New Deal for Communities (NDC) and the Neighbourhood Management Pathfinders (NMP) programmes.

Evaluation evidence from across these programmes identified some positive trends – for example, the proportion of young people getting good GCSEs and residents' satisfaction with local services, such as police and street cleaning. A review of the NDC[478] found more than half of residents said the area improved as a place to live. The feeling of being part of a local community increased from 35 per cent in 2002 to 42 per cent in 2006, still below the national average at 53 per cent, but nonetheless showing an increase in deprived communities, where improvements are more difficult to achieve. Self-reported health rose slightly from 77 per cent feeling that their health was good or fairly good in 2002 to 80 per cent in 2006 (still below the national average at 87 per cent).

Overall, despite these efforts, the proportion of people who do not feel they could affect decisions locally has not changed since the start of the decade and in the last 20 years a consistent number of adults, around two-fifths, have felt that their neighbourhood was not the type of area where people would help each other.[479] Other evaluations have identified that a failure to commit to mainstreaming and a lack of ability to think strategically about how core services could work better in regeneration areas meant that progress was limited.[480] While the NDC programme highlighted some real challenges on engaging and developing communities, it did provide long-term funding, which alleviates funding stresses from local communities who often survive on year-to-year funding programmes.

Engagement of residents tends to have been most successful at the neighbourhood level and where there is engagement in individual projects and initiatives rather than at strategic or general consultative level. The National Strategy for Neighbourhood Renewal has had most success in influencing mainstream services to adopt a greater focus on deprived neighbourhoods where complemented by existing national policies and targets.

The experience of these programmes offers some important lessons for the future and what has and has not been most effective in supporting deprived neighbourhoods. For example:

— A need to focus more on underlying economic drivers of deprivation, such as the wider labour market, which will most likely operate at a higher spatial level than the neighbourhood
— A need to engage with mainstream agencies and ensure core services work better in regeneration areas

Communities need to be involved in developing and delivering their own regeneration programmes and initiatives – but that involvement needs to be real and fit for purpose (i.e. at the right spatial level and reflecting the capacity of local communities). Interventions work best with national guidance but accompanied by local freedom to develop relevant local programmes. As indicated in section E2.2, the design of neighbourhoods can also have an impact on community participation.

To achieve sustainable change it is necessary to take an integrated and appropriately sequenced approach that considers the social, economic and physical problems of an area and the interactions between them, and how best to complement the interventions of other agencies.

Reduce social isolation

Reducing social isolation, and increasing individual and community empowerment and health outcomes, is challenging but much needed as the number of one-person households increases. In 1991 26.3 per cent of households contained one person, rising to 30 per cent in 2001, but social isolation and exclusion concerns more than just those living alone. Social exclusion encompasses social, political, cultural and economic dimensions and has different impacts at different stages in a person's life. It is the multiple disadvantages experienced by particular groups and individuals existing outside the 'mainstream' of society.[481]

Social isolation impacts on health: social networks and social participation act as protective factors against dementia or cognitive decline over the age

of 65.[482] Individuals who are socially isolated are between two and five times more likely than those who have strong social ties to die prematurely. Social networks have a larger impact on the risk of mortality than on the risk of developing disease, that is, it is not so much that social networks stop you from getting ill, but that they help you to recover when you do get ill.[483]

Four pathways suggest the interventions and policies that could reduce social isolation and exclusion:

1 First, identifying population needs better quality information from communities. In theory this can lead to health improvements and reduced health inequalities through an increased uptake of more effective services, particularly preventative services, and/or more effective interventions.
2 Second, improving governance and guardianship and promoting and supporting communities to participate in directing and controlling local services and/or interventions. This will help to improve the appropriateness and accessibility of services and interventions, increase uptake and effectiveness and influence health outcomes.
3 A third way to reduce social isolation is to develop social capital by enhancing community empowerment. This helps to develop relationships of trust, reciprocity and exchange within communities, strengthening social capital.
4 Lastly, increasing control and community empowerment may result in communities acting to change their social, material and political environments.[484]

Summary

— Understanding of the relationship between social and community capital and health is growing.
— Communities facing multiple deprivation often have high levels of stress, isolation and depression.
— Social networks and participation can improve mental health inequalities.
— Area-based initiatives have demonstrated some limited successes.
— Social isolation can lead to increased risk of premature death.
— Including communities and individuals in designing interventions to address social isolation will help improve their effectiveness.

E.3 Policy Recommendations

Time period: 2011–2015

1 Prioritise policies and interventions that reduce both health inequalities and mitigate climate change, by:
— Increasing active travel across the social gradient
— Improving access and quality of open and green spaces available across the social gradient
— Improving local food environments across the social gradient
— Improving energy efficiency of housing and reducing fuel poverty.

2 Prioritise integration of planning, transport, housing, environmental and health policies to address the social determinants of health in each locality.

3 Support locally developed and evidence-based community regeneration programmes, that:
— Remove barriers to community participation and action
— Emphasise a reduction in social isolation.

Time period: 2016–2020

1 Implement policies and interventions that both reduce health inequalities and mitigate climate change, including:
— Maintaining active travel across the social gradient
— Maintaining access and quality of open and green spaces available across the social gradient
— Sustained and continued upgrade of housing stock.

2 Implement greater integration of the planning, transport, housing, environmental and health systems to address the social determinants of health in each locality.

3 Increase development of locally designed and evidence-based community regeneration programmes, by making long-term funding available for evidence-based community regeneration programmes.

Time period: 2020 and beyond

1 Monitor policies and interventions that both reduce health inequalities and mitigate climate change for complementarity:
— Maintain and monitor active travel across the social gradient
— Monitor access and quality of open and green spaces available across the social gradient.

2 Fully integrate the planning, transport, housing, environmental and health systems to address the social determinants of health in each locality.

3 Make sustainable investments in community engagement and neighbourhood renewal.

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Public Health

A systematic review of the influence of the retail food environment around schools on obesity-related outcomes

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Summary

The high prevalence of childhood obesity has led to questions about the influence of 'obesogenic' environments on children's health. Public health interventions targeting the retail food environment around schools have been proposed, but it is unclear if they are evidence based. This systematic review investigates associations between food outlets near schools and children's food purchases, consumption and body weight. We conducted a keyword search in 10 databases. Inclusion criteria required papers to be peer reviewed, to measure retailing around schools and to measure obesity-related outcomes among schoolchildren. Thirty papers were included. This review found very little evidence for an effect of the retail food environment surrounding schools on food purchases and consumption, but some evidence of an effect on body weight. Given the general lack of evidence for association with the mediating variables of food purchases and consumption, and the observational nature of the included studies, it is possible that the effect on body weight is a result of residual confounding. Most of the included studies did not consider individual children's journeys through the food environment, suggesting that predominant exposure measures may not account for what individual children actually experience. These findings suggest that future interventions targeting the food environment around schools need careful evaluation.

Keywords: Child obesity, food environment, schools, systematic review.

Abbreviations: AOR, adjusted odds ratio; BMI, body mass index; CS, convenience store; FF, fast food; FFR, fast food restaurant; FO, food outlet; FRI, food retail index; HEI, healthy eating index; HFAI, healthy food availability retail index; HFSS, high in fat, sugar or salt; HFZ, healthy fitness zone; IRR, incidence rate ratio; OR, odds ratio; OW, overweight; SE, standard error; SM, supermarket; TA, takeaway.

obesity reviews (2014) **15**, 359–374

Introduction

The prevalence of childhood obesity in the world has increased dramatically over the past three decades and is considered by the World Health Organization to be one of the most serious public health problems of the 21st century (1,2). Overweight or obese children are likely to remain overweight as adults and have an increased risk of developing chronic conditions such as cardiovascular disease or type 2 diabetes. Swinburn and Egger coined the term the

'obesogenic environment' in 1997, and since then a growing body of research has looked at ways that external factors (such as access to food outlets) may influence dietary behaviours (3).

Despite significant methodological and conceptual limitations in research about the environment and health (4–8), there has been interest in potential environmental interventions to support healthy dietary behaviours (9,10). This has led to regulation of the food environment *within* schools (11) – but these policies aimed at improving the food environment for children do not generally extend beyond school boundaries. Planning or licensing controls to restrict unhealthy food retailing operations around schools have been proposed (and in a few cases implemented) in the UK, United States and Australia (12–20), but it is unclear whether such interventions are effective. Some of this lack of clarity is due to a conflicted and equivocal evidence base.

Existing systematic reviews

Despite a growing body of primary research examining the retail food environment surrounding schools and its potential influence on children, we were unable to find any systematic reviews that focus specifically on food retailing around schools and its associated outcomes among schoolchildren. Existing reviews have considered the broader subject of possible environmental determinants of health (4,5,7,8,21–23), but they have not focused specifically on the retailing around schools. For the first time, our review tackles this knowledge gap by examining associations between these environmental exposures and obesity-related outcomes, as well as how they were defined and measured.

Aim of this review: focusing on school food environment studies

The primary aim of this systematic review was to examine the associations between the retail food environment around schools and dietary intake, weight status or food purchasing behaviour among school-age children. Our hypothesis was that the food environment around schools influences food purchasing behaviour of schoolchildren at three points in the day: (i) on the journey to school; (ii) at lunchtime during 'breaks' from school and (iii) on the journey from school. We also hypothesize that the influence on food purchasing behaviour results in changes in dietary intake and changes in weight status. Our secondary aim was to catalogue and critique the various methods employed within this body of literature.

Methods

We developed a full protocol that is available from the authors on request.

Search strategies

We conducted a search using a combination of free-text terms and subject headings to describe schools and schoolchildren, the retail food environment and our outcomes of interest: food purchasing, food consumption and body weight (please see Supporting Information Appendix S1 for the Medline strategy). The following publication databases were searched from database inception to 24 October 2013: MEDLINE (OvidSP, 1946-), EMBASE (OvidSP, 1974-), Global Health (OvidSP, 1973-), CINAHL (EBSCOHost, 1982-), Education Resources Information Centre (ERIC, Proquest, 1966-), Web of Science (Thomson Reuters, 1945-), the Cochrane Public Health Group Specialized Register, PsychINFO(OvidSP, 1967-), Dissertations & Theses (Proquest, 1637-), LILACS(Virtual Health Library) and Science Direct. Additionally, we handsearched the reference lists of articles for additional relevant papers with an end search date of October 2013. We did not conduct a Cochrane review because of the small number of intervention studies at present and the observational nature of most of the studies we were considering.

Inclusion/exclusion criteria

Studies were required to include at least one measurement of the school food environment. We defined this as the retailing in the area surrounding schools that schoolchildren encounter either on the journey to or from school, or at a lunchtime break from school. We used this definition because we wanted to consider environmental exposures that children were likely to encounter during the school day. This definition included food stores (e.g. supermarkets, convenience stores, farmers' markets) and catering outlets (e.g. fast food, full-service restaurants) but excluded food provision within the school building (e.g. cafeterias, vending machines, school tuckshops). Additionally, we required studies to include outcome data for schoolchildren 5–18 years old. The outcome data needed to include at least one of the following: (i) food purchases; (ii) dietary intake and (iii) body weight.

Study selection

One researcher examined the titles, abstracts and full-text articles. After the first researcher scanned titles and identified exclusions, a second researcher checked a 10% sample of exclusions and identified three papers where there was some disagreement. The title scan was then conducted for a second time, and the second researcher checked a different sample of exclusions and there was complete agreement. The same two researchers reviewed and cross-checked abstracts and full papers.

Classifying and coding the studies

We initially planned to group the studies by exposure and outcome and then, if possible, to perform a meta-analysis of the results. However, because of differences among study research questions, exposure measurements, outcome measurements and methods, formal meta-analysis was not possible, so we followed a semi-quantitative procedure used by Sallis *et al.* (24) and Dunton *et al.* (25). For each study, we identified how the food environment was defined and measured (e.g. type of food outlet, the size of the school neighbourhood) and whether or not it was associated with increased frequency of food purchases, increased consumption of specific foods or increased body weight. We identified whether or not the finding was statistically significant, which we defined as a result that confirmed the hypothesis and had an associated P value of less than or equal to 0.05.

The aim of this semi-quantitative method was to allow a rapid assessment of the strength of the evidence of an association between the exposure and the outcomes of interest by reducing a range of results from heterogeneous analytical designs to two binary questions: Did the study show a positive association between the school food environment and the outcome of interest? If so, was this finding statistically significant ($P < 0.05$)?

Quality assessment

We assessed study quality using standard criteria for reviewing primary research papers that are not randomized controlled trials and following the guidelines presented by Zaza *et al.* (26,27). Because of the heterogeneity of study designs and the lack of a robust framework for ranking studies, we adopted a descriptive approach. Quality was assessed according to study methods (e.g. use of random sampling, use of objective or validated outcome measures, controlling for potential confounders) and reporting (e.g. defining exposure and outcome measures, describing the sample) (see Supporting Information Appendix S2).

After the team established the quality assessment criteria, one researcher completed an initial evaluation of the studies. A second researcher independently completed quality assessments for a 10% sample of the papers and the scores were checked for inter-rater reliability. The quality checks were sent to the corresponding authors of the included studies for verification.

Results

The search retrieved 5,789 articles (see Fig. 1). Results come from 30 papers and 29 studies, featuring results from more than 10,000 schools and 1.5 million students (see Table 1).

General characteristics of included studies

The earliest publication was in 2008 and about three quarters of the papers ($n = 23$) were published between 2011 and 2013. The papers were largely cross-sectional, but there were two longitudinal exceptions from Rossen *et al.*

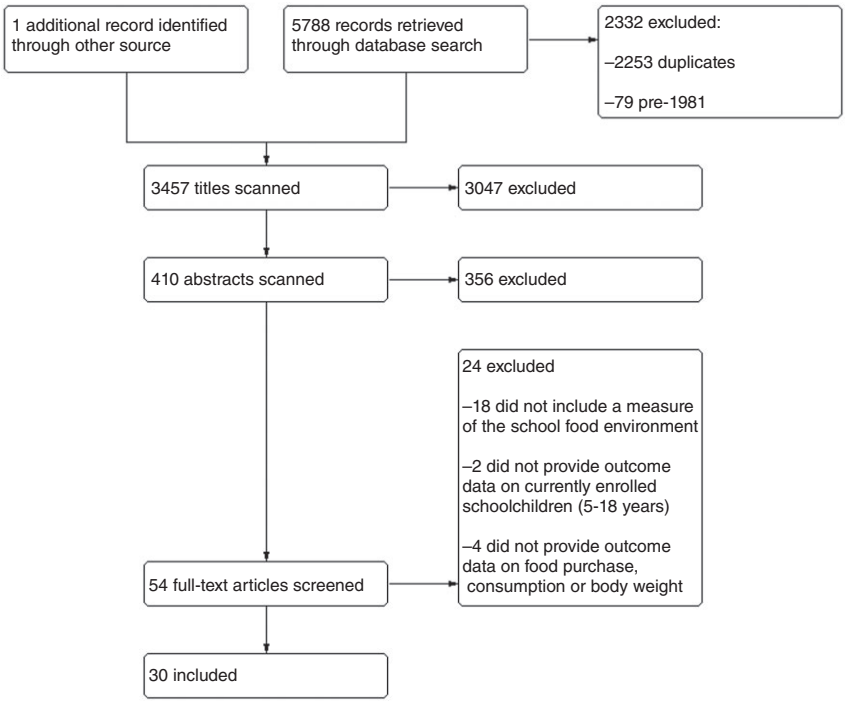

Figure 1 Processing the articles for inclusion in this review.

Table 1 Description of included studies on associations between food outlets around schools and student food purchases, consumption and body weight

Author, year	Country	Age in years (grade)*	Number of students (schools)	Exposure	Type of food outlet	Outcome	Covariates/stratification
An 2012 (46)	United States	5–17	13,462	GIS: density within 0.1, 0.5, 1.0 and 1.5 mile circular buffer of school	CS, FFR, grocery stores and SMs , small food stores	Diet^{SR}: F, V, FF, juice, milk, soda, high-sugar foods	Age, gender, household size, education, parent weight, race/ethnicity, survey wave
Buck 2013 (67)	Germany	6–9	610	GIS: clustering around schools, food retail index (kernel density estimates of FOs per km^2)	Bakeries, FFR, kiosks, SMs	BMI^{M}, Diet^{SR}: Junk food (SSB, chocolate, crisps, etc.)	Age, sex, household income, parent education, under and over-reporting
Chiang 2011 (38)	Taiwan	6–13	2,283	GIS: density within 500-m circular buffer of school	CS, FFR, fresh produce markets, street vendors	BMI^{M}	Age, ethnicity, father's education, household income, pocket money, birth weight, time spent watching TV on weekdays, diet quality, region
Currie 2010 (43)	United States	14–15 (9)	8,373	GIS: presence within 0.1, 0.25 and **0.5** mile straight line buffer	FFR	Body fat^{M}	Census demographics of nearest block, ethnicity, free school meals, school characteristics, school test scores, student : teacher ratio
Davis 2009 (39)	United States	12–17 (7–12)	529,367	GIS: presence within 0.25, 0.25–0.5 and 0.5–0.75 mile straight line buffer. Density within 3 miles	FFR, 'other restaurants'	BMI^{SR} and diet: F, V, juice, soda, fried potatoes	Age, gender, grade, physical activity, FSM eligibility, race/ethnicity, school location type, school type
Forsyth 2012 (68)	United States	11–14 (6–9)	2,724 (20)	GIS: Density within 800-m street network buffer	FFR: traditional, pizza, subs/sandwiches, other FF	Diet: FF	Ethnicity/race, grade level, gender, SES
Gebremariam 2012 (30)	Norway	11–12 (6)	1,425 (35)	Survey of school staff: presence 'within walking distance from school'	'Food outlets where food or drinks could be purchased'	Diet^{SR}: F, V, snacks, SSB, fruit drinks	Canteen/food booth at school, food outlets present, gender, parent education, school nutrition committee, school's perceived responsibility for student diet, two parents
Gilliland 2012 (34)	Canada	10–14	1,048 (28)	GIS: presence within 500 and 800-m straight line buffer, street network buffer and school walkshed†	CS, FFR	BMI^{SR}	Age, sex
Grier 2013 (40)	United States	12–17	1,000	GIS: straight line distance to closest outlet	FFR	BMI^{SR} and diet^{SR}: soda	Age, grade, sex, physical activity, race/ethnicity, school time, per cent eligible for FSM, school urbanicity
Harris 2011 (69)	United States	14–17 (9–12)	552 (11)	GIS: density within 2 km (1.24 mile) straight line buffer of school, distance to closest store	Bagel shops, bakeries, coffee shops, FFR (burger/fries or Mexican), fried chicken restaurant, ice cream shops, pizza parlours, sandwich/sub shops, sit-down restaurants, snack bars	BMI^{SR}	Age, birth weight, diet quality, ethnicity, father's education, household income, pocket money, region, time spent watching TV on weekdays
Harrison 2011 (33)	England	9–10	1,995	GIS: density within 800-m pedestrian network buffer weighted sum of the distance to every facility within 6 km of home and school	'Healthy outlets' (SMs and green grocers), 'unhealthy outlets' (CS and takeaway)	Fat mass index^{M}	Age, sex, parent education, mode of travel to school
He 2012 (45)	Canada	11–13 (7–8)	810 (21)	GIS: density within 1-km straight line buffer; shortest network distance to nearest outlet	CS, FFR	Food purchase^{SR}	Mode of transportation, father's education, land use mix
He 2012 (35)	Canada	11–13 (7–8)	810 (21)	GIS: density within 1-km straight line buffer; shortest network distance to nearest outlet	CS, FFR	Diet^{SR}: HEI	Gender, grade level, neighbourhood distress score, annual family income, ethnicity, family structure, parent education
Heroux 2012 (65)	Canada, Scotland, United States	13–15	26,778 (687)	GIS: density within 1-km straight line buffer	CS, chain FFR restaurants and cafés	BMI^{SR}	Family affluence, grade, sex
Howard 2011 (44)	United States	14–15 (9)	(879)	GIS: Presence within 800-m network buffer	CS, FFR	BMI^{M}	Ethnicity, percentage of students receiving free meals, urbanicity

Table 1 *Continued*

Author, year	Country	Age in years (grade)*	Number of students (schools)	Exposure	Type of food outlet	Outcome	Covariates/stratification
Langellier 2012 (70)	United States	10–15 (5–9)	(1,694)	GIS: presence within 800-m network buffer	Corner stores, FFR	BMI^{M}	Eligibility for title 1 funding, race/ethnicity, school type, urbanicity
Laska 2010 (71)	United States	11–18	334	GIS: density within 800, 1,600 and 3,200 m network buffer	Bakeries/doughnut shops, FFR, gas stations, grocery stores, variety stores	BMI^{SR}	Age, parent education, school and area-level SES, sex
Leatherdale 2011 (72)	Canada	9–13 (5–8)	2,429 (30)	GIS: density within 1-km straight line buffer	Any retail facilities, CS, FFR, grocery stores	BMI^{SR}	Ethnicity, gender, grade, physical activity
Li 2011 (36)	China	11–17	1,792 (30)	Survey of school staff: 'presence within 10-min walk of school'	Western FFR	BMI^{M}	Age, household wealth, parent BMI, parent education
Nixon 2011 (41)	United States	14–15 (9)	(41)	GIS: density within 400- and 800-m straight line buffer, closest facility, degree of clustering around schools	FFR	BMI^{SR}	School lunch policy, percentage of students receiving free meals, race/ethnicity, percentage of students in talented education program, parent education level
Park 2013 (37)	South Korea	9–15 (4–9)	1,342	Survey: density within 500-m radius of school	SM, traditional markets, F and V markets, street vendors, snack bars, CS, FFO, doughnuts, ice cream, bakery shops, full-service restaurants	BMI^{M}, HEI	Age, sex, screen time, family affluence, mother's employment, school nutrition environment (composite index), social safety net program participants
Richmond 2013 (73)	United States	11–14 (6–8)	18,281 (47)	GIS: density within a 1,500-m straight line buffer	FFR, CS	$Diet^{SR}$: SSB	Age, sex, race/ethnicity, percentage of students receiving free school meals
Rossen 2013 (28)	United States	8–13	319	GIS: mean healthy food availability index (HFAI), density of outlets within 100 m of shortest street network path between home and school	CS, SM/GS, CS, restaurants (full service or carry-out), gas stations	BMI^{M} , waist circumference (baseline and 1 year)	Age, gender, race/ethnicity, number of siblings, receipt of free or reduced price lunch, walking to school status, distance to school (log km), school violence strata, census-tract deprivation index
Sánchez 2012 (42)	United States	10–15 (5–9)	926,018 (6,362)	GIS: density within 800-m straight line buffer around school	CS, FFR	BMI^{M}	Age, sex, school-level characteristics and interactions with race/ethnicity
Schafft 2009 (74)	United States	10–13 (5, 7)	243 school districts	GIS: absence of 'large grocery store' within 10 mile straight line buffer around 'population based centroid' of the school district	Large grocery store: grocery or retail food store with more than 50 employees	BMI	Median family income, per cent mobile home residence, per cent incomplete kitchen
Seliske 2009 (75)	Canada	11–16	7,281 (178)	GIS: density within **1** and 5 km straight line buffer	CS, doughnut/coffee shops, FFR, full-service restaurants, sub/sandwich shops	BMI^{SR} ‡	BMI, family affluence scale, physical activity, sex, urbanicity
Smith 2013 (29)	England	11–16	1,382 (29)	GIS: density within 400 and **800-m** road network buffer, median and minimum distance to grocer or TA	TA, grocer/SM/CS	Diet quality: 'Healthy' or 'Unhealthy' (aggregate score)	Age, gender, FSM eligibility, ethnicity, school-level deprivation
Svastisalee 2012 (47)	Denmark	11–15 (5–9)	6,034 (80)	GIS: 'Exposure:' number of FOs divided by total road segments within 300 m of schools	FFR, SMs	$Diet^{SR}$: F, V	Age, family social class, sex
Timperio 2009 (32)	Australia	5–12	816	GIS: density within 50 m buffer along route to school, Presence of FO along route	Cafes, FFR, restaurants, takeaway stores	$Diet^{SR}$: FF or takeaway	Age, SES
van der Horst 2008 (31)	Netherlands	12–15	1,293 (15)	GIS: density within 500-m straight line buffer	Bakery, FFR, fruit/vegetable store, large SM, small food store	$Diet^{SR}$: SSB and snacks	Date of measurement, ethnicity, education

Buffer size in **bold** indicates the buffer distance that we used in our analysis.
*When papers reported student grade level only, we inferred age in years from the grade described in parentheses.
†The walkshed is the territory within a school's catchment that encompasses only those students living within walking distance.
‡Outcome was percentage of students falling within a 'healthy fitness zone', which includes both fitness measures and BMI.
BMI, body mass index; CS, convenience store; F, fruit; FF, fast food; FFR, fast food restaurant; FO, food outlet; FSM, free school meal; HEI, healthy eating index (a composite variable that reflects overall diet quality); M, measured; SES, socioeconomic status; SM, supermarket; SR, self-report; SSB, sugar-sweetened beverage; V, vegetable.

(28) and Smith *et al.* (29). Most of the studies took place in North America (United States: $n = 14$; Canada: $n = 5$) but there were also studies from Europe ($n = 6$), Asia ($n = 3$) and Australia ($n = 1$). One multi-country study from the United States, Scotland and Canada was also included. Participant age ranged from 5 to 17 years. Sample sizes ranged widely from 334 to 926,018 students and more than three quarters of the studies had more than 1,000 students. Most of the papers did not explicitly identify the theoretical model informing their work, but those that did (30,31) cited social ecological models.

Methods for defining and measuring the school food environment

Studies varied in their methods of constructing exposure measures in terms of the level of the exposure (whether or not it accounted for individual variation) and the source of information (primary vs. secondary sources).

Level of exposure: area-level vs. individual-level exposures

Area-level exposures were based on a static area such as a buffer around the school or the school's census tract. Most of the included studies used area-level measures, defined at the level of the school, which meant that all students attending the same school had a shared exposure value ($n = 21$). The alternative approach of using an individual-level exposure, where quantification of food outlets accounted for individual factors such as a student's home address, was used by nine studies. Three papers (28,32,33) accounted for the student's journey through the food environment by taking the student's school and residential address and calculating the number of outlets falling along the route between the two locations. Gilliland *et al.* (34) used multilevel structural equation modelling techniques to simultaneously test the effects of the school-environment and home-environment predictors on body mass index (BMI) scores and He *et al.* (35) calculated individual participants' 'junk food density' based on the density of stores around both students' home and school address.

Geographical information systems vs. survey-based measures of exposure

The predominant method of characterizing the food environment exposure was by using geographical information systems (GIS) ($n = 27$). Most commonly, this was done through use of a software program to construct a buffer zone (straight line, street or pedestrian network) around the child's school or the route between home and school and then counting the number of food outlets within that area (density). For studies using this density method, the buffer distances ranged from 0.1 to 3.0 miles (about 160–4,800 m) for the area around schools and from 50 to 100 m for the area around routes. For the former category, the most frequently used buffer distance was half a mile (about 800 m). Most of the papers using buffer zones provided rationale for using the buffer distance that they did ($n = 25$) and for about one-third of them ($n = 12$), at least one of the cited reasons was to be consistent with earlier studies. Another GIS method calculated the distance from the school to the nearest outlet (proximity). For these GIS-based studies, information about the locations, names and types of food outlets came predominantly from large secondary data sources including private companies and local business directories ($n = 18$) or public records such as census data, tax registry documents or government food premise databases ($n = 8$). Harris *et al.* collected store data using a global positioning system (GPS) unit and adding these geo-referenced points to a digital map.

Subjective measures of the retail food environment included the use of questionnaires. Two studies identified food outlets via a questionnaire in which school administrators identified the presence of food outlets 'within walking distance' (30) or within 'ten minutes' walk' (36) of the school. Park *et al.* (37) used an audit tool to record observations of the various types of food outlets found within a 500-m radius of the school.

Defining types of food outlets

Food outlet definitions and categories varied between papers and, in the instances when they were explicitly defined, often depended on the definitions provided by the original data source. A range of food outlets were included, but most of the studies narrowed their measures to a few specific types. The most common types of outlets to be included were fast food restaurants ($n = 23$), convenience stores ($n = 10$), supermarkets ($n = 6$) and grocery stores ($n = 7$).

Types of outcomes: food purchasing behaviour, consumption and body weight

Of the three outcomes we considered in this review, the most common was body weight, with 20 papers evaluating environmental associations with BMI ($n = 18$) and fat mass ($n = 2$). The second most common outcome was food consumption, with 14 papers evaluating associations between the environment and diet. Food consumption was predominantly assessed as daily or habitual consumption (rather than food consumption at school). A range of specific foods were measured, but the most frequently evaluated were fruit and vegetables ($n = 4$), soda or sugar-sweetened beverages ($n = 7$), or fast food ($n = 4$). Three papers used a composite variable such as a Healthy Eating Index (HEI; $n = 2$) or a

healthy diet score ($n = 1$). Of the three types of outcomes we considered, food purchases were measured least frequently, with only one paper including it as an outcome. This measure was based on participant's self-report of purchasing fast food at least once in the previous week.

Quality assessment

We assessed the quality of studies using 13 criteria that included whether or not studies randomly selected participants, provided clear definitions of the study area, validated their exposure and outcome measurements, or attempted to control for potential confounders. When it was applicable, most papers randomly selected schools ($n = 18$) and students ($n = 19$), and defined the area of measurement (i.e. the 'school neighbourhood') in terms of a defined spatial size ($n = 27$). Nine studies validated their exposure measures via ground-truthing and three via Google Maps. Nine of the 14 studies measuring diet used a validated instrument. Twelve of the 20 studies with BMI or weight as an outcome used objective measures and eight relied on self-report. Almost all of the studies adjusted for potential confounders in their final analysis with the most common adjustments for socioeconomic status ($n = 26$), race/ethnicity ($n = 20$) and urbanicity/population density ($n = 8$).

Results from the included studies

The results below are organized according to their outcome measures. Because of the heterogeneity in study design, we report the following results in terms of increased food purchases, increased consumption or increased body weight. We chose an arbitrary level of significance ($P = 0.05$).

Because of a diverse range of exposures, outcomes, levels of adjustments and the number of analyses reported by individual studies, and to avoid over-representing results from papers that reported many results, we used the following criteria to determine which results to feature in Tables 2–4. When papers presented results using multiple levels of adjustment, we took the most adjusted. When results were stratified using categorical variables (e.g. ethnicity), we included all results, but when they were stratified using ordered variables (e.g. grade or social class) we took the result from the highest and lowest levels only. When papers presented results using multiple exposure measures (varying buffer sizes and types, GIS methods, and means of quantifying food outlets), we included the network buffer size closest to 800 m and the 'density' variable that accounted for the most individual-level variation. When papers presented results of multiple outcomes related to weight (BMI, waist circumference, triceps skinfold thickness), we used the outcome closest to our primary outcome of interest (BMI). All of the results (both included and excluded) have been provided (Supporting Information Appendixes S3–S5).

Food outlets and body weight

Twenty papers looked at the relationship between food outlets and body weight. Of the 72 associations (reported in Table 2), 43 showed a positive relationship between body weight and exposure to food outlets. Nineteen of these positive relationships were significant, with most in the expected direction after adjustments. These included positive associations between exposure to fast food outlets and BMI (34,36,38–40), obesity (37) and the proportion of overweight (41,42) or obese (43) students. Positive associations were also observed between the presence of 'unhealthy outlets' (convenience stores and takeaways) and adiposity among girls who walk or cycle to school (33) or convenience stores and proportion of overweight students (42,44).

Food outlets and food purchases

Although three studies reported measuring food purchases, only one paper provided results. He *et al*. found that high fast food outlet density was positively correlated with student report of fast food purchases in the past week and this was significant ($P < 0.05$) (45) (see Table 3).

Food outlets and consumption of foods high in fat, sugar or salt

Ten papers measured associations between food outlets and consumption of foods high in fat, sugar or salt, the most common of which were sugar-sweetened beverages ($n = 6$) and 'fast-food' (including fried potatoes) ($n = 4$) or an aggregate variable that took these foods into account) (see Table 3). In total, 54 associations between these foods and retail outlets were reported and in about half ($n = 28$), food outlets were associated with increased consumption. However, only two of these results were significant ($P < 0.05$); Smith *et al*. found that unhealthy diet scores (reflecting frequency of consuming crisps, sweets, biscuits, fried food, fizzy drinks) were negatively correlated with the minimum distance to grocery stores and takeaways within 800 m (29).

Food outlets and consumption of fruits, vegetables or overall diet quality

Four papers considered associations between food outlets and fruit and vegetable consumption (see Table 4) (30, 39,46,47). A total of 32 associations were reported and in about half ($n = 18$), exposure to food outlets was associated with increased consumption of fruit and vegetables. Three of these associations were significant ($P < 0.05$) and they all related to fast food outlets. An (46) observed positive association between the presence of fast food outlets and vegetable consumption among adolescents and Davis

Table 2 Summary of findings: food outlets around schools and student body weight

Author	Type of food outlet	Outcome			Increases weight?	$P < 0.05$
Buck 2013 (67)			β	*P* value		
	FRI	BMI *z* score	0.110	0.17	Yes	No
Chiang 2011 (38)	# within 500 m	BMI *z* score	β			
	CS	Boys	0.010		Yes	No
	FF		0.080		Yes	Yes
	CS	Girls	0.020		Yes	No
	FF		0.030		Yes	No
Currie 2009 (76)	FO within 800 m*	% obese	β	SE		
	FFR	Ninth graders	–0.0391	0.4475	No	No
	Other		0.4638	0.4881	Yes	No
	FFR	Fifth graders	0.4341	0.1844	Yes	Yes
	Other FO		0.2879	0.2312	Yes	No
Davis 2009 (39)	FO within 800 m*	BMI	*b*	95% CI		
	FF		0.10	0.03, 0.16	Yes	Yes
	Other FO		0.08	0.01, 0.14	Yes	Yes
Gilliland 2012 (34)	FO within school walkshed	BMI *z* score	Estimate	SE		
	FFR		0.073	0.034	Yes	Yes
	Presence of CS (school walkshed)		0.020	0.021	Yes	No
Grier 2013 (77)	Distance	B	95% CI			
	FFR	BMI	–0.050	–.10, .00	Yes†	Yes
Harris 2011 (69)	# within 2 km	BMI	β	*P*		
	Restaurants		0.010	0.31	Yes	No
	Pre-packed food stores		3×10^{-4}	0.96	Yes	No
	Grocery stores		0.046	0.53	Yes	No
	Other stores		0.020	0.78	Yes	No
	Stores overall		0.000	0.66	Yes	No
Harrison 2011 (33)	School access (high vs. low)	FMI for girls	*B*	95% CI		
	Healthy FOs	Car, bus or train	0.020	–0.068, 0.110	Yes	No
	Unhealthy FOs		0.010	–0.107, 0.130	Yes	No
	Healthy FOs	Walk or cycle	–0.090	–0.183, –0.006	No	No
	Unhealthy FOs		0.140	0.009, 0.280	Yes	Yes
	Route to school access (present vs. not)					
	Healthy FOs present	Car, bus or train	–0.021	–0.104, 0.062	No	No
	Unhealthy FOs present		0.041	–0.029, 0.110	Yes	No
	Healthy FOs present	Walk or cycle	–0.032	0.143, 0.078	No	No
	Unhealthy FOs present		0.007	–0.068, –0.082	Yes	No
Heroux 2012 (65)	# within 1 km (ref: 0)	OW/obesity	OR	95% CI		
	All FOs (5+)	Canada	0.97	0.80, 1.18	No	No
	CS (5+)		1.00	0.79, 1.26	No	No
	FFR (5+)		0.81	0.63, 1.06	No	No
	Cafes (3+)		0.79	0.53, 1.21	No	No
	All FOs (5+)	Scotland	0.89	0.61, 1.29	No	No
	CS (5+)		1.05	0.61, 1.80	Yes	No
	FFR (5+)		0.60	0.32, 1.15	No	No
	Cafes (3+)		0.66	0.42, 1.03	No	No
	All FOs (5+)	United States	1.01	0.84, 1.23	Yes	No
	CS (5+)		1.11	0.87, 1.40	Yes	No
	FFR (5+)		0.99	0.81, 1.22	No	No
	Cafes (3+)		0.98	0.66, 1.41	No	No
Howard 2011 (44)	FO within 800 m	% OW	β	SE		
	FFR		–0.010	0.58	No	No
	CS		0.050	0.59	Yes	Yes
	SM		–0.010	0.65	No	No

Table 2 *Continued*

Author	Type of food outlet	Outcome			Increases weight?	$P < 0.05$
Langellier 2012 (70)	FO within 800 m*	% OW	β	SE		
	Corner store or liquor store		1.63	0.61	Yes	Yes
	FFR		0.35	0.52	Yes	No
Laska 2010 (71)	Presence within 800 m		β	95% CI		
	Any restaurant	BMI *z* score	–0.28	–0.50, –0.07	No	Yes
Leatherdale 2011 (78)	# within 1 km	OW (vs. normal weight)	AOR	95% CI		
	Gas stations		1.46	0.79, 2.68	Yes	No
	FFO		0.96	0.82, 1.13	No	No
	Bakeries/doughnut shops		0.89	0.68, 1.15	No	No
	Variety stores		0.82	0.59, 1.13	No	No
	Grocery stores		1.10	0.86, 1.42	Yes	No
Li 2011 (36)	# within 10 min walk (ref: 0)	BMI	β	95% CI		
	FFR (1)		0.60	–0.02, 1.1	Yes	No
	FFR (≥2)		0.80	0.1, 1.4	Yes	Yes
Nixon 2011 (41)	FFR clustering	% not within HFZ*	Moran's I index*	*P* value		
	400 m		1.24	$P < 0.01$	Yes	Yes
	800 m		0.37	$P < 0.05$	Yes	Yes
Park 2013 (37)	FO density (low: ref)	Obese	OR	95% CI		
	Markets (SM, traditional, FV)		1.04	.99, 1.11	Yes	No
	Street vendors, snack bars, CS		0.98	.95,1.01	No	No
	FFR, doughnuts, ice cream, bakery shops		1.02	1.00,1.04	Yes	Yes
	Full-service restaurants		0.99	.98, 1.01	No	No
Rossen 2013 (79)	FO within 100-m path to school	1 year change	*b*	95% CI		
	HFAI*	BMI	–0.15	–0.26, –0.13	No	Yes
Sánchez 2012 (42)	Presence within 800 m	% OW	APR	95% CI		
	FFR (≥1 vs. 0)		1.02	1.01, 1.03	Yes	Yes
		White	1.02	1.00, 1.04	Yes	Yes
		Hispanic	1.02	1.01, 1.03	Yes	Yes
		Black	1.03	1.00, 1.06	Yes	Yes
		Asian	0.94	0.91, 0.97	No	Yes
	CS (per additional FO)		1.01	1.00, 1.01	Yes	Yes
		Fifth grade	1.01	1.00, 1.02	Yes	Yes
		Ninth grade	1.00	0.99, 1.01	No	No
Schafft 2009 (74)	Absence within 10 miles	% OW/at risk	*b*	SE		
	Large grocery or SM		0.044	0.020	No†	Yes
Seliske 2009 (75)	Presence within 1 km (ref: 0 vs. high)	OW vs. normal	OR	95% CI		
	FFR		0.83	0.70, 0.98	No	Yes
	Sub/sandwich shops		0.78	0.64, 0.93	No	Yes
	Doughnut/coffee shops		0.81	0.68, 0.96	No	Yes
	Total FRI		0.70	0.61, 0.81	No	Yes

*Approximate: rounded from ½ mile (804.7 m).
†Measure is the distance from food outlet and weight outcome or the absence of food outlet and weight outcome.
AOR, adjusted odds ratio; APR, adjusted prevalence ratio; BMI, body mass index; CS, convenience store; FFR, fast food restaurant; FO, food outlet; FRI, food retail index (# of FOs per 1,000 residents); HFAI, healthy food availability index (based on the availability of foods from eight food groups within each outlet); HFZ, healthy fitness zone (accounts for school fitness levels and student BMI); IRR, incidence rate ratio; OR, odds ratio; OW, overweight; SE, standard error.

(39) observed a negative association between proximity to fast food and fruit or vegetable consumption.

Food outlets and healthy eating indexes

Three papers included composite variables that reflected overall diet quality (29,37,45) (see Table 4). Of seven associations, four were positively correlated with increased healthy eating scores. Among these, there were two significant ($P < 0.05$) findings. He *et al.* (35) looked at associations between food outlets around schools and the HEI score, which reflects overall diet quality, and found that students attending schools with a convenience store or fast

Table 3 Summary of findings: food outlets around schools and student consumption or purchase of foods high in fat, sugar or salt (HFSS)

Author	Type of food outlet	Outcome			Increases consumption	$P < 0.05$
An 2012 (46)	# within 500 m		Child IRR	SE		
	FFR	Soda	1.006	0.011	Yes	No
		High-sugar food	0.998	0.008	No	No
		Fast food	0.991	0.01	No	No
	CS	Soda	0.984	0.036	No	No
		High-sugar food	0.986	0.027	No	No
		Fast food	0.987	0.033	No	No
	Small FO	Soda	1.002	0.011	Yes	No
		High-sugar food	0.999	0.007	No	No
		Fast food	1.006	0.009	Yes	No
	Grocery	Soda	1.013	0.039	Yes	No
		High-sugar food	1.022	0.025	Yes	No
		Fast food	1.029	0.035	Yes	No
	Large SM	Soda	0.995	0.035	No	No
		High-sugar food	0.955	0.024	No	No
		Fast food	1.008	0.031	Yes	No
			Adolescent			
	FFR	Soda	0.989	0.011	No	No
		High-sugar food	1.029	0.016	Yes	No
		Fast food	0.993	0.012	No	No
	CS	Soda	0.984	0.039	No	No
		High-sugar food	1.051	0.055	Yes	No
		Fast food	1.005	0.032	Yes	No
	Small FO	Soda	1.002	0.009	Yes	No
		High-sugar food	1.013	0.015	Yes	No
		Fast food	1.01	0.009	Yes	No
	Grocery	Soda	1.023	0.036	Yes	No
		High-sugar food	0.96	0.047	No	No
		Fast food	1.042	0.043	Yes	No
	Large SM	Soda	1.038	0.039	Yes	No
		High-sugar food	1.033	0.04	Yes	No
		Fast food	1.06	0.036	Yes	No
Buck 2013 (67)	# per 1,000 people		Exp β	*P* value		
	FRI	Junk food*	1.04	0.57	Yes	No
		Simple sugar food†	0.99	0.87	Yes	No
Davis 2009 (39)	Proximity	# of servings	b	95% CI		
	FFR	Soda	0.02	–0.01, 0.04	Yes	No
		Fried potatoes	0	0.02, 0.02	No	No
Forsyth 2013 (80)	# within 800 m	Adjusted weekly frequency		Dif *P* value‡		
	FFR type		Boys			
	Traditional§	0	1.0			
		1+	0.7	0.066	No	No
	Pizza	0	0.9			
		1+	0.9	0.998	No	No
	Sandwiches	0	0.8			
		1+	0.9	0.341	Yes	No
	Other	0	1.2			
		1+	1.2	0.832	No	No
	All types	0	3.6			
		1–2	4			
		3+	4.4		Yes	No
		Trend *P* value**	0.644			
			Girls			
	Traditional	0	1.0			
		1+	0.9	0.673	No	No
	Pizza	0	0.9			
		1+	0.9	0.822	No	No
	Sandwiches	0	0.8			
		1+	0.8	0.949	No	No
	Other	0	1.2			
		1+	1.2	0.927	No	No
	All types					
		0	3.6			
		1–2	4.3			
		3+	3.2		No	No
		Trend *P* value**	0.299			
Gebremariam 2012 (30)	# within walking distance		β	SE		
	FOs	Snacks	–0.193	0.494	No	No
		SSB	–0.002	0.153	No	No

Table 3 *Continued*

Author	Type of food outlet	Outcome			Increases consumption	$P < 0.05$
Grier 2013 (81)	Distance from school		β	95% CI		
	FFR	Soda	–0.01	–.03,.04	Yes**	No
Richmond 2013 (73)	# within 1,500 m	Mediational effect¶	β	SE		
	FFR and CS	SSB (servings per day)	0.0001	0.001	Yes	No
Smith 2013 (29)	Distance to school (min)	Unhealthy diet	β	95% CI		
	Grocer (800 m)		–0.001	–0.003, 0.000	Yes**	Yes
	Takeaway (800 m)		–0.002	–0.004, 0.000	Yes**	Yes
Timperio 2009 (32)	Access along route to school		AOR	95% CI		
	# of FF or TA	Consumed ≥1/wk	1	1.0, 1.0	No	No
van der Horst 2008 (31)	# within 500 m	Litres per day	β			
	SM	Soft drinks	0.077		Yes	No
	FFR		–0.055		No	No
	Small food stores		–0.259		No	Yes
Food outlets and purchases of HFSS foods						
He, 2012 (35)	# within 1 km	Previous week	OR	95% CI		
	FFR	FF purchase	1.4	1.1, 1.7	Yes	Yes

*SSB, chocolate, nut-based spreads, crisps, chocolate bars, candies.
†Fruit juice, SSB, sugar-added cereals, chocolate, candy, etc.
‡Dif *P* value: difference between those with 0 and those with 1 at $P < 0.05$; *t*-test.
§Traditional FF: burgers and fries.
¶Mediational effect of FO density on association of race/ethnicity and SSB consumption.
**Exposure is expressed as *distance* to food outlet.
AOR, adjusted odds ratio; CS, convenience store; FF, fast food; FFR, fast food restaurant; FO, food outlet; FRI, food retail index (# of FOs per 1,000 residents); HFAI, healthy food availability index (based on the availability of foods from eight food groups within each outlet); OR, odds ratio; OW, overweight; SM, supermarket.

food outlet farther than 1 km away had a significantly higher HEI score than students with an outlet within 1 km (35). Smith *et al*. found a positive correlation between distance to grocers and healthy diet scores.

Discussion

Principal findings

This review examined associations between the food environment around schools and children's food purchases, consumption or body weight. The methods for defining and measuring the food environment varied widely between studies and few consistent findings emerged. We found little reported evidence for an effect of the school food environment on food consumption patterns and limited evidence of an effect on food purchases, but some evidence of an effect on body weight. However, these results should be interpreted cautiously. These studies were observational and therefore susceptible to confounding. With only two exceptions (from the longitudinal studies of Smith *et al*. and Rossen *et al*.), the evidence base is composed almost entirely of cross-sectional data. Measurement bias is likely, particularly with the diet-related outcomes, where misreports have been shown to vary children's characteristics (age, sex, weight) and social factors (48). Reporting bias is possible, which is suggested by the fact that several papers reported significant results only.

Strengths and weaknesses

We were unable to assess pooled effects as there were many definitions and measures of the food environment surrounding schools (6). One strength of this review was that it provided some focus by honing in on one specific element of the food environment – the presence of retail food outlets in the area surrounding schools. However, this strength was also a weakness; this definition does not account for all of the other relevant obesogenic environments that a child will encounter over the course of a day (49,50) and it prevented us from considering research about the other elements of food access, such as availability, accessibility, affordability and accommodation (5,7,51). The recent review by Caspi *et al*. provides a helpful overview of these other influences (5). Additionally, the focused nature of this review kept us from considering the environment within retail outlets (e.g. product availability or placement within stores), but another recent review by Ni Mhurchu *et al*. suggests that this aspect of the food environment is not consistently associated with dietary outcomes (52). As here, methodological heterogeneity makes it difficult to draw firm conclusions.

As noted earlier, given the heterogeneity of the studies and the wide range in the number of exposures, outcomes and analyses that individual papers reported, we did not include every single result that every paper provided in our overall assessment. We used a consistent and transparent

Table 4 Summary of findings: food outlets around schools and student consumption of fruit and vegetables or healthy eating indexes

Author	Type of food outlet	Outcome			Increases consumption?	$P < 0.05$
An 2012 (46)	FO within 800 m*		Child			
			IRR	SE		
	FFR	Fruits	1.003	0.005	Yes	No
		Vegetables	0.997	0.006	No	No
	CS	Fruits	0.986	0.015	No	No
		Vegetables	1.003	0.019	Yes	No
	Small FO	Fruits	1.002	0.005	Yes	No
		Vegetables	1.004	0.005	Yes	No
	Grocery	Fruits	1.015	0.015	Yes	No
		Vegetables	1.015	0.018	Yes	No
	Large SM	Fruits	1.009	0.016	Yes	No
		Vegetables	0.996	0.019	No	No
			Adolescent			
	FFR	Fruits	1.007	0.006	Yes	No
		Vegetables	1.017	0.008	Yes	Yes
	CS	Fruits	1.000	0.021	No	No
		Vegetables	0.987	0.026	No	No
	Small FO	Fruits	0.996	0.007	No	No
		Vegetables	1.002	0.010	Yes	No
	Grocery	Fruits	0.962	0.028	No	No
		Vegetables	0.995	0.029	No	No
	Large SM	Fruits	1.020	0.021	Yes	No
		Vegetables	1.001	0.026	Yes	No
Davis 2009 (39)	*P*	*# of servings*	*b*	95% CI		
	FFR	Fruit	–0.02	–0.04, 0.00	No	Yes
		Vegetables	–0.02	–0.03, 0.00	No	Yes
Gebremariam	FO within walking distance		β	SE		
2012 (30)	FOs	Fruits	–0.016	0.096	No	No
		Vegetables	–0.087	0.122	No	No
Svastisalee			Low family social class			
2012 (47)	SMs (low vs. high)	Infrequent consumption	AOR	95% CI		
		Fruit	1.17	0.89, 1.54	Yes§	No
		Vegetables	1.33	0.92, 1.90	Yes§	No
	FFR (high vs. low)	Fruit	1.32	0.98, 1.76	No§	No
		Vegetables	1.17	0.80, 1.71	No§	No
			High family social class			
	SMs (low vs. high)	Infrequent consumption	AOR	95% CI		
		Fruit	1.08	0.80, 1.45	Yes§	No
		Vegetables	1.04	0.80, 1.35	Yes§	No
	FFR (high vs. low)	Fruit	1.23	0.89, 1.69	No§	No
		Vegetables	1.26	0.95, 1.66	No§	No
Food outlets and composite variables						
He 2012 (45)	# within 1 km	HEI‡ score	Daff	SE		
	FFR (0) (ref: ≥3)		2.75	1.06	Yes	Yes
	FFR (1–2) (ref: ≥3)		0.66	1.14	Yes	No
Park 2013 (37)	# within 500 m	HEI‡	β	SE		
	Markets (SM, traditional, FV)		–0.02	0.06	No	No
	Street vendors, snack bars, CS		0.04	0.08	Yes	No
	FFR, donuts, ice cream, bakery		–0.13	0.07	No	No
	Full-service restaurants		0.03	0.07	Yes	No
Smith 2013 (29)	Minimum distance	Healthy diet	β	95% CI		
	Grocer (800 m)		0.002	0.000, 0.003	No‡	Yes

*Approximate: rounded from ½ mile (804.7 m).
†Difference in HEI score compares the difference in scores between schools where nearest outlet was <1 km away and schools where nearest outlet was ≥1 km away.
‡Exposure is expressed as *distance* to food outlet.
§Outcome is *infrequent* consumption.
AOR, adjusted odds ratio; CS, convenience store; FF, fast food; FFR, fast food restaurant; FO, food outlet; FRI, food retail index (# of FO's per 1000 resident); HE, healthy eating index, a composite variable based on habitual meal habits (e.g. skipping breakfast) or consumption (fruit, vegetables, milk, soda, FF, Ramen noodles, chips, fried food, etc.); HFAI, healthy food availability index (based on the availability of foods from eight food groups within each outlet); IRR, incidence rate ratio; OR, odds ratio; OW, overweight; SE, standard error; SM, supermarket; TA, takeaway.

approach to select results from studies so as to avoid conclusions being overweighted by studies that reported multiple findings from the same dataset. For example, for the BMI outcome, we reported 72 associations, with 43 showing a positive correlation with food outlets (28 of those being significant). Comparing these figures to all results reported (and featured in the Supporting Information Appendix S3), there were 142 associations, with 89 showing a positive correlation of weight with food outlets and 53 being significant. We have highlighted the instances

when there were significant associations that varied from what we reported (either in terms of direction or significance) in the Supporting Information Appendix. Davis *et al.* (39) presented associations on the school food environment and body weight within three buffer sizes: 0–0.25 miles, 0.25–0.5 miles and 0.5–0.75 miles. We showed the results from 0.5 miles, which again were in the same direction of association as the other two buffer sizes, although the association between fast food outlets and BMI was not significant at the 0.5–0.75 mile area of exposure while it was significant at the two smaller sizes. Therefore, choosing to present the results as we did may have altered our assessment of the number of associations that are significant compared to if we had chosen to use the larger buffer. Finally, Currie (43) presented associations with exposure at 0.1, 0.25 and 0.5 mile buffers and we presented the latter. For exposure to 'other restaurants', the results are in the same direction and at the same significance level, but for fast food exposure, the associations were not significant at the smaller buffer sizes (as they were at the larger size for fifth graders). For dietary outcomes, please see the Supporting Information Appendix for a full list of results and how our inclusion decision may have altered the assessment. For example, Svastisalee *et al.* reported additional analyses assessing interactions between fast food and supermarkets and associations with fruit and vegetable consumption according to social class and found that children from low and middle social class backgrounds attending schools with high fast food and low supermarket exposure were most likely to report infrequent fruit intake. A final limitation is that despite a comprehensive search in 10 databases and hand-searching references, we failed to identify one paper that did not have MeSH headings attached. Fortunately, this paper was identified by a reviewer and it is represented here.

Implications for policy

Overall, this review did not find strong evidence at this time to support policies aimed at regulating food environments around schools. However, given that food retailing is already influenced by a number of other policy drivers (related to economics, antisocial behaviour, litter and pollution, food hygiene, etc.), it is important that broader public health evidence is also considered. However, it is not possible to draw conclusions until a higher quality evidence base is developed.

Implications for research

To improve the quality of the evidence base, future longitudinal data are required to account for changes that may occur in the food environment over time. As earlier reviews found (7), the research has relied on cross-sectional data with the most common approach to characterizing the retail food environment in this body of literature being to calculate the density or proximity of outlets within a buffer using indirect sources of food outlet data (such as directories or large databases). These methods bring up several questions about data accuracy and comprehensiveness, especially given that food outlet data are imperfect (53), which may have implications for exposure assessment accuracy. Questions also remain about which types of outlets to focus on. Earlier reviews noted a focus on fast food outlets and recommended that future studies include other types of outlets in their exposure measures (7), but we found that a much wider range of food outlet types were included, such as fast food, convenience stores, grocery stores and supermarkets. While this may provide a more comprehensive picture of the retail food environment, it brings up questions about the best way to classify a food outlet and how to compare results from studies using different classification systems. To enable between-study comparisons, future work should integrate validated classification systems into the design (54). Future studies should also explore the capacity of alternative methods for validating exposure data, including Google Street View (55,56).

Additionally, future work should also incorporate a child's usual mode of travel to and from school into decisions about appropriate buffer distances. We found only three of the studies in this review accounted for mode of travel in their final analyses. If buffers are to reflect the real ability of children to walk or cycle to school (and hence their real exposure to environments), it is important that studies account for transport exposure and adjust for active vs. motorized transport as Harrison's (33) study did. Capturing this individual-level data may become easier as advances in measurement technologies foster a new era of 'people-based' rather than 'place-based' exposure measures (57–59). Promising examples include the use of GPS devices or interactive mapping tools to capture individual mobility patterns, characterize the individual's activity space and then quantify outlets within that space (60–62). The specificity that individual-level measures of exposure to the food environment would allow is vital if we are to accurately measure what is likely to be a small-effect size.

In addition to improving these GIS-based measures of the food environment (e.g. density of food outlets), future work may benefit from collecting complementary measures of both qualitative (participant perception-based) and quantitative measures of food access (63).

Future research needs to collect outcome measures that are appropriate relative to the exposures. For example, all of the papers assessed daily or habitual diet patterns, but these outcomes cannot be linked to the school food environment without knowing the time or place of consumption, and where the food was originally sourced. Future studies concerned with specific environments should collect this additional contextual information.

The age range of included studies encompassed both primary and secondary school settings and there are potentially important theoretical differences regarding how age may influence a child's interaction with the food environment as he grows older and develops more autonomy. This may lead to differences in travel time, distance travelled, availability of pocket change and other factors.

Another issue related to between-country generalizability. As Feng noted in his review, most of the associations came from North America, but food environments vary between countries (6,64). It was promising to see that one included study by Heroux *et al.* (65) looked at between-country food environments and outcomes. Future work is needed to develop standardized tools to monitor local food environments across countries (66).

Conclusions

In conclusion, we did not find strong evidence at this time to justify policies related to regulating the food environments around schools. Our findings may provide some timely insight to debate about prevention of obesity among children. Future work with longitudinal cohorts and more refined exposure and outcome measures may lead to higher quality evidence that may inform more effective public health interventions. Additionally, these improvements will allow researchers to better understand how this particular component of the food environment in the school neighbourhood interacts with other components of a child's environment and investigate the effects this may have on obesity risk.

Conflict of interest statement

None declared.

Author contributions

PS was the PI, supervised the data collection and contributed to finalization of the manuscript. NR conducted the keyword search. JW and AM completed the data extraction. JW drafted the manuscript. AM, CF, GC, NR, PS and MR assisted with writing the manuscript.

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Supporting information

Additional Supporting Information may be found in the online version of this article, http://dx.doi.org/10.1111/obr.12142

Appendix S1. Medline search terms
Appendix S2. Quality assessment of studies assessing the relationship between the school food environment and food purchase, consumption or body weight
Appendix S3. Food outlets around schools and student body weight (all results)
Appendix S4. Food outlets around schools and student consumption or purchase of food high in fat, sugar or salt (HFSS) (all results)
Appendix S5. Food outlets around schools and student consumption of fruit and vegetables and healthy eating indexes (all results)*

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