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Evidence Check

The effect of urban form on wellbeing

An **Evidence Check** rapid review brokered by the Sax Institute for the NSW Centre for Population Health. October 2015.

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This report was prepared by:

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Contents

1 Executive summary

The purpose of this Evidence Check was to conduct a rapid review of existing evidence on the impact of the built environment on mental health and psychological wellbeing (hereafter referred to collectively as wellbeing). A total of 103 studies were reviewed after a systematic search of the literature. Most studies used the Center for Epidemiologic Studies Depression scale, the General Health Questionnaire, or the Kessler scales to measure wellbeing.

The findings from this review are summarised below in order of each question. This is followed by an outline of current gaps in the evidence, as well as discussion of potential implications for policy.

Question 1: What is the evidence regarding the impact of the built environment on wellbeing?

Although the evidence for the impact of the built environment on wellbeing appears voluminous, with approximately 75% of the 103 studies reviewed reporting some degree of correlation between at least one feature of the built environment and wellbeing, the quality of evidence was mostly very weak. No randomised trials were found. Most studies were of cross-sectional design and relied on self-reported data. Only 11 studies were conducted in Australia.

The evidence regarding the impact of the built environment on wellbeing can be classified into three study themes: (i) green space and public open space (e.g. parks); (ii) signs of neighbourhood physical disorder (e.g. broken windows and graffiti); and (iii) places where people can interact with one another (e.g. cafes and community centres) within a walkable distance from home.

The strongest evidence for impacts on wellbeing was observed for quantity of green and public open space; this was due to the greater use of objectively measured built environment data and the number of longitudinal studies. Studies of green and public open space quality were too few to be able draw strong conclusions. The research on neighbourhood physical disorder and walkable destinations was based largely on self-reported data, with specific exposures conflated within a single composite index. As such, the evidence for these two themes was particularly low in quality, with only general conclusions able to be drawn.

Question 2: What are the benefits to wellbeing that accrue as side effects of built environments that promote physical activity and/or social capital?

Approximately 10% of studies reported that some of the potential benefit of the three built environment indicators for wellbeing described above could be mediated by increased levels of physical activity and/or higher levels of social capital or cohesion. Only three studies of this type were set in Australia.

These studies tended to find that only a relatively small amount (up to 11% in one study) of the impact of the built environment on wellbeing may be attributable to greater physical activity and/or social capital. Other, as yet unstudied, mechanisms may also play a role in linking the built environment with wellbeing (e.g. diet).

Question 3: What is the relationship between neighbourhood disadvantage, built environment and wellbeing?

Only three studies reported differences in the degree of association between the built environment and wellbeing when comparing people living in less and more disadvantaged neighbourhoods. However, none of these studies had strong evidence or theoretical underpinning for their findings, rendering recommendations for policy moot.

Question 4: What built environment characteristics have an effect on wellbeing?

Most of the studies of green and public open space reported that a greater quantity of parkland near where people lived was associated with better wellbeing. In addition, some studies reported that higher quality green space, measured by features such as walking paths, shade, water features, lighting, sporting facilities, playgrounds, and the absence of litter, was also associated with greater wellbeing. These studies tended to emphasise the amount of green space within the neighbourhood or a short distance from participants' homes (usually around 1km). Four out of twenty-five studies in this theme were conducted in Australia. Many of these studies noted the lack of evidence available on what sizes and types of green space are beneficial for wellbeing among different groups of people (e.g. age groups, ethnic groups, genders) and in different areas (e.g. inner city versus urban fringe). They also note that definitions of quality may vary (e.g. water features may be attractive for older adults, but seen as safety hazards by parents of young children).

The literature reviewed was dominated by studies that examined features of the built environment that were in some degree of physical deterioration (63 out of 103 studies). Only five studies examining this theme were conducted in Australia. These studies tended to examine multiple aspects of the built environment associated with physical deterioration within a single (i.e. composite) index, such as poor building quality, maintenance, crowding, litter, traffic noise, broken windows, and vandalism. They also relied on self-reported data introducing potential bias. These studies mostly found that people reporting greater levels of neighbourhood deterioration tended to also report poorer wellbeing. However, the widespread application of composite indices made it very difficult to disentangle which specific elements were the most or least important predictors of wellbeing.

A relatively large number of studies (n=27) assessed correlations between wellbeing and access to local places where people could interact (e.g. cafes and community centres). Three of these studies were conducted in Australia. The general finding was that a person was more likely to have greater wellbeing if they lived in a neighbourhood with more places they could walk to (some studies referred to this as walkability). One study in Australia however, observed that greater level of more retail availability was associated with an increased risk of depression. The evidence was largely from cross-sectional studies and is unable to fully account for potentially strong selection mechanisms relating service provision with wellbeing.

Gaps in the evidence

The absence of randomised trial evidence was not surprising, though the lack of (quasi)experimental and longitudinal studies to identify which features of built environments are promoters (or inhibitors) of wellbeing constitutes the main gap in evidence. The reliance on cross-sectional studies and self-rated exposure measures, particularly in studies of neighbourhood physical deterioration and walkable destinations, also constitutes a significant gap in the literature.

From a study theme perspective, few studies examined the quality of green and public open space limiting the ability to make recommendations on how to design these spaces for optimising wellbeing. Similarly, there was insufficient evidence to conclude which aspects of neighbourhood physical deterioration and

what types of walkable destinations have the greatest influence on wellbeing. These are policy relevant gaps in the evidence that require attention in Australia and internationally.

Finally, most studies used the Kessler scales, the General Health Questionnaire and the Centre for Epidemiologic Studies Depression scale to measure outcome variables. These scales tend to focus on psychological distress and minor psychiatric morbidity. Few studies focussed on positive wellbeing, measured with tools such as the Warwick-Edinburgh Mental Well-being Scale.

Implications for policy

While the evidence suggests that better maintained neighbourhoods with more green spaces and walkable destinations are associated with better wellbeing among residents, we raise caution as to the quality and specificity of the currently available evidence, particularly in Australia. There is insufficient evidence to make recommendations to policy makers regarding which particular features of the built environment, in isolation and in concert, best promote wellbeing across all population groups in the community.

According to the studies reviewed, physical activity and/or social capital may mediate these associations, but only partially. Other unstudied factors could also explain why built environment characteristics may be important for wellbeing (e.g. diet). There also appears to be some potential for modification of the aforementioned associations by neighbourhood disadvantage; although this is based on only three studies covering a very narrow set of built environment characteristics.

Overall, there is insufficient evidence on the factors which mediate and moderate the influence of the built environment on wellbeing to be able to make recommendations for policy. It cannot be assumed therefore, that changes in policy based on the available evidence for the association between the built environment and physical activity and/or social capital in Australia will necessarily result in co-benefits for promoting greater wellbeing.

For Australian based decision making, the small pool of studies found indicate that recommendations for optimising built environments to promote greater wellbeing need to be either based largely on studies from other countries, or fuelled by a new research agenda. On balance, wellbeing will be best supported by well-maintained neighbourhoods containing larger amounts of quality green space and with places nearby that people can walk to. This balance is precarious, however, given the limited quantity of high quality evidence in Australia and internationally on what specific features of the built environment effect wellbeing.

2 Introduction

The purpose of this systematic review is to synthesise existing evidence on the relationship (if any) between the built environment and wellbeing. Broadly defined, the built environment can be thought to encompass aspects of our neighbourhoods that are human made or modified, such as streetscapes, parks, transportation and retail infrastructure. Epidemiologic interest in how built environments affect our health and wellbeing harks back (at least) to Chadwick's investigations of sanitation in the mid-nineteenth century. In the last 10 years, there has been a notable increase in synergy among epidemiologists and urban planners in the appreciation that how we design the built environments in which we live may hold tremendous potential for addressing many of our most daunting public health challenges.(1-8)

The scientific literature is replete with studies that draw attention to the relationship between socioeconomic disadvantage and indicators of mental health, psychological distress and social capital (hereafter referred to collectively as wellbeing).(9-12) For planners however, more studies of associations between health and socioeconomic disadvantage are moot points. Convincing evidence already indicates that poorer places do not always contain built environments that are thought to be unhealthy per se.(13) Instead, for urban planners and epidemiologists, there has been converging interest in identifying what types of built environments promote better health, and should, therefore, be integrated within current best practice now to benefit future generations.

The handful of literature reviews previously conducted have either focussed on the degree to which wellbeing is associated with neighbourhood level factors (using aggregations of population data such as indicators of socioeconomic deprivation, population turnover and ethnic density), or conflated those articles with evidence on the built environment.(9-12) The remit of this systematic review is focussed squarely on the built environment as the exposure of interest and this forms the first research question: What is the evidence regarding the impact of the built environment on wellbeing?

As much of the built environment and health literature is focussed on determinants of energy balance(8, 14-20) – what we eat and how physically active we are – a secondary interest of this review is the degree to which the built environment may foster influences on wellbeing via physically active lifestyles. Likewise, with particular features of built environments widely considered public spaces that serve to bring people together in their communities, such as parks and other green space,(21) there may also be spill over effects for wellbeing via the accrual of social capital or cohesion.(22) These mediating pathways are the basis for the second research question: What are the benefits to wellbeing that accrue as side effects of built environments that promote physical activity?

A third area of interest is whether similar types of built environments can have the same impacts on wellbeing regardless of whether they are in socioeconomically disadvantaged or advantaged neighbourhoods. The third research question is thus: What is the relationship between neighbourhood disadvantage, built environment and wellbeing?

The fourth and final research question of this systematic review concerns the level of detail in studies that have examined particular aspects of the built environment: What specific built environment characteristics have a significant effect on wellbeing?

The remainder of this report is structured as follows. In the Method section we outline the search and screening strategies used to identify studies for review. The Results section provides detailed synthesis on the types of studies found, study designs, sample sizes, country of origin, built environment variables, wellbeing and key findings. We then address to what extent the evidence stacks up against each of the research questions in the Discussion section, with particular reference to the challenges of identifying convincing (i.e. causal) context effects, before concluding with some comments on the implications of this Evidence Check for policy and what remains to be understood; that is, the priorities for future research on the built environment and wellbeing in Australia.

3 Method

The literature search focussed on peer reviewed articles that were published between January 1990 and May 2015 (inclusive). The search terms built environment; neighbourhood; and neighborhood were used to identify exposure data. The neighbourhood terms were included as some features of the built environment may not be specifically classified as such, but are nonetheless of direct interest to the research questions (e.g. noise pollution). These were entered into PubMed simultaneously with terms for the wellbeing outcome data, including: mental health (e.g. SF-12 scale); mental wellbeing (e.g. Warwick-Edinburgh Mental Well-being Scale); stress; psychological distress (e.g. General Health Questionnaire); depressive symptoms (e.g. Center for Epidemiologic Studies Depression scale); and depression. These terms were selected as we were focussed on wellbeing as the outcome variable, rather than self-rated health or other related outcomes (e.g. physical activity). Additional studies were identified from the reference lists of the papers identified in PubMed.

Articles included in this review are studies reported in English of any methodological design (qualitative, cross sectional, longitudinal, experimental) with at least one built environment exposure and one wellbeing outcome. Excluded articles included previous reviews, discussion and opinion pieces wherein no empirical data collection or analysis was reported, studies without any geographical component and those which examined wellbeing only as a mediating pathway for some other type of outcome variable (e.g. sleep quality).

Studies that included physical activity and/or social capital as mediating variables between the built environment and wellbeing were specifically coded, as were analyses of effect measure modification wherein the nature of the association between the built environment and mental health could differ according to different levels of neighbourhood disadvantage.

This systematic review was conducted in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.(23) Each study was also subjected to a risk of bias assessment performed independently by the two authors using the Cochrane Risk of Bias tool.(24) Although the Cochrane Risk of Bias tool was intended for randomised controlled trials, it reflects our aim to identify and highlight the uppermost quality of evidence published to date on the built environment and wellbeing and, rightly, allocates lower scores to studies employing designs that incur some form of bias. Agreement between each author for the coding of each article and the associated risk of bias assessments was achieved through discussion.

4 Results

The PRISMA flowchart is illustrated in Figure 1 below. The literature search yielded an initial sample of 1596 articles between 1990 and 2015 (inclusive) prior to exclusions. A total of 1451 records were omitted after screening article titles and abstracts only. A further 13 were excluded as they were reviews or opinion pieces. Nine additional articles were identified through the examination of article reference lists and grey literature. Of 141 taken forward, three were not found and 35 did not include a measure of the built environment as the exposure variable. Overall, 103 studies were included for qualitative synthesis. The tabulation of data on each article is available in Appendix 1, with the risk of bias results shown in Appendix 2.

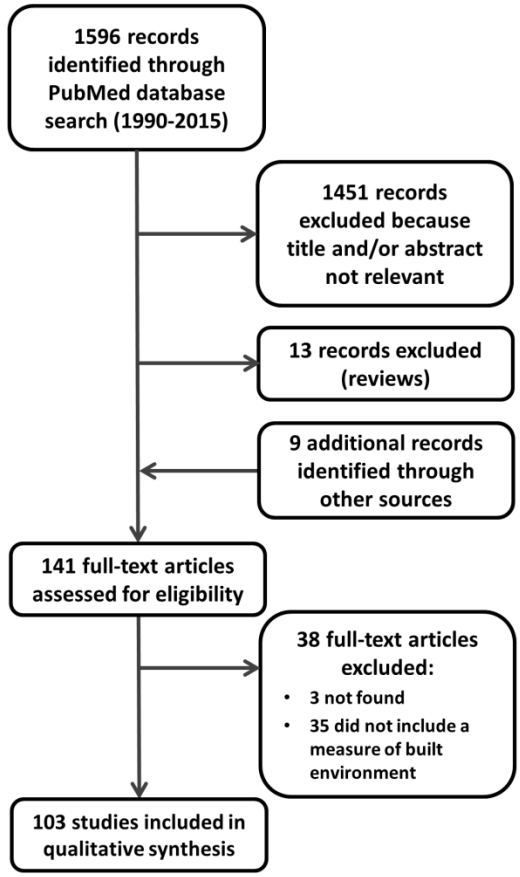

Figure 1: PRISMA flowchart of literature search records, excluded articles and studies taken forward

4.1 Study population

Studies from the United States (US) (n=46) and the United Kingdom (UK) (n=20) dominated the literature, followed by Australia (n=11), Canada (n=6), the Netherlands (n=5), New Zealand (n=2), Sweden (n=2), and single studies from China, Denmark, France, Germany, Iran, Jamaica, Kenya, Lithuania, and Spain. Sample sizes varied markedly. The smallest quantitative studies were fewer than a couple of hundred participants(25-29) whereas the largest contained in the order of a quarter of a million participants.(30) Fourteen studies focussed on younger ages (<20 years), whereas 22 focussed on samples aged 45 years and over (or had a mean sample age of 50 years or over). The majority of studies focussed on populations aged over 16 years. In Australia, seven studies examined samples aged over 16 years while a further four focussed on samples in middle to older age.

4.2 Measurement of built environment exposures

Forty-three of 103 studies measured some feature of the built environment using a Geographic Information System (GIS). The remainder (n=60) ascertained exposure data via participant reports or observer based auditing tools. Approximately half (51 of 103) of the studies focussed on aspects of built environment disorder, such as vandalism, litter, graffiti, damage to property, excessive noise, or disturbance from traffic speed. Thirty-six of these neighbourhood disorder orientated studies relied on subjective measures to ascertain exposure. Fifteen studies focussed on exposures related to walkable destinations (e.g. shops, cafes, supermarkets, community centres, parks), six of which were based on subjective measurements (e.g. three studies used the Neighbourhood Environments Walkability Scale). An additional 12 studies relied fully on subjective measurements to examine both neighbourhood walkable destinations and physical disorder, many collapsing each concept into a single composite indicator. A further 25 studies examined some form of green space as the exclusive exposure of interest (these studies are classified separately to those examining walkable destinations). Six from 25 of these studies used subjective measurement to measure exposure to green space. Of the 10 quantitative studies conducted in Australia, four focussed on neighbourhood physical disorder (two using objective measures), two on walkable destinations (one using objective measures), and four focussed on green space (two using objective measures).

4.3 Measurement of wellbeing outcomes

The most common outcome measure used (n=20) was the Center for Epidemiologic Studies Depression Scale (CES-D), followed by the General Health Questionnaire (n=13). The Kessler scales (10-item and 6-item) were the third most common (n=7). Five studies used the SF-36 (the wellbeing index of the Short Form Health Survey 36). Four studies used the SF-12 (the wellbeing index of the Short Form Health Survey 12). Four other studies used the Warwick-Edinburgh Mental Well-being Scale. In the 11 Australia-specific studies, the Kessler scales were the most common outcome measures (n=5), followed by the SF-12 (n=3).

4.4 Study designs and analysis

There were no randomised controlled trials found, only observational studies of variable design quality. This is reflected in the risk of bias being uniformly high across all included studies. The majority of studies employed exclusively quantitative methodologies (99 of 103 studies). Three studies used qualitative methods and one employed a mixed methods strategy. The 100 studies that employed quantitative analysis used some form of multivariate regression (mainly binary logistic models) or structural equation model. Among the quantitative studies, the majority (n=78) employed a cross-sectional analysis of ecological or person-level data. There were 20 longitudinal studies, four of which explicitly focussed on within-person change in exposure and change in outcome. Four longitudinal studies used fixed effects strategies to

examine within-person change over time. Three of these examined change in green space exposure occurring as a result of residential mobility. The fourth examined change in levels of crime related to the built environment (e.g. malicious damage to property) among a residentially stable sample. In Australia, seven studies used cross-sectional analysis while two used longitudinal analysis. Person-level confounders most commonly adjusted for across all quantitative studies were age, gender, marital status, highest educational qualification and employment status; though none appeared to provide a directed acyclic graph (DAG)(31) to visualise the hypothesised pathways and sources of potential bias.

4.5 Results of the reviewed studies

Thirteen of the 103 studies reported null findings. Seventy-seven studies reported confirmatory findings by main effects of the built environment and wellbeing (i.e. no mediation or effect measure moderation). Thirty-eight of these studies focussed on neighbourhood physical disorder, whereas 14 analysed walkable destinations only. A further eight focussed on the combination of walkable destinations and neighbourhood physical disorder. Seventeen focussed on some form of neighbourhood green space. In Australia, two studies found confirmatory findings for the benefits of more walkable destinations, three for the effects of neighbourhood physical disorder and one for green space.

Physical activity and/or social capital or cohesion as mediators

Eleven studies reported evidence of mediation either by some form of physical activity or measure of social capital or cohesion. Two focussed on walkable destinations and neighbourhood physical disorder. Three were neighbourhood physical disorder only studies. Six were green space studies.

Physical activity was identified as a potential mediator of the effects of walkable destinations and neighbourhood disorder in one study but this was not found in studies that focussed on neighbourhood disorder alone. Five studies of the effects of green space found physical activity to be a potential mediator. Social capital or cohesion was identified as mediators of the effects of walkable destinations and neighbourhood disorder in one study. They were also identified as mediators in three studies focussing only on the effects of neighbourhood disorder. They were identified as mediators in four studies of the effects of green space. Some degree of mediation by both physical activity and social capital or cohesion was reported in four studies of green space.

Socioeconomic circumstances as an effect modifier

Just three studies reported evidence for effect measure modification by levels of neighbourhood socioeconomic circumstances. One of these studies focussed on the complex interplay between green space, perceptions of neighbourhood safety and neighbourhood disadvantage as interacting predictors of wellbeing.(32) The other two studies examined the interplay between neighbourhood physical disorder (e.g. traffic noise and vandalism) and disadvantage in relation to wellbeing.

Results by type of study design

Confirmatory findings were reported by 12 from 13 cross-sectional studies focussing on walkable destinations reported confirmatory findings, compared with two from two longitudinal studies. No mediation or effect measure moderation was reported. Among the studies focussing only on neighbourhood disorder, 28 from 35 cross-sectional studies reported confirmatory results. A further two reported mediation effects. Eight from 13 longitudinal studies reported confirmatory results, with one mediation and one effect measure moderation findings. Seven from 11 cross-sectional studies focussing on combined walkable destinations and disorder exposures reported confirmatory results. A further two reported evidence of mediation. Of 19 cross-sectional studies of green space, 13 reported confirmatory

results, with an additional five noting mediation and one effect measure moderation. Four from six longitudinal studies of green space reported confirmatory results, with one reporting mediation.

Australian studies

In Australia, six of 11 studies found main effects only, three found evidence of mediation and one found moderation. Of the 11 studies, four focussed on green space, four on neighbourhood disorder, two focussed on walkable destinations, and one focussed on walkable destinations and neighbourhood disorder combined. All four studies of green space were of cross-sectional design, with one reporting a main effect only, two reporting mediation and one observed effect measure modification. All studies of walkable destinations exclusively and in combination with neighbourhood disorder were cross-sectional (n=3). One longitudinal study focussed solely on neighbourhood disorder, finding confirmatory results.

5 Discussion: Answers to review questions

The aim of this systematic review was to examine the breadth and quality of published evidence on the potential impacts of built environment on wellbeing. In this Discussion section, we summarise the findings for each of the key questions:

1. What is the evidence regarding the impact of the built environment on wellbeing?
2. What are the benefits to wellbeing that accrue as side effects of built environments that promote physical activity and/or social capital?
3. What is the relationship between neighbourhood disadvantage, built environment and wellbeing?
4. What built environment characteristics have an effect on wellbeing?

5.1 Review Question 1: What is the evidence regarding the impact of the built environment on wellbeing?

The evidence for the impact of the built environment on wellbeing appears voluminous, with 75% of the 103 studies reviewed reporting some degree of correlation between at least one feature of the built environment and wellbeing. This evidence was, however, generally weak and not specific with respect to what particular features of the built environment are more or less beneficial for wellbeing. The built environment characteristics thought to influence wellbeing that were covered by the 103 included papers are listed in Table 1 below. We also summarise the quality of evidence based on risk of bias assessment (Appendix 2).

Table 1: Characteristics of the built environment thought to influence wellbeing

Built environment characteristics	Longitudinal	Cross-sectional	Mixed method	Qualitative	N of papers	Quality of evidence
		N of papers (%) per type of study design				
Green space and public open space	6 (24.0%)	19 (76.0%)	0 (0.0%)	0 (0.0%)	25	Moderate to weak
Physical disorder	13 (20.6%)	46 (73.0%)	1 (1.6%)	3 (4.8%)	51	Weak
Walkable destinations	2 (13.3%)	13 (86.7%)	0 (0.0%)	0 (0.0%)	15	Weak
N of papers	**21**	**78**	**1**	**3**	**103**	

The main weakness in the evidence is the widespread use of cross-sectional designs that limit causal inferences. Another weakness is the tendency for studies to correlate how people perceive their neighbourhoods with how they report their wellbeing. Longitudinal studies and those making use of built environment indicators derived using Geographic Information Systems (GIS) are, therefore, held in higher regard in this review.

A third weakness of the literature which is of specific interest for Australian health policy is that only 11 of the studies reviewed were conducted in Australia. This is problematic as it means that much of what we have reviewed has been set in places that are very different to the Australian context. For example, the same built environment features may not have the same impact on wellbeing in Australia and they do in the UK or US. The quality of evidence regarding the impact of the built environment on wellbeing is therefore, not yet of sufficient quality that we would regard it as suitable for guiding decision making related to urban planning.

On balance, the limited evidence available indicated that wellbeing will be best supported by well maintained neighbourhoods containing larger amounts of quality green space (though definitions of quality are likely to be subjective and contingent on population group) and with retail (or other community related) destinations which people can walk to and interact within. Unfortunately, specifics on what detailed features are important for wellbeing (e.g. a supermarket versus a different type of retail space) are not distinguishable from the current literature.

The evidence on the role of physical activity and social capital in mediating the built environment and wellbeing is discussed in section 5.2 below. The potential impact of neighbourhood disadvantage for modifying associations between the built environment and wellbeing is discussed in section 5.3. Details of which features of the built environment may influence wellbeing are addressed in section 5.4.

5.2 Review Question 2: What are the benefits to wellbeing that accrue as side effects of built environments that promote physical activity and/or social capital?

Of 11 studies assessing how the built environment might influence wellbeing via increases in physical activity and/or social capital, only three were conducted in Australia. Frequencies of international studies by study theme and mediating factor are presented in Table 2. Studies mostly focussed on mental health, psychological distress or depressive symptomology. There were no studies examining positive mental wellbeing. Overall, the quality of evidence for mediation was weak.

Table 2: Number of papers by theme and mediating factor

Type of wellbeing measured	Green space and public open space	Physical disorder	Walkable destinations	N papers	Quality of evidence
	N of papers per theme of built environment				
Mediation by physical activity					
Mental health (e.g. Mental Health Inventory)	4	1	0	5	Weak
Psychological distress and depression (e.g. General Health Questionnaire)	4	0	0	4	Weak
Objective assessment (e.g. C-reactive protein concentration)	0	0	1	1	Weak
N of papers	**8**	**1**	**1**	**10**	
Mediation by social capital					
Mental health (e.g. Mental Health Inventory)	3	2	0	5	Weak
Psychological distress and depression (e.g. General Health Questionnaire)	2	3	0	5	Weak
Objective assessment (e.g. cortisol assessment)	0	1	0	1	Weak
N of papers	**5**	**6**	**0**	**11**	

In Australia, Van Dyck and colleagues'(33) study of mental health related quality of life in Victoria found that physical activity explained up to 11% of the link between wellbeing and the neighbourhood built environment related to physical activity (inclusive of walkable destinations). Measurement of wellbeing, physical activity and built environment was entirely self-reported, however, reducing study quality due to potential same source bias.

Sugiyama and colleagues'(34) study of mental health in Adelaide reported that better wellbeing was experienced by people who also reported higher perceived quantities of local green space, but this was only partially accounted for by higher levels of recreational walking and social capital. As with Van Dyck's study, reliance on self-reported outcome, mediator and exposure data limited the quality of this study.

Astell-Burt and colleagues'(30) study of psychological distress in New South Wales found better wellbeing in relation to higher quantities of green space was only experienced among participants who were more physically active. This study used objectively-measured green space exposure data, unlike the previous two, which raises the quality of the analysis. However, it like the previous two is also limited by cross-sectional

design, with potential reverse causation of physical activity or social capital and measures of wellbeing a possible source of bias.

Overall, these Australian studies and those conducted overseas collectively indicate that the wellbeing benefits of particular built environment characteristics, such as green spaces, may be only partially accounted for by physical activity and social capital. However, it is clear that with so few studies conducted and with inconsistencies in study design and variable measurement, it would be premature to place an exact figure on how much wellbeing benefit a particular feature of the built environment induces via physical activity, social capital, or other less researched pathways (e.g. diet).

5.3 Review Question 3: What is the relationship between neighbourhood disadvantage, built environment and wellbeing?

Three studies(32, 35, 36) investigated whether the relationship between the built environment and wellbeing varied according to differing levels of neighbourhood disadvantage (effect measure modification). It is important to clarify that many researchers considered indicators of socioeconomic disadvantage as variables in their analyses, of which neighbourhood disadvantage is but one of many. These variables were often viewed as surrogate markers of person-level disadvantage rather than a genuine indicator of ecological phenomena and, perhaps more importantly, the consideration of disadvantage in those studies was of a nuisance to be controlled for, rather than something to be explicitly investigated, as was the case in these three studies.(32, 35, 36)

Only one of these studies was conducted in Australia. Chong and colleagues'(32) study of psychological distress in NSW found no association between participants' wellbeing and the quantity of green space within their postcodes of residence. However, they did find evidence to indicate that poorer wellbeing was more common among those living in disadvantaged postcodes perceived as unsafe with higher quantities of green space.

Bocquier and colleagues'(35) study in France found higher purchases of sleep-related medications (as a proxy of poor wellbeing) with higher levels of traffic noise, but only in less deprived neighbourhoods. This may reflect greater levels of health service access and healthcare seeking behaviour among more affluent groups rather than genuine effect measure modification of neighbourhood socioeconomic circumstances on the relationship between the built environment and wellbeing. Aneshensel and Sucoff's(36) study in Los Angeles County, US, reported poorer wellbeing with greater perceived levels of so-called 'ambient hazards' (e.g. graffiti) among adolescents living in less, rather than more, deprived neighbourhoods.

In summary, none of these studies comprise a sufficient evidence base to draw any firm conclusions on whether particular features of built environment are more or less beneficial for wellbeing depending on the socioeconomic circumstances of the neighbourhood. Aside from the paucity of studies, another important gap in this type of research is the lack of theoretical justification as to why the relationship between wellbeing and the built environment may genuinely differ according to the level of neighbourhood disadvantage. This gap also needs to be further unpacked with respect to whether neighbourhood disadvantage is merely a proxy for person-level socioeconomic circumstances, an ecological phenomena in its own right, or a surrogate for other built environment characteristics that remain unmeasured. Based on these considerations, the quality of evidence available to answer the question is very weak.

5.4 Review Question 4: What built environment characteristics have an effect on wellbeing?

In answering Question 4, we highlight nine Australian based studies and draw conclusions based on allnb 85 studies identified. While the Australian studies are a small sample, they are by definition the most relevant to Australian health policy. The discussion of studies is split into three themes: (i) green space and public open space; (ii) neighbourhood physical deterioration; and (iii) walkable destinations.

5.4.1 Green space and public open space

Studies reviewed in this theme (30, 32, 34, 37-58) indicated that more green space or public open space within a short distance from home was advantageous for wellbeing. Distances varied, with some studies using 1–1.6 km catchment areas (e.g. Astell-Burt et al.(30) and Francis et al. (44)) and others relying on administrative boundaries of varying geographical size (e.g. Richardson et al.(53)).

Of the 25 studies reviewed four were conducted in Australia.(30, 32, 34, 44) In one of the largest studies of green space and wellbeing reviewed, Astell-Burt, Feng and Kolt(30) found a lower risk of psychological distress (using the K-10(59)) among people 45 years and older living in NSW neighbourhoods with more green space within 1 km of their home addresses (measured using a GIS). Sugiyama and colleagues(34) found corroborative findings in an Adelaide-based study using a much smaller sample and a self-reported green space indicator. In comparison, Chong and colleagues study in NSW found no relationship between the same green space data and the K-10 score (as used by Astell-Burt and colleagues), but their green space indicator was measured at the postcode level – much larger than the standard 1 km catchment area used in most studies, which is likely to have introduced bias into their results.(32)

Meanwhile, a smaller number of studies also took green space quality into account. In an Australian example set in Perth, Francis and colleagues(44) measured green space quality in terms of the provision of walking paths, shade, water features, lighting, sporting facilities, playgrounds and the absence of litter. They found that living close to a higher quality park was associated with better wellbeing. It should be noted that quality in this study was measured by tangible features of green spaces that may be calming for some population groups, such as lakes for older adults, but which may be seen as safety hazards for others, such as parents of young children. Green space quality is an under-researched area, especially in Australia.

Overall, the research for green space and wellbeing is dominated by studies reporting wellbeing benefits of living within close proximity to higher quantities of green space. There is some evidence that the physical quality of green space also matters for wellbeing. There is insufficient evidence to indicate what the minimum quantity of green space is, or what the necessary features within a green space are to promote better wellbeing.

5.4.2 Neighbourhood physical deterioration

The literature reviewed was dominated by studies that examined features of the built environment that were in some degree of physical deterioration (63 out of 103 studies), such as poor building quality, poor maintenance, crowding, litter, noise from traffic, vandalism, and broken windows. Most of those studies examined multiple aspects of physical deterioration within a single index via self-report, making it difficult to disentangle which specific elements were the most or least important predictors of wellbeing. Only five of these studies were conducted in Australia.(29, 33, 60-62)

Australian studies mostly found that people reporting higher levels of physical deterioration in their neighbourhood tended to also report poorer wellbeing. For example, Van Dyck and colleagues(33) study in Victoria found participants were likely to have better wellbeing if they had also reported more favourable perceptions of neighbourhood safety, aesthetics and places to be physically active. Francis and

colleagues(61) study in Perth and Ziersch and colleagues(60) study in Adelaide found similar results for perceived neighbourhood safety and aesthetics.

Importantly, these studies relied on self-report of both the exposure and the outcome variables, which is well known to incur same source bias. Two longitudinal studies in Australia used objectively measured data to shed further light on this important issue. Astell-Burt and colleagues(62) large study of adults aged 45 years and older in New South Wales used a time-series of official crime records to report that an improvement in wellbeing was associated with a decrease in the level of local crime related to the local built environment (malicious damage to property). The proposed mechanism for this result is in line with cross-sectional evidence; with a reduction in local crime related to the built environment hypothesised to promote perceptions that the neighbourhood was becoming a safer place to live, which would have knock on effects for wellbeing among residents.

In contrast, Jalaludin and colleagues(29) study of built environment regeneration in south west Sydney reported no significant benefits for wellbeing. This regeneration program included property painting, new front and back fencing, new carports, letterboxes, concrete driveways, drainage, landscaping, and general external maintenance such as repairs to roofs, as well as internal upgrades and efforts to increase social cohesion. Jalaludin and colleagues cautioned against a causal interpretation of their results, however, as the sample size of the study was very small and likely to be from a highly selected group of residents.

On balance of the limited evidence available, these Australian studies are generally in line with those reviewed from overseas, in that lower levels of neighbourhood deterioration as measured across a number of factors is likely to play an important role in maintaining the wellbeing of residents. The evidence is not yet at a stage that all of the different aspects of neighbourhood physical deterioration can be isolated as the most or least important determinants. However, damage to the built environment that diminishes the aesthetic qualities and negatively influences perceptions of neighbourhood safety are likely to be among the most salient factors. More research is needed to understand the extent that improvements in wellbeing may be brought about by improvements in built environment physical quality.

5.4.3 Walkable destinations

Twenty-seven studies examined some aspect of the local built environment that constituted destinations that people could walk to (e.g. grocery stores) as predictors of wellbeing. Only three of these studies were conducted in Australia. Leslie and Cerin's study in Adelaide(63) reported higher levels of walkability as a predictor of wellbeing, though did not discern precisely which destinations were most important for making a place walkable and for better wellbeing. Van Dyck and colleagues(33) study in Victoria found greater levels of wellbeing among residents of neighbourhoods who also reported there were more places to be physically active near where they lived, though without specification on what types of places are more important than others.

Saarloos and colleagues'(64) study of men in Western Australia reported better wellbeing among men living in neighbourhoods described as having greater street connectivity and residential density. However, the authors also found that a greater level of retail availability within the neighbourhood of residence was associated with an increased risk of depression among men in the study. These inconsistent results in Australia are not reflected in the majority of the international literature, where most studies of walkable destinations tend to focus on their impact on walking and physical activity rather than wellbeing.(65-68) A recent study in Australia (not included in this review as the focus was not strictly on wellbeing, but nonetheless relevant here) reported that a larger number of walkable destinations nearby was associated with an increased fear of crime, potentially due to a rise in prevalence of strangers and potential incivilities (e.g. litter and graffiti) in the local area attracted by shops and cafes.(69) This observation is supported by a

range of studies that have reported a discord between which features of the built environment are available where people live, and which are recognised or appreciated by the residents of those neighbourhoods.(70-75)

While the evidence suggests that neighbourhoods with more walkable destinations are associated with better wellbeing among residents, there are cautionary signals that we do not yet know the types and mixes of destinations that are optimal for promoting wellbeing across all population groups in the community.

5.5 Implications of the evidence for policy and gaps in the evidence

The implications for policy makers of the evidence synthesised in this report are that access to green spaces and other places where people can interact, within a walkable distance from home, tend to be associated with better wellbeing. Furthermore, greater levels of neighbourhood physical disorder appear to be potentially detrimental for wellbeing.

According to the studies reviewed, physical activity and social capital may account for only a small amount of these associations, with other unstudied factors (e.g. diet) potentially also explaining why built environment characteristics may be important for wellbeing. There appears to be some potential for modification of these associations by neighbourhood disadvantage, though this is based on only three studies covering a very narrow set of built environment characteristics.

The precise nature of the built environment characteristics that may be important for wellbeing such as: the minimum amount of green space needed; the features that need to be within a green space; what types of destinations need to be within a walkable distance from home; and what specific aspects of physical disorder need to be addressed for promoting better wellbeing remain largely unspecified. Furthermore, there is very little evidence in the literature reviewed as to what types of built environment are important for the wellbeing of particular groups of people e.g. different ethnic groups, age groups and genders. As such at this stage, only tentative conclusions can be drawn about what specific features of the built environment are important for wellbeing beyond the generality of well-maintained streetscapes with places nearby where people can interact, such as green and open spaces like parks, and retail outlets like cafes and community centres.

Caution in the interpretation of all of these findings must be paramount. The quality of available evidence is low and the risk of biased estimates is high due to the reliance on cross-sectional study designs. The strongest evidence available was for the wellbeing benefits of green spaces, due to the use of objective exposure measures and some longitudinal study designs. Strengthening causal inference through the use of more rigorous longitudinal study designs across the board should be a scientific priority if investments in the built environment for health reasons are to be evidence-based.

For Australian based decision making, the small pool of studies found indicate that recommendations for optimising built environments to promote greater wellbeing needs to be either based largely on studies from other countries, or fuelled by a new research agenda. It should be underlined that with the studies in this review indicating that physical activity and social capital only partially explain the wellbeing benefit of certain types of built environment, it cannot therefore be assumed that changes in policy based on the evidence base of built environment and physical activity and/or social capital in Australia will necessarily result in co-benefits for promoting greater wellbeing.

In conclusion, reliable evidence on the impact of the built environment on wellbeing, and on the mechanisms that link one with the other, constitutes an important gap in knowledge that cannot be resolved with the extrapolation of evidence from related studies. A research agenda on the impact of the

built environment on wellbeing in Australia needs to be re-energised if recommendations for policy are to be based on local and reliable evidence.

This research agenda needs to prioritise randomised control trials and natural experiments with the deployment of a richer epidemiologic imagination.(76, 77) It needs to identify what specific features of the built environment are important for wellbeing, rather than yet more small-scale cross-sectional studies focussing on general concepts. Good intentions and received wisdom are no substitute for high quality local evidence.

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7 Appendices

Appendix 1: Detailed table of included studies

Reference	Study Design	Country	Population	Intervention	Control	Physical activity as a mediator	Social capital or social cohesion as a mediator	NSEC[i] as an effect modifier	Outcome	Follow-up (mths)	Outcome measures	Risk of bias
Alcock et al. (2014)	Longitudinal, fixed effects (i.e. 'within person') analysis	UK	594 participants aged 16+	People moving to greener areas, green space objectively reported (% of lower super output area)	Own control before and after	No	No	No	Mental health significantly improved among movers to greener areas	60	GHQ[ii]	High
Aneshensel and Sucoff (1996)	Cross-sectional study	US	877 adolescents aged 12 to 17	Subjective exposure to ambient hazards including property damage, graffiti, clean housing, but also less relevant factors such as violent crimes and drug use	Lower scores of subjective exposure to ambient hazards	No	Measured social cohesion, but not as a mediating variable	Yes	Youth in low NSEC areas perceived greater ambient hazards, this was associated with mental health	None	Depressed mood: CDI[iii] Anxiety: subset of 8 items from HSCL Conduct and oppositional defiant disorder: subscales of Stony Brook 30R[iv]	High

[i] Neighbourhood socioeconomic circumstances
[ii] General Health Questionnaire
[iii] Children's Depression Inventory (21-item inventory of depressive symptomology over the previous 2 weeks)
[iv] Stony Brook Child Psychiatric Checklist 30R

Annerstedt et al. (2012)	Longitudinal study	Sweden	24,945 participants aged 18 to 80	Objectively measured land-use classification with emphasis on green space within 300m of residential address	Absence, or lower amounts of green space	Yes	No	No	No main effect, but evidence of interaction between higher amounts of green space and physical activity on mental health among women at follow-up	48–60	GHQ	High
Araya et al. (2006)	Cross-sectional study	UK	1058 participants aged 16 to 75	Favourable perceptions of neighbourhood quality and accessibility	Less favourable perceptions	No	Included in analysis but not specifically as a mediator	No	No main effect after adjusting for individual factors, trust and social cohesion	None	GHQ	High
Arcury et al. (2014)	Cross-sectional study	US	248 participants aged 18 to 45	Self-reported heavy traffic and drive time to grocery stores	More favourable perceptions	Not specifically – traffic difficult to walk was one exposure	No	No	Traffic impeded walking was associated with more stress	None	Farmworker Stress Inventory	High

Astell-Burt et al. (2015)	Longitudinal study, fixed effects (i.e. 'within person') analysis of a residentially stable sample	Australia	54,844 aged 45 to 100	Objectively measured crime related to built environment (e.g. malicious damage to property)	Own control – before and after	No	No	No	Rises in crime related to built environment were associated with increasing levels of psychological distress	60	K10[v]	High
Astell-Burt et al. (2013)	Cross-sectional study	Australia	260,061 participants aged 45 to 100	Objectively measured green space %	Less green space	Yes	Yes	No	More green space, lower levels of psychological distress, but only among people who were more physically active	None	K10	High
Astell-Burt T et al. (2014)	Longitudinal study	UK	13,617 participants aged 18 to 100	Objectively measured green space %	Less green space	No	No	No	More green space, lower levels of psychological distress among men. A moderate amount of green space was most favourable for women	108	GHQ	High

[v] Kessler Psychological Distress Scale

Bakker et al. (2012)	Cross-sectional study	Nether-lands	725 participants, mean age of 51	Objectively measured proximity to wind turbines	Less proximity	No	No	No	Proximity to wind turbines was not with psychological distress	None	GHQ	High
Barahmand et al. (2013)	Cross-sectional study	Iran	137 participants aged 26 to 54	Perceptions of neighbourhood characteristics (safety, noise)	Less favourable perceptions	No	No	No	Perceived neighbourhood was not associated with mental health	None	SF-36[vi] mental health component	High
Barnes et al. (2011)	Cross-sectional study	UK	14,700 mothers with 9-month-old infants living in deprived neighbour-hoods	Perceptions of neighbourhood characteristics (noise, rubbish, vandalism, pollution)	More favourable perceptions	No	No	No	Lower (interviewer-rated) neighbourhood quality predicted higher mother-reported mental health problems	None	Malaise Inventory, developed for the UK Millenium Cohort Study	High
Barrington et al. (2014)	Cross-sectional study	UK	514 participants aged 53 to 76	Fear of crime	More favourable perceptions	No	Yes	No	Fear of crime was associated with blunted cortisol reactivity in women only	None	Cortisol assessment	high
Berke et al. (2007)	Cross-sectional study	US	740 participants aged 65 and over	Objectively measured neighbourhood walkability	lower walkability scores	Included but not as a mediator	Included in analysis but not specifically as a mediator	No	More walkability, fewer depressive symptoms among men, but not for women	None	CESD	High

[vi] Short Form-36 Health Survey

Beyer et al. (2014)	Cross-sectional study	US	2479 participants aged 18 to 74	Objectively measured neighbourhood green space and tree canopy	Lower green space scores	No	No	Not specifically	More green space, fewer symptoms of depression, anxiety and stress	None	DASS	High
Bierman A. (2009)	Longitudinal study	US	1167 participants aged 65+	Perceived neighbourhood disorder (incl. vandalism, trash, heavy traffic)	More favourable perceptions	No	No	No	More neighbourhood disorder, higher risk of depression, but only for the non married	24	HSCL for depression	High
Blackman et al. (2001)	Longitudinal study	UK	749 participants aged 16+ and 249 children	Neighbourhood renewal	Own control – before and after	No	No	No	Neighbourhood renewal associated with improved mental health among adults and children	60	Self-reported indicator, but not clear if validated	High
Bocquier et al. (2014)	Longitudinal study	France	190,617 participants aged 18 to 64	Objectively measured night-time road traffic noise	Lower noise levels	No	No	Yes	Higher purchases of anxiolytics-hypnotics with greater traffic noise, but only in low deprivation areas	24	Anxiolytics or hypnotic prescriptions	High

Bond et al. (2012)	Cross-sectional study	UK	3911 participants aged 16+	Perceived neighbourhood aesthetic quality (including quality of local amenities, attractiveness of buildings, vandalism, graffiti)	More favourable perceptions	No	No	No	Poorer perceived neighbourhood aesthetic quality was associated with poorer mental health	None	Warwick-Edinburgh Mental Well-being Scale	High
Brown et al. (2009)	Cross-sectional study	US	273 participants aged 70+	Researcher-reported architectural features of the built environment	Less favourable perceptions	No	Yes	No	Architectural features of the built environment may benefit mental health via the facilitation of direct, in-person interactions	None	MMSE[vii]	High
Burke et al. (2009)	Qualitative study	Canada	36 participants (no age specified)	Participants reported a range of built environment features, including aesthetics, destinations, and disorder	n/a	n/a	n/a	n/a	120 'unique neighbourhood characteristics were felt to be related to mental well-being', with differences by socioeconomic circumstances	None	Holistic definition inclusive of substance abuse)	High

[vii] Mini Mental State Examination, a measure of cognitive functioning

Butler et al. (2012)	Cross-sectional study	US	64,076 children aged 6 to 17	Parent-reported neighbourhood amenities (e.g. recreation centre) and indicators of safety and physical disorder	More favourable perceptions	No	No	No	More disorder in the neighbourhood, higher odds of poor mental health	None	Parent-reported doctor-diagnosed child current status of depression, ADHD, anxiety problems and behaviour or conduct problems	High
Byck et al. (2015)	Longitudinal study	US	592 adolescents	Neighbourhood relocation from high to low poverty and change in subjective neighbourhood disorder	No relocation	No	No	No	Moving from high to low poverty neighbourhoods was not associated with better mental health	144	Major Depressive Disorder and Conduct Disorder, and the Child Behaviour Checklist and Youth Self-Report	High
Chong et al. (2013)	Cross-sectional study	Australia	10,710 participants aged 16+	Higher levels of objectively measured green space	Less green space	No	No	Yes	Area deprivation was an effect modifier of the association between green space and psychological distress	None	K10	High

Cohen-Cline et al. (2015)	Cross-sectional study	US	4338 participants, mean aged of 38	Higher levels of objectively measured green space	Less green space	Not as a mediator specifically	No	Not as a moderator specifically	More green space, less depression, but less convincing results for anxiety	none	Depression: PHQ-2[viii] Stress: PSS[ix] Anxiety: BSI[x]	High
de Vries S et al. (2013)	Cross-sectional study	Nether-lands	1641 participants, mean age of 51	Audit-measured green space quantity and quality	Lower quantity and quality scores	Yes	Yes	No	More and higher quality green space especially, better mental health. Apparent mediation of this effect by social cohesion and stress	none	MHI-5[xi]	High
DeGuzman et al. (2013)	Cross-sectional study	US	1800 women, mean age of 38	Objectively measured distance to public transport and residential density	Longer distances/ less walkability	No	Not specifically as a mediator	No	No association between mental health and distance to public transport and density	None	BSI 18[xii]	High

[viii] Patient Health Questionnaire 2 (2-item version of the Patient Health Questionnaire)
[ix] Perceived Stress Scale
[x] Brief Symptom Inventory
[xi] Mental Health Inventory (5-item version of the Mental Health Inventory)
[xii] Brief Symptom Inventory (18-item version of the Brief Symptom Inventory)

Downey and Van Willigen (2005)	Cross-sectional study	US	2482 participants aged 18+	Objectively measured average number of waste facilities within a census tract, and perceptions of neighbourhood disorder	Lower average number of waste facilities and more favourable perceptions	No	No	No	Residential proximity to industrial activity has a negative impact on mental health	None	CES-D[xiii]	High
Duncan et al. (2013)	Cross-sectional study	US	1170 mean age 16	Objectively measured: – Access to walking destinations – Density of: recreational open space; parks; bus stops; subway stops; total retail destinations; total service destinations; total cultural/educational destinations – Median pedestrian route directness – Intersection density – Sidewalk completeness – Avg. sidewalk width – Avg. speed limit – Highway density and residential density	Less favourable density scores	No	No	No	Protective association between recreational open space density on depressive symptoms for Asian participants. Higher density of subway stops associated with more depressive symptoms within 400 m. Greater pedestrian route directness predicted depressive symptoms among females. Higher park density	None	Modified Depression Scale	High

[xiii] Center for Epidemiologic Studies Depression Scale

									associated with more depressive symptoms among Black participants			
Echeverría et al. (2008)	Cross-sectional study	US	5943 participants, mean age of 62	Perceived neighbourhood problems (excessive noise, heavy traffic, lack of access to adequate food shopping, lack of parks and playgrounds, trash/litter, no sidewalks or poorly maintained sidewalks)	More favourable perceptions	No	Not specifically as a mediator	Not specifically as a moderator	More neighbourhood problems, higher risk of depressive symptoms	None	CES-D	High
Fan et al. (2011)	Cross-sectional study	US	1544 participants aged 18 to 75	Objectively measured total park acreage and distance to the nearest park	Less green space	Yes	Yes	No	More park, more physical activity and social support, and less stress. More overall green space, more stress and less social support	None	PSS	High

Fauth et al J. (2008)	Cross-sectional study	US	247 participants with average age of 41	Moving to a neighbourhood with less disorder	Remaining in the previous neighbourhood with higher disorder	No	No	No	Moves to neighbourhoods with less disorder were not associated with better mental health outcomes	None	Self-reported symptomology of depression and anxiety	High
Ford et al. (2012)	Cross-sectional study	US	32,499 adolescents aged 12 to 17	Parental perceptions of neighbourhood physical disorder and lack of safety	More favourable perceptions	No	No	No	More neighbourhood disorder and lack of safety, more adolescent depression symptoms	None	Current depression diagnosis and current depression symptoms	High
Francis et al. (2014)	Qualitative study	Australia	38 participants aged 26 to 74	Aesthetically pleasing environment	n/a	n/a	n/a	n/a	Results suggest that mental health is strongly influenced by aesthetically pleasing environments, as well as a sense of community and security	None	n/a	High

Francis et al. (2012)	Cross-sectional study	Australia	911 participants aged 20 to 79	Audit-measured public open space quality. Geographic Information System was used to measure public open space size and number within 10-15 min walk	Poorer public open space quality and quantity	No	Not specifically as a mediator	Not specifically as a moderator	More higher quality public open space was associated with lower odds of psychological distress, irrespective of use	None	K6[xiv]	High
Gale et al. (2011)	Cross-sectional study	UK	1157 participants aged 69 to 78	Perceptions of neighbourhood problems (including vandalism, litter and rubbish, smells and fumes, traffic, noise)	Fewer neighbourhood problems	No	Not specifically as a mediator	Not specifically as a moderator	Fewer neighbourhood problems, higher levels of mental wellbeing	None	Warwick-Edinburgh Mental Well-being Scale	High
Galea et al. (2005)	Cross-sectional study	US	1355 participants aged 18+	Audit-measured quality of built environment (including evidence of deterioration, vandalism, cleanliness of sidewalks, etc.)	Higher quality built environment	No	No	No	Poorer quality built environment, greater likelihood of depression	None	National Women's Study depression module	High

[xiv] Kessler Psychological Distress Scale 6 (6-item version of the Kessler 10)

Gapen et al. (2011)	Cross-sectional study	US	615 participants aged 18 to 81	Perceived neighbourhood disorder	Lower disorder scores	No	Yes	No	Higher neighbour-hood disorder, more symptoms of post traumatic stress disorder. This association was mediated by community cohesion	None	Modified Post Traumatic Stress Disorder Symptom Scale	High
Gariepy et al. (2014)	Longitudinal study	Canada	9026 participants with type 2 diabetes aged 18 to 80	Objectively-measured density of businesses, services, parks, recreational facilities, and land-use patterns	Lower density scores	No	Not specifically as a mediator, but as an effect modifier	No	Living nearer a park was associated with a lower risk of depression for people living in crowded households	120	CIDI-SF[xv]	High

[xv] The Composite International Diagnostic Interview Short-Form (CIDI-SF) – a clinically validated screening instrument for depression

Gariepy et al. (2014)	Longitudinal study	Canada	1298 participants with type 2 diabetes aged 18 to 80	Objectively measured neighbourhood service density and green space land-use	Lower density scores and less green space	No	Not specifically as a mediator, but as an effect modifier	Not specifically as a moderator	More physical activity facilities, cultural services and green space was associated with a lower risk of depression	72	PHQ[xvi]	High
Gariepy et al. (2013)	Cross-sectional study	Canada	578 participants with type 2 diabetes	Perceived neighbourhood disorder and access to services	More favourable perceptions	No	No	Not specifically as a moderator	More neighbourhood order and access, less diabetes distress	None	Diabetes Distress Scale	High
Gary et al. (2007)	Cross-sectional study	US	1408 participants aged 18+	Audit-measured perceived neighbourhood problems (including unsafe roads, poor public transport, lack of recreational facilities, etc.)	More favourable perceptions	No	Not specifically as a mediator	No	The perception of severe neighbour-hood problems was associated with higher levels of stress and depression	None	GHQ	High

[xvi] Patient Health Questionnaire

Giurgescu et al. (2015)	Cross-sectional study	US	1383 pregnant women aged 18 to 45	Perceived neighbourhood disorder, safety and walkability	Less favourable perceptions	No	Yes	No	Lower neighbour-hood quality was associated with higher prevalence of depressive symptoms during pregnancy. Social support partially mediated this association	None	CES-D	High
Giurgescu et al. (2012)	Cross-sectional study	US	72 women, mean age 23	Objectively measured neighbourhood disorder from US census variables and land use data. Perceived neighbourhood disorder (including vandalism, vacant lots, etc.)	Lower disorder scores	No	No	No	Higher objective and perceived neighbourho od disorder, higher levels of psychological distress	None	Psychological General Well-Being Index	High

Giurgescu et al. (2015)	Longitudinal study	US	95 pregnant women aged 18 to 41	Objectively measured neighbourhood disorder using census and vandalism count data. Perceived neighbourhood disorder included vandalism, vacant housing, rubbish on sidewalks	Lower neighbour-hood disorder scores	No	Yes	No	Higher perceived neighbourhood environment, lower depressive symptoms at follow-up. Social support partially mediated this association	6	CES-D	High
Guite et al. (2006)	Cross-sectional study	UK	1012 participants aged 18+	Satisfaction with neighbourhood design features, including access to green open spaces, community facilities, incivilities (e.g. vandalism), and safety	Lower neighbour-hood satisfaction scores	No	No	No	Poorer mental health associated with perceived noise level, feeling overcrowded, dissatisfaction with access to green open spaces, poor access to community facilities and feeling unsafe to go out in the day	None	SF-36 mental health component	High

Hale et al. (2013)	Cross-sectional study	US	1298 participants aged 21 to 74	Perceived neighbourhood quality, including pleasantness for physical activity, safety from crime, safety from traffic, 'interestingness', community maintenance, and lack of litter	Less favourable neighbour-hood perceptions	No	No	No	Better perceived neighbourhood quality, lower depressive symptoms	None	DASS[xvii] depression module	High
Harkness et al. (2004)	Cross-sectional study	US	670 participants aged 17 to 85	Objectively measured neighbourhood problems using census data with onsite audited data (boarded up buildings, trash on streets, etc.)	More favourable perceptions	No	No	No	Mental health care costs were lower in neighbourhoods with many nonresidential land uses and a higher proportion of renters	None	Mental health costs based on health service utilisation data from Medicaid and from state and local departments of mental health	High

[xvii] Depression Anxiety and Stress Scales

Hernandez et al. (2015)	Longitudinal study	US	570 participants aged 60+	The Neighbourhood Environment Walkability Scale (NEWS) and subscales (walking/cycling facilities, neigbourhood aesthetics, traffic safety, and crime safety)	lower walkability scores	No	No	No	Lower perceived neighbour-hood crime was associated with lower odds of psychological distress. No prospective association with a validated (NEWS) measure of perceived walkability however	24	Depressive symptoms measured at baseline, 12 months and 24 months using the five-item Geriatric Depression Scale	High
Hill et al. (2009)	Cross-sectional study	US	1444 participants aged 18 to 94	Perceived neighbourhood disorder including noise, cleanliness and crime	More favourable perceptions	Not specifically as a mediator	No	No	Neighbourhood disorder increases psychological distress (via reduced sleep quality)	None	K6	High
Huynh et al. (2013)	Cross-sectional study	Canada	17,249 participants aged 11 to 16	Objectively measured public natural space (parks and water) within a 5 km buffer	Lower public natural space exposure	No	No	Not as a moderator specifically	Modest evidence of higher public natural space, more positive emotional wellbeing	None	the Cantril ladder (students self-rank their current state of life on a 10-point scale, with positive emotional wellbeing scored as 8+)	High

Ivey et al. (2015)	Cross-sectional study	US	884 participants aged 65+	Objectively measured number of services/walking destinations within 400 m, and perceived walkability as measured by the abbreviated Neighbourhood Environment Walkability Scale (NEWS)	Fewer neighbour-hood destinations and lower perceived walkability	No	No	Not as a moderator specifically	Depressive symptoms were associated with higher reports of neighbourhood crime and unsafe traffic, but not with the objectively measured number of walkable destinations	None	CES-D	High
Jalaludin et al. (2012)	Longitudinal study	Australia	42 participants aged 18 to 54	Urban renewal including upgrades to property painting, fencing, new carports and driveways, drainage, landscaping and external maintenance	Own control – before and after	No	No	No	Urban renewal did not have an appreciable impact on psychological distress	30	K10	High
Jones et al. (2014)	Cross-sectional study	UK	8237 participants aged 16+	Perceived environmental incivilities (rubbish in the street, noise and disturbances)	More favourable perceptions	No	Not specifically as a mediator	No	More perceived environmental incivilities, lower positive wellbeing	None	Warwick-Edinburgh Mental Well-being Scale	High

Jones-Rounds et al. (2014)	Cross-sectional study	Eight European cities	5605 participants aged 18 to 64	Perceived neighbourhood quality relating to satisfaction with views from home, ease of household travel connections to the city centre, satisfaction with household parking arrangements, litter or trash in the immediate environment, traffic vibrations felt in the dwelling, construction sites, subway, aeroplanes, noise, public recreational spaces for children, teenagers, elderly, spaces where residents can sit and relax/talk peacefully, and perceived safety when returning home in the dark. Audit-measures also included ratings on the household, quality of green spaces, presence of graffiti, litter, etc.	More favourable perceptions	No	No	No	Better neighbour-hood quality is associated with better psychological wellbeing and buffers against poor housing quality	None	Psychological Well-Being consisting of 6-point self-ratings	High

King and Ogle (2014)	Cross-sectional study	US	3105 participants aged 18+	Perceived disorder scale	More favourable perceptions	No	Not specifically as a mediator	Not specifically as a moderator	More disorder, greater depressive symptoms	None	CES-D	High
Kruger et al. (2007)	Cross-sectional study	US	801 participants aged 18 to 100	Audit-based measure of neighbourhood physical deterioration, including ratings of roofs, porches, gutters, windows, doors and landscaping	More favourable perceptions	No	Yes	No	Greater neighbour-hood deterioration, poorer wellbeing, mediated by social capital and social contact	None	BSI 18 Depression Subscale	High
Latkin and Curry (2003)	Longitudinal study	US	818 participants aged 18+	Perceived neighbourhood disorder, including vandalism, litter, vacant housing, etc.	More favourable perceptions	No	Not specifically as a mediator	No	More neighbour-hood disorder, higher risk of depressive symptomology	9	CES-D	High
Lercher et al. (2002)	Cross-sectional study	Germany	1280 participants with an average age of 9	Objectively measured noise level	Lower noise levels	No	No	No	Noise exposure was marginally associated with child mental health, but only in children with a history of early biological risk (e.g. low birth weight)	None	22-item INDI index of child quality of life – 2 subscales chosen as indicative of symptoms of anxiety and depression	High

Leslie et al. (2008)	Cross-sectional study	Australia	2194 participants aged 20 to 65	Perceived neighbourhood characteristics from the Neighbourhood Environmental Walkability Scale (NEWS) including density, land use mix, street connectivity, infrastructure for walking and cycling, aesthetics and greenery, traffic load and safety, hilliness, physical barriers to walking, presence of cul-de-sacs and parking difficulty	More favourable perceptions	No	No	No	Walkability, traffic and noise were associated with mental health	None	SF-12[xviii] mental health summary score	High
Li et al. (2014)	Cross-sectional study	China	3824 participants aged 60+	Village infrastructure deficiencies, including roads, sewage, waste management and toilet facilities	Lower deficiency scores	No	No	No	Village infrastructure deficiency was associated with a higher odds of being depressed	None	CES-D	High
Lowe et al. (2014)	Cross-sectional study	Jamaica, the Bahamas, St Vincent , St Kitts and Nevis	1955 participants aged 12 to 19	Perceived neighbourhood disorder including presence of litter, graffiti and abandoned buildings	More favourable perceptions	No	No	No	Greater neighbour-hood disorder, higher depression scores	none	Beck Depression Inventory - II	High

[xviii] 12-item Short Form Health Survey

Maas et al. (2009)	Cross-sectional study	Nether-lands	10,089 participants aged 18+	Objectively measured green space %	Lower green space scores	No	Yes	No	More green space, lower depressive symptoms, partially mediated by higher levels of social support	None	GHQ	High
Mair et al. (2015)	longitudinal study	US	596 participants aged 45 to 84	Perceived neighbourhood aesthetic quality – based on well maintained buildings and homes	Less favourable perceptions	No	Not specifically as a mediator	No	Increases in aesthetic quality were associated with decreases in depressive symptomology	60	CES-D	High
Mair et al. (2010)	Cross-sectional study	US	3105 participants aged 18+	Perceived neighbourhood disorder including graffiti, litter, abandoned cars, broken glass and other incivilities	More favourable perceptions	No	No	NO	Greater neighbourhood disorder, higher depression scores	None	CES-D	High
Mair et al. (2009)	Cross-sectional and longitudinal analysis	US	2619 participants aged 45 to 84	Perceived neighbourhood aesthetic quality – based on well maintained buildings and homes	Less favourable perceptions	No	No	No	Greater neighbourhood disorder, higher depression scores, but only in a cross-sectional sample. No significant association for incident depression	60	CES-D	High

Mehdipanah et al. (2014)	Cross-sectional study - repeated	Spain	2792 participants aged 16+ in 2001; 778 participants in 2006; 1221 participants in 2011	Neighbourhood renewal, including public space and accessibility	Neighbour-hoods not receiving renewal package	No	No	No	Neighbour-hood renewal was associated with improved mental health among women only	120	GHQ	High
Messer et al. (2013)	Cross-sectional study	US	723 women aged 18+	Audit-measured built environment index, including housing damage, property disorder, nuisances (i.e. incivilities), territoriality and vacancy	More favourable perceptions	No	No	No	Higher built environment scores were not associated with lower depressive symptoms	None	CES-D	High
Meyers and Miller (2004)	Cross-sectional study	US	348 adolescent aged 14 to 17	Parent-reported neighbourhood disorder, including abandonned and run-down buildings	More favourable perceptions	No	No	No	Less favourable parental neighbour-hood perceptions, poorer psychological adjustment among adolescents	None	Adolescent self-reported psychological symptomology (14-items)	High

Miles et al. (2012)	Cross-sectional study	US	1980 participants (no data presented on age)	Objectively measured housing density and green space	Lower density and less green space	No	No	No	Higher density, fewer depressive symptoms. More green space, fewer depressive symptoms (though not statistically significant)	None	CES-D	High
Mitchell (2013)	Cross-sectional study	UK	1890 participants aged 16+	Self-reported green space for physical activity	Self-reported non-green surroundings for physical activity	Yes	No	No	Physical activity in natural environment is associated with reduced psychological distress than physical activity in non-green settings	None	GHQ	High

Morrison et al. (2004)	Longitudinal study	UK	242 participants aged 15+ at baseline, 183 at follow-up	Traffic calming scheme	Own control – before and after	No	No	No	Following the traffic calming scheme, pedestrian activity in the area rose. Traffic-related problems improved but other local nuisances were reportedly worse. Mental health was unchanged	12	SF-36 Version 2	High
Mullings et al. (2013)	Cross-sectional study	Jamaica	2848 participants aged 15 to 74	Audit-measured neighbourhood infrastructure, amenities/services, physical conditions and green spaces	Lower audit scores	No	No	No	Among males, more depressive symptoms were associated with poor neighbour-hood infrastructure. For females, depressive symptoms were more common among those living in unplanned neighbourhoods	None	Diagnostic and Statistical Manual of Mental Disorders (DSM-IV)	High

Nielsen and Hansen (2007)	Cross-sectional study	Denmark	1200 participants aged 18 to 80	Perceived distance to the nearest green space, frequency of visits to green space	Longer distances and fewer visits	No	No	No	Short distances to green spaces were associated with less stress. The number of visits cannot explain the effects of green space on stress.	None	5-item composite scale of stress	High
Nutsford et al. (2013)	Cross-sectional (ecological) study	New Zealand	Ecological study focussed on 3149 of 3247 areas of Auckland City (excluding Islands)	Objectively measured total and useable green spaces, distance to the nearest useable green space	Less green space	No	No	No	More green space within 3 km, fewer anxiety/mood disorder treatment counts. No association with for green space within 300 m	None	Counts of anxiety/mood disorder treatment using the Ministry of Health's 'Health Tracker'	High

Ochodo et al. (2014)	Cross-sectional study	Kenya	544 participants aged 18 to 80	Satisfaction with street lighting, green spaces, density of dwelling units, walking materials used on buildings, types of doors, states of roofs, and states of windows	More favourable perceptions	No	No	Not specifically as a moderator	Mental health disorders were associated with walking, building materials, density of dwelling units, state of street lighting, types of doors, states of roofs, and states of windows	None	MINI plus[xix]	High
Polling et al. (2014)	Cross-sectional Study	UK	1698 participants aged 18+	Perceived neighbourhood disorder, including vandalism, safety, rubbish and litter	More favourable perceptions	No	No	No	More neighbourhood disorder, higher odds of common mental illness	None	Revised Clinical Interview Schedule covering non-psychotic symptoms	High

[xix] Mini-International Neuropsychiatric Interview plus

Putrik et al. (2015)	Cross-sectional study	Nether-lands	9879 participants, mean age 55	Routinely collected data on neighbourhood physical environment, including car traffic nuisance, disturbance from railway noise, quality of parking and shopping facilities, public transport access, neighbourhood aesthetics, green space, industrial nuisance, sewerage	More favourable neighbour-hood physical environment	No	No	No	More car traffic nuisance and disturbance from railway noise were associated with worse mental health. No association between mental health and quality of parking, shopping facilities, public transport access, neighbourhood aesthetics, green space, industrial nuisance, or sewerage	None	Kessler Psychological Distress Scale (no specification between 6 or 10 item versions)	High

Razani et al. (2014)	Cross-sectional study	US	64,076 child participants aged 6+ (no higher bound reported)	Parent-reported neighbourhood amenities including a park or playground area, sidewalks or walking paths, library and recreation centre. Parent-reported neighbourhood disorder, including litter or garbage on the street or sidewalks, poorly kept housing, vandalism and graffiti	More favourable perceptions	No	No	No	Neighbourhood amenities and disorder were not associated with child ADHD prevalence or severity	None	Parent reported doctor diagnoses child ADHD status and severity	High
Reklaitiene et al. (2014)	Cross-sectional study	Lithuania	6944 participants aged 45 to 72	Objectively measured distance to the nearest green space and participant-reported frequency of green space visits	Longer distance and fewer visits to green space	No	No	No	Among women who visited a park for more than 4hrs a week, longer distance travelled to the park was associated with increased odds of depressive symptomology. No comparable result among men	None	CES-D	High

Richardson et al. (2013)	Cross-sectional study	New Zealand	8157 participants aged 15+	Objectively measured green space %	Lower green space scores	Yes	No	No	More green space, lower risk of poor mental health. Physical activity had only a small impact as a mediating variable	None	SF-36	High
Roe et al. (2013)	Cross-sectional study	UK	106 participants not in work aged 35 to 55	Objectively measured green space %	Lower green space scores	No	No	No	More green space, less stress, especially for women	None	Cortisol assessment	High
Saarloos et al. (2011)	Cross-sectional study	Australia	5218 participants aged 69+	Objectively measured street connectivity, residential density and land use mix	Lower density, connectivity and less diverse mix	No	Not specifically as a mediator	No	Higher land use mix and higher retail availability was associated with a higher odds of depression	None	15-item Geriatric Depression Scale	High

Sarkar et al. (2013)	Cross-sectional study	UK	687 men aged 65 to 84	Objectively measured dwelling level, land use and street-network accessibility (public transport stops, retail, community services, recreation and leisure density)	Lower neighbour-hood scores	No	No	No	Lower levels of psychological distress among participants residing in neighbour-hoods with greater land-use mix, higher local-level street network accessibility and flatter topography	None	GHQ	High
Schaefer-McDaniel (2009)	Cross-sectional study	Canada	126 participants aged 9 to 13	Audit-measured neighbourhood physical disorder, incl. graffiti, vandalism, abandoned housing, garbage, litter, poor condition of street and sidewalk, etc. Also perceived neighbourhood quality incl. things to do in the neighbourhood, places such as stores or restaurants nearby, good places to play	Less neighbour-hood disorder	No	No	No	Higher perceived neighbour-hood quality, lower odds of depression. No association between depression and neighbourho od 'decay'	None	Child Depression Inventory	High

Singh and Ghandour (2012)	Cross-sectional study	US	91,642 participants aged 6 to 17	Perceived neighbourhood, garbage, vandalism, litter, poor or dilapidated housing	More favourable perceptions	No	No	No	Higher neighbour-hood disorder was associated with higher odds of serious behavioural problems	None	Behavioural Problems Index	High
Smith et al. (2015)	Cross-sectional study	UK	3105 participants aged 11 to 12	Perceived neighbourhood aesthetics and walkability/ cycleability	Less favourable perceptions	No	No	No	Mental health was associated with positive perceptions of neighbour-hood aesthetics	None	Warwick-Edinburgh Mental Well-being Scale, and the Short Moods and Feelings Questionnaire for assessment of depression symptoms	High
Sturm and Cohen (2014)	Cross-sectional study	US	1070 participants, no age range specified	Objectively measured distance to the nearest park	Longer distance to park	Yes	No	No	Proximity to a park is associated with better mental health, but not mediated by physical activity	None	5-item Mental Health Inventory from the Medical Outcomes Study	High

Sugiyama et al. (2008)	Cross-sectional study	Australia	1895 participants aged 20 to 65	Perception of neighbourhood green space quantity	Lower perceived green space quantity	Yes	Yes	No	More perceived green space, better mental health. Physical activity and social interactions only partially explained the association between green space and mental health	None	SF-12	High
Theall et al. (2013)	Cross-sectional study	US	99 participants aged 4 to 14	Perceived neighbourhood disorder reported by the main caregiver, including garbage, litter, graffiti, vacant or abandoned buildings, broken steps, broken glass and toys, the presence of strewn garbage / litter outside home	More favourable perceptions	No	No	No	Higher perceived neighbourhood disorder, higher stress (shorter telomere length)	None	Telomere length	High
Theall et al. (2012)	Cross-sectional study	US	11,866 participants aged 12 to 20	Objectively measured neighbourhood destinations, including places to be physically active and to purchase food, collapsed into a 'cumulative	Lower cumulative neighbour-hood risk index scores	Yes	No	No	Higher allostatic load was observed among adolescents in neighbourhoods scoring higher on the	None	Allostatic load, based on 10 biomarkers: waist circumference (cm), triglyceride concentration	High

				neighbourhood risk index'					cumulative risk index		s (mg/dL), fasting glucose concentration (mg/dL), insulin resistance, high density lipoprotein (HDL) cholesterol concentration (mg/dL), low density lipoprotein cholesterol concentration (mg/dL), glycosylated hemoglobin level (%), hypertension, asthma diagnosis, and C-reactive protein concentration (mg/dL). Asthma diagnosis was added as an immune marker	

Toma et al. (2015)	longitudinal study	UK	6134 participants with a mean age of 64	Perceived neighbourhood disorder, including vandalism and graffiti	More favourable perceptions	No	No	No	Greater perceived neighbourhood disorder, poorer wellbeing on all three measures	60	Wellbeing: Hedonic wellbeing measured using the 4-item Pleasure subscale of the CASP-19 scale[xx]; Eudaimonic wellbeing was measured using the remaining 15 items of the CASP scale; Evaluative wellbeing was measured using the Diener Life Satisfaction scale	High
Tomey et al. (2013)	Cross-sectional study	US	5959 participants aged 45 to 84	Perceived neighbourhood aesthetic quality, safety, and walking environment	Less favourable perceptions	Not specifically as a mediator	No	Not specifically as a moderator	Mental health was not associated with neighbourhood walkability	None	SF-12 mental health component	High
van den Berg et al. (2010)	Cross-sectional study	Nether-lands	4529 participants aged 19+	Objectively measured neighbourhood green space	Less green space	No	No	No	Green space buffered the impact of stressful life events on mental health	None	GHQ	High

[xx] CASP scale: Control, autonomy, self-realisation and pleasure scale

van Dyck et al. (2015)	Cross-sectional study	Australia	3965 participants aged 55 to 65	Perceived neighbourhood physical environment, including aesthetics, safety and physical activity locations, such as sports clubs	Less favourable perceptions	Yes	No	No	More favourable perception of neighbourhood physical environment, better mental health. This association was only partially mediated by physical activity.	None	SF-36 Health Survey	High
Wallace D. (2012)	Cross-sectional study	US	1773 participants with a mean age of 43	Perceived neighbourhood disorder, including vandalism, graffiti, and abandoned buildings	More favourable perceptions	No	No	No	Greater neighbourhood disorder, poorer mental health	None	CES-D	High
Weich et al. (2002)	Cross-sectional study	UK	1887 participants aged 16+	Audit-measured built environment site survey checklist including predominant form, height and age of housing, number of dwellings and type of access, provision of gardens, use of public space, amount of derelict land, security and distances to local shops and amenities	Lower built environment survey checklist scores	No	No	No	Odds of depression were greater among residents in areas characterised by properties with predominantly deck access and of recent construction	None	CES-D	High

Weimann et al. (2015)	Longitudinal study, (i.e. 'within person') analysis of movers	Sweden	9444 participants aged 18 to 80	Change in separate survey collated responses on neighbourhood 'serenity, wildness, species richness, spaciousness and cultural history' brought about by neighbourhood relocation	No change	No	No	No	Weak evidence for mental health benefit with increasing green space brought about by neighbourhood relocation	120	GHQ	High
White et al. (2013)	Longitudinal study, fixed effects (i.e. 'within person') analysis of movers	UK	10,168 participants aged 18+	Objectively measured green space % brought about by neighbourhood relocation	No change	No	No	No	More green space, lower mental distress	60	GHQ	High
Whitley and Prince (2006)	Qualitative study	UK	16 participants with likely mental illness	Improvements in shared community facilities and environmental improvements (e.g. landscaping)	Own control – before and after	No	No	No	Participants reported that improvements in neighbourhood safety were more important than improvements in the quantity or quality of shared community facilities. Environmental landscaping was perceived to	None	CES-D	High

									have only marginal benefit			
Wilbur et al. (2009)	longitudinal study	US	278 women mean age 48.5	Neighbourhood deterioration - objective and subjectively measured, based on density of abandoned buildings	Lower deterioration scores	Not specifically as a mediator	No	No	Perceived neighbourhood deterioration was associated with higher depressive symptoms at 24 weeks. Objectively measured neighbourhood deterioration was associated with fewer depressive symptoms	6	CES-D	High
Wright and Kloos (2007)	Cross-sectional study	US	249 participants mean age 46	Perceived neighbourhood quality scale, focussing on the availability of services perception of crime and peceived utility of public spaces	Lower perceived quality	No	No	No	Higher neighbourhood quality, lower risk of psychiatric distress	None	53-item BSI	High

Yen et al. (2006)	Cross-sectional study	US	435 participants aged 22+	Perceived neighbourhood problems, including too much traffic, excessive noise, trash and litter, smells or odours from factories or farms, and smoke from fires or burning	More favourable perceptions	No	No	No	Poorer perception of neighbourhood, greater odds of depressive symptoms	None	CES-D	High
Ziersch et al. (2005)	Mixed methods	Australia	40 participants in interviews, 2560 survey respondents	Perceptions of neighbourhood pollution, cleanliness and safety		No	No	No	Survey analysis showed no association between mental health and neighbourhood pollution / cleanliness. Qualitative analysis observed the availability of services as of potential relevance to health	None	SF-12 mental health component	High

Appendix 2: Risk of bias analysis

Allocation sequence: Was the allocation sequence adequately generated?
Allocation concealment: Was allocation adequately concealed?
Baseline measurements: Were baseline outcome measurements similar?
Baseline characteristics: Were baseline characteristics similar?
Incomplete data: Were incomplete outcome data adequately addressed?
Blinding: Was knowledge of the allocated intervention adequately prevented during the study?
Contamination: Was the study adequately protected against contamination?
Selective reporting: Are reports of the study free of suggestion of selective outcome reporting?

	Risk of bias								
Reference	**Random allocation sequence**	**Allocation concealment**	**Baseline outcome measurements**	**Baseline characteristics**	**Incomplete data**	**Blinding**	**Contamination**	**Selective reporting**	**Risk of bias summary**
Alcock et al. (2014)	No	No	Yes	Yes	Unclear	No	Unclear	Yes	High
Aneshensel and Sucoff (1996)	No	No	Unclear	Unclear	Unclear	No	Unclear	Yes	High
Annerstedt et al. (2012)	No	Unclear	No	No	No	No	Unclear	Yes	High
Araya et al. (2006)	No	No	No	Yes	No	No	Unclear	Yes	High
Arcury et al. (2014)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Astell-Burt et al. (2015)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Astell-Burt et al. (2013)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Astell-Burt et al. (2014)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Bakke et al. (2012)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Barahmand et al. (2013)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Barnes et al. (2011)	No	No	Yes	Yes	No	No	Unclear	Yes	High

Barrington et al. (2014)	No	No	Yes	Yes	No	No	Unclear	Yes	high
Berke et al. (2007)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Beyer et al. (2014)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Bierman A. (2009)	No	No	No	No	No	No	Unclear	Yes	High
Blackman et al. (2001)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Bocquier et al. (2014)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Bond et al. (2012)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Brown et al. (2009)	No	No	No	No	No	No	Unclear	Yes	High
Burk et al. (2009)	No	No	No	No	No	No	Unclear	Yes	High
Butler et al. (2012)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Byck et al. (2015)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Chong et al. (2013)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Cohen-Cline et al. (2015)	No	No	Yes	Yes	No	No	Unclear	Yes	High
de Vries et al. (2013)	No	No	Yes	Yes	No	No	Unclear	Yes	High
DeGuzman et al. (2013)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Downey and van Willigen (2005)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Duncan et al. (2013)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Echeverría et al. (2008)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Fan et al. (2011)	No	No	Yes	Yes	No	No	Unclear	Yes	High

Fauth et al. (2008)	Yes, but not fully (54% of the control 'stayers' never entered the lottery for relocation)	Yes	No	No	No	No	Unclear	Yes	High
Ford and Rechel (2012)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Francis et al. (2014)	No	No	No	No	No	No	Unclear	Yes	High
Francis et al. (2012)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Gale et al. (2011)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Galea et al. (2005)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Gapen et al. (2011)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Gariepy et al. (2014)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Gariepyet al. (2014)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Gariepy et al. (2013)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Gary et al. (2007)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Giurgescu et al. (2015)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Giurgescu et al. (2012)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Giurgescu et al. (2015)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Guite et al. (2006)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Hale et al. (2013)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Harkness et al. (2004)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Hernandez et al. (2015)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Hill et al. (2009)	No	No	Yes	Yes	No	No	Unclear	Yes	High

Huynh (2013)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Ivey et al. (2015)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Jalaludin et al. (2012)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Jones et al. (2014)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Jones-Rounds et al. (2014)	No	No	Yes	Yes	No	No	Unclear	Yes	High
King and Ogle (2014)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Kruger et al. (2007)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Latkin and Curry (2003)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Lercher et al. (2002)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Leslie and Cerin (2008)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Li et al. (2014)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Lowe et al. (2014)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Maas et al. (2009)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Mair et al. (2015)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Mair et al. (2010)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Mair et al. (2009)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Mehdipanah et al. (2014)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Messer et al. (2013)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Meyers and Miller (2004)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Miles et al. (2012)	No	No	No	No	No	No	Unclear	Yes	High
Mitchell (2013)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Morrison et al. (2004)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Mullings et al. (2013)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Nielsen and Hansen	No	No	No	No	No	No	Unclear	Yes	High

(2007)									
Nutsford et al. (2013)	No	No	No	No	No	No	Unclear	Yes	High
Ochodo et al. (2014)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Polling et al. (2014)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Putrik et al. (2015)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Razani et al. (2014)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Reklaitiene et al. (2014)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Richardson et al. (2013)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Roe et al. (2013)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Saarloos et al. (2011)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Sarkar et al. (2013)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Schaefer-McDaniel (2009)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Singh and Ghandour (2012)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Smith et al. (2015)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Sturm and Cohen (2014)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Sugiyama et al. (2008)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Theall et al. (2013)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Theall et al. (2012)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Toma et al. (2015)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Tomey et al. (2013)	No	No	Yes	Yes	No	No	Unclear	Yes	High
van den Berg et al. (2010)	No	No	Yes	Yes	No	No	Unclear	Yes	High
van Dyck et al. (2015)	No	No	Yes	Yes	No	No	Unclear	Yes	High

Wallace (2012)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Weich et al. (2002)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Weimann et al. (2015)	No	No	Yes	Yes	No	No	Unclear	Yes	High
White et al. (2013)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Whitley and Prince (2006)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Wilbur et al. (2009)	No	No	Yes	Yes	No	No	Unclear	Yes	High
Wright and Kloos (2007)	No	No	No	No	No	No	Unclear	Yes	High
Yen et al. (2006)	No	No	No	No	No	No	Unclear	Yes	High
Ziersch et al. (2005)	No	No	No	No	No	No	Unclear	Yes	High