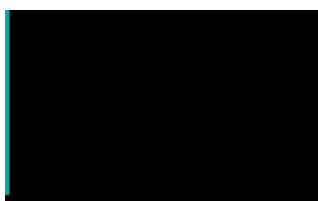


Spatial planning for health: An evidence resource for planning and designing healthier places

Full technical report

Commissioned by Public Health England

June 2017



Authors

Bird, E.L.¹, Ige, J.O.¹, Burgess-Allen, J.² Pinto, A.² & Pilkington, P^{1*}.

¹Faculty of Health and Applied Sciences, University of the West of England, Bristol.

²Public Health England

*Corresponding author. Email address: paul.pilkington@uwe.ac.uk (P. Pilkington, Senior Lecturer in Public Health, UWE Bristol).

Authors' contributions

PP was the project lead. EB was the project manager. The project design was conceived by PP and EB. JI was responsible for data collection. JI and EB reviewed and analysed the data and discussed the findings with PP. EB drafted the first version of the report. All authors contributed to the report and approved the final version.

The findings of this evidence review have been summarised by Public Health England: Public Health England. (2017). Spatial planning for health: An evidence resource for planning and designing healthier places. London, UK: Public Health England. For Public Health England's publication site, see <https://www.gov.uk/government/publications>.

Contents

	Page
Acknowledgements	4
1. Project overview	5
2. Introduction	7
3. Umbrella review methodology	10
4. Findings of the review	13
- Topic 1: Neighbourhood design	13
- Topic 2: Housing	26
- Topic 3: Healthier food environment	39
- Topic 4: Natural and sustainable environment	51
- Topic 5: Transport	70
5. Discussion	83
Appendices	89
- Appendix A: Umbrella review methods	89
- Appendix B: Umbrella review results	101
- Appendix C: Detailed evidence for neighbourhood design	103
- Appendix D: Detailed evidence for housing	117
- Appendix E: Detailed evidence for healthier food environment	126
- Appendix F: Detailed evidence for natural and sustainable environment	134
- Appendix G: Detailed evidence for transport	152

Acknowledgements

Project Advisory Group

We are grateful for the support and feedback provided by members of our project advisory group based at the University of the West of England, Bristol:

- Professor Jane Powell
- Professor Judy Orme
- Professor Selena Gray
- Emeritus Professor Hugh Barton
- Dr Laurence Carmichael
- Dr Jo Barnes
- Professor Adrian Davis

Project Working Group

We would also like to thank the following members of the project working group for their advice and feedback: Carl Petrokofsky, Andre Pinto, Dr Ann Marie Connolly, Bola Akinwale, Jamie Blackshaw, Louis Levy, Dr Michael Brannan, Jacy McGaw-Cesaire.

Note on review conceptualisation and presentation

The conceptual framework used for this review and the presentation of findings were inspired by the Canadian *Healthy Built Environment Linkages Toolkit* (Provincial Health Services Authority, 2014)*. It was in response to this publication that in January 2016 Public Health England commissioned this umbrella review.

* Since completion of this umbrella review, the *Healthy Built Environment Linkages Toolkit* has been updated and version 2.0 was published in May 2018.

BC Centre for Disease Control (2014). *Healthy Built Environment Linkages Toolkit: making the links between design, planning and health, Version 1.0*. Vancouver, B.C., Canada: Provincial Health Services Authority, Population and Public Health.

BC Centre for Disease Control (2018). *Healthy Built Environment Linkages Toolkit: making the links between design, planning and health, Version 2.0*. Vancouver, B.C., Canada: Provincial Health Services Authority, Population and Public Health.

1. Project overview

Aim

The aim of the project was to develop a series of practical diagrams that illustrate the associations, and strength of evidence, between spatial planning and health based on the findings from an umbrella literature review of the impacts of the built environment on health.

Objectives

1. To undertake an umbrella literature review to assess the impact of the built and natural environment on health, concentrating on five key built environment topics:
 - Neighbourhood design
 - Housing
 - Healthier food environment
 - Natural and sustainable environment
 - Transport
2. To appraise the quality and strength of the available evidence, using an agreed grading system.
3. To use the findings of the review to develop a series of diagrams illustrating the associations between planning principles, health impact and health-related outcomes.
4. To illustrate the associations set out in the diagrams with UK-centric evidence, where possible.

Purpose of the project

Although there is a multitude of guidance supporting and advocating action on the built and natural environment to improve health outcomes, the evidence base underpinning these principles is still a matter of debate amongst scientific and practitioner communities. The subjective and individual nature of the built and natural environment make it difficult to develop evidence based-approaches that can be universally applied,

and successful practices in one community setting may not always be transferrable to another.

This project was commissioned by Public Health England to address the need for a UK centric evidence review which analyses and demonstrates the links between health and the built and natural environment. This review attempts to provide an overview, ***based on umbrella review methodology***, of the strength of the evidence of the impacts on health of the built and natural environment with the purpose to inform action and policy.

Intended audience

The primary target audience is public health professionals, but also planners working in local authority settings. The findings are designed to be suitable for both public health and planning professionals, facilitating two-way communications between disciplines.

Structure of the report

- **Chapter 1** provides an overview of the project.
- **Chapter 2** provides an introduction to the built and natural environment and its influence on health and wellbeing.
- **Chapter 3** describes the umbrella review methodology adopted for this review. A detailed description of the methods is provided in Appendix A.
- **Chapter 4** presents the findings of this review for each of the five aspects of the built and natural environment covered in this review (neighbourhood design, housing, healthier food environment, natural and sustainable environment, and transport).
- **Chapter 5** provides a summary and discussion of the findings, including implications for policy and practice, and a reflection on the strengths and limitations of the available evidence and of the review methods.
- The **Appendices** include a detailed description of the methods utilised in this review and tables containing detailed evidence extracted from each of the reviews included in this umbrella review.

2. Introduction

What is the built and natural environment?

The built and natural environment is a key environmental determinant of health and wellbeing. In this report 'built and natural environment' refers to the characteristics (objective and subjective) of a physical environment in which people live, work and play, including: schools, workplaces, homes, communities, and parks/recreation areas, green spaces (i.e., visible grass, trees and other vegetation) and blue spaces (i.e., visible water).

Built environment and health

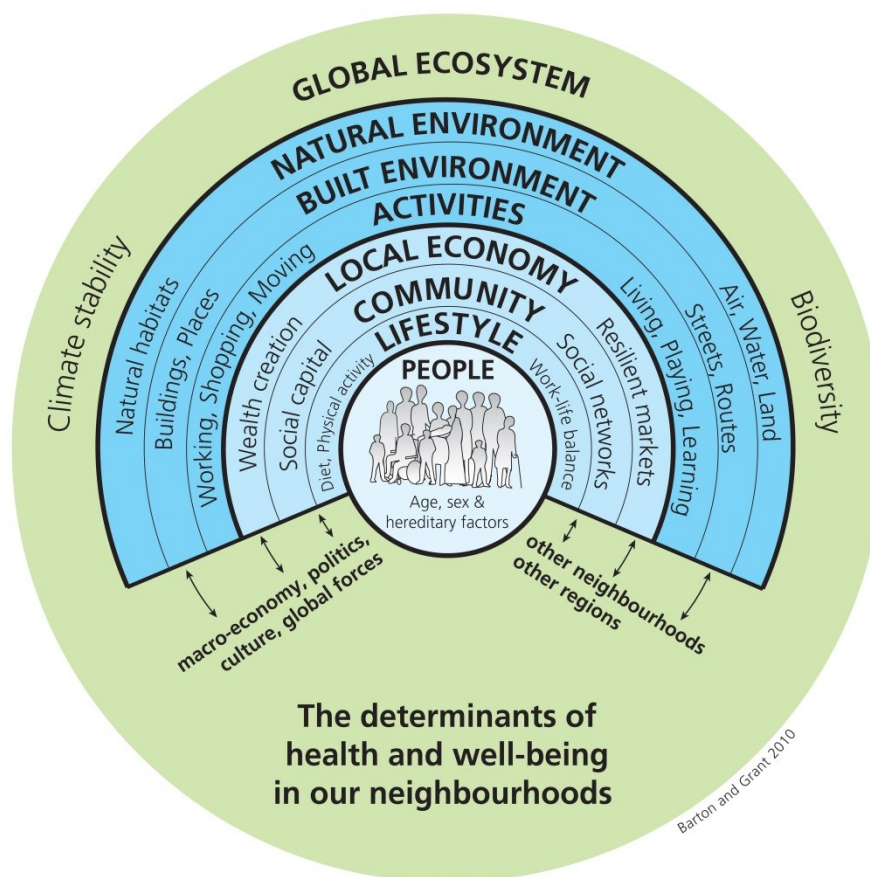
The linkages between health and the built and natural environment have long been established and the role of the environment in shaping the social, economic and environmental circumstances which determine health is increasingly recognised and understood.

An ever-increasing body of research indicates that the environment in which we live is inextricably linked to our health across the life course. For example, the design of our neighbourhoods can influence physical activity levels, travel patterns, social connectivity, mental and physical health and wellbeing outcomes. However, it is important to recognise that the causal links between built environment and health are often complex, in that they are influenced by numerous, sometimes conflicting factors. Furthermore, successful practices in one community setting may not always be transferrable to another.

Although it is difficult to quantify with precision the impact of the built and natural environment on health, research does seem to consistently report that the majority of our health outcomes are explained by factors other than healthcare (Kuznetsova, 2012; McGuinness, Williams-Russo & Knickman, 2002).

To aid understanding of the built and natural environment and health, Barton and Grant (2006), drawing upon the work of Dahlgren and Whitehead (1991), devised the Health Map (Figure 1). The map is focused on the role of neighbourhood and planning and emphasises the importance of built and natural environment influences contributing to health and wellbeing outcomes, in line with the socio-ecological approach to health.

Figure 1. The Health Map



Source: Barton, H. and Grant, M. (2006) A health map for the local human habitat.

References

Barton, H., & Grant, M. (2006). A health map for the local human habitat. *The Journal for the Royal Society for the Promotion of Health*, 126 (6), 252-253.

Dahlgren, G., & Whitehead, M. (1991). "The main determinants of health" model, version accessible in: Dahlgren G, and Whitehead M. (2007) *European strategies for tackling social inequities in health: Levelling up Part 2*. Copenhagen: WHO Regional Office for Europe.

Kuznetsova, D. (2012). *Healthy places: Councils leading on public health*. London: New Local Government Network.

McGinnis, J.M., Williams-Russo, P. & Knickman, J.R. (2002). The case for more active policy attention to health promotion. *Health Affairs*, 21 (2), 78-93.

3. Umbrella review methodology

We conducted an umbrella literature review to examine the health and built environment evidence base, identifying relevant built environment topics, planning principles and characteristics that are associated with health outcomes.

Umbrella reviews have emerged in recent years as an attractive strategy for assessing existing review level evidence. Unlike traditional systematic reviews, umbrella reviews involve a 'rapid review' approach to evidence synthesis and aim to produce an overview of the evidence in a short space of time (Joanna Briggs Institute, 2014; Khangura *et al.*, 2012).

Umbrella reviews are increasingly used in public health research and practice, bringing together a wide range of evidence to explore what is known about a topic in an attempt to guide the decisions of policy makers (Bambra *et al.*, 2009; Bambra *et al.*, 2010; Horodyska *et al.*, 2015; Theodoratou *et al.*, 2014).

This umbrella review identifies, critically appraises and summarises existing review level evidence of associations between the built environment and health outcomes. The review is concentrated on five aspects of the built environment:

- Neighbourhood design
- Housing
- Healthier food environment
- Natural and sustainable environment
- Transport

Traditionally, umbrella reviews focus on existing systematic review level evidence alone (Becker & Oxman, 2008; Ioannidis, 2009). However, as the findings of this review are targeted at public health and built environment practitioners, whose understanding of 'evidence' may differ according to context, we have examined relevant stakeholder organisation documentation (e.g., non-systematic evidence reviews by professional bodies), as well as systematic review level evidence.

In some cases, we identified apparent 'gaps' in the evidence (i.e., areas/issues for which there was no eligible review-level evidence that met our inclusion criteria, despite anecdotal awareness of primary studies relating to the area/issue). It is important to note that although for some built environment areas and/or issues, no review level evidence was found and/or no evidence has yet been systematically reviewed, this does not mean that the built environment area/issue does not exist or is not important. In essence – absence of evidence is not the same as evidence of absence. In response to this, where we identified an apparent 'gap' in the review level evidence, we report selected findings from relevant empirical studies to highlight that the built environment area/issue may be important for consideration, despite a lack of review-level evidence. Notably, however, caution is advised when viewing these studies as they were hand-picked examples and they were not subject to the same quality assessment procedures as the review level evidence.

Note. A detailed description of the methods applied to this review is provided in Appendix A.

References

Bambra, C., Gibson, M., Sowden, A., Wright, K., Whitehead, M., & Petticrew, M. (2009). Working for health? Evidence from systematic reviews on the effects of health and health inequalities of organisational changes to the psychosocial work environment. *Prev Med, 48*, 454-461.

Bambra, C., Gibson, M., Sowden, A., Wright, K., Whitehead, M., & Petticrew, M. (2010). Tackling the wider social determinants of health and health inequalities: Evidence from systematic reviews. *J Epidemiol Community Health, 64*, 284-291.

Becker, L.A., & Oxman, A.D. (2008). *Overviews of reviews*. In J. P. T. Higgins & S. Green (Eds.), *Cochrane handbook for systematic reviews of interventions* (pp. 607– 631). Chichester, West Sussex, England: Wiley. doi:10.1002/9780470712184.ch22.

Horodyska, K., Luszczynska, A., van den Berg, M., Hendriksen, M., Roos, G., De Bourdeaudhuij, & Brug, J. (2015). Good practice characteristics of diet and physical activity interventions and policies: an umbrella review. *BMC Public Health*, 15:19.

Ioannidis, J.P.A. (2009). Integration of evidence from multiple meta-analyses: A primer on umbrella reviews, treatment networks and multiple treatments meta-analyses. *CMAJ*, 181 (8), 488-493.

Joanna Briggs Institute. (2014). *Joanna Briggs Institute Reviewers Manual 2014*. [Accessed online 6 January 2016 from [http://joannabriggs.org/assets/docs/sumari/ReviewersManual-methodology-JBI Umbrella%20Reviews-2014.pdf](http://joannabriggs.org/assets/docs/sumari/ReviewersManual-methodology-JBI%20Umbrella%20Reviews-2014.pdf)].

Khangura, S., Konnyu, K., Cushman, R., Grimshaw, J., & Moher, M. (2012). Evidence summaries: the evolution of a rapid review approach. *Systematic Reviews*, 1:10.

Theodoratou, E., Tzoulaki, I., Zgaga, L., & Ioannidis, J.P. (2014). Vitamin D and multiple health outcomes: umbrella review of systematic reviews and meta-analyses of observational studies and randomised controlled trials. *BMJ*, 348:g2305.

4. Findings of the umbrella review

Topic 1: Neighbourhood Design

Neighbourhoods are places where people live, work, and play and have a sense of belonging. The design of a neighbourhood can contribute to the health and well-being of the people living there. Several aspects of neighbourhood design (walkability and mixed land use) can also maximise opportunities for social engagement and active travel. Neighbourhood design can impact on our day-to-day decisions and therefore have a significant role in shaping our health behaviours.

Planning principles

1. *Enhance neighbourhood walkability*

- Increase walkability: Walkability is a measure of how supportive an area is to walking. Improved street connectivity, mixed land use and compact residential design are considered to be important features of a walkable neighbourhood. There is strong evidence to suggest that walkable neighbourhoods can encourage active travel and thereby promote physical activity. Improving neighbourhood walkability may also impact positively upon social interaction among older adults.
- Improve infrastructure to support walking and cycling: There is consistent moderate-to-high quality evidence to suggest that investing in infrastructure to support walking is associated with increased levels of physical activity among the general population and research has shown that investing in physical infrastructure (such as the installation of greenway trails) with the aim of improving neighbourhood walkability may improve mobility among older adults.
- The overall quality of the evidence reviewed on neighbourhood walkability is mixed, with the majority of reviews classified as being of moderate quality. Although evidence suggests strong links between walkability and physical activity, there are still gaps relating to the impact of walkability on other specific health-related outcomes, such as obesity.

2. *Build complete and compact neighbourhoods*

- Compact neighbourhoods: Neighbourhoods with higher street connectivity (typically designed using finer grid patterns) with diverse land use and greater residential density are generally more conducive to non-motorised transport (e.g., walking and cycling) as a result of there being more people to visit and a greater demand for accessible community services, such as shops and parks. Street connectivity, land use mix and residential density are therefore positively associated.
- Increased housing density is associated with higher levels of physical activity and active travel among all age groups. Low-to-moderate quality evidence from high-income countries demonstrates that diverse housing types and increased access to open green space may also increase physical activity. This review found no conclusive evidence on the impact of density on mental health, however, evidence from a narrative review concluded that higher density housing developments need to have clear guidelines for dealing with issues such as pets, parking and noise in order to not cause undue stress and poor mental health (Haigh, Chok, & Harris, 2011).
- Increase access to facilities and amenities: Long distance trips have been identified as having a potentially negative impact on walking and cycling and social engagement. Mixed land use developments that prioritise access to schools, recreational centres and social amenities may increase physical activity among children, adolescents and older adults. The provision of local amenities may improve mobility and social engagement among older adults.
- The overall quality of available evidence on complete and compact neighbourhoods was either low or not reported, therefore caution is required when drawing conclusions from these findings.

3. *Enhance connectivity with safe efficient infrastructure*

- Improve street connectivity: Street connectivity is a measure of the connection between a point of origin and destination (Berrigan, Pickle, & Dill, 2010) and it is also one of the main elements of neighbourhood planning. Enhancing street connectivity via provision of walking and cycling infrastructure and improving access to public transportation may help reduce perceptions of long distance trips

and provide alternative routes for active travel users to arrive at a destination.

Improving street connectivity may promote active travel and lower car use, which may in turn reduce exposure to residential car pollution.

- **Public realm improvements:** Public realm improvements such as provision of street lighting in residential areas may be effective in preventing road traffic collisions (RTCs) and increasing pedestrian activity. Such environmental improvements may have the potential to reduce fear of crime, however, evidence suggests that installation of CCTV systems may be ineffective in reducing fear of crime.

Supporting evidence

4. Enhance neighbourhood walkability

- 4.1 **Increase walkability:** Evidence of unknown quality from Europe and Asia demonstrates that adults living in neighbourhoods of high walkability accumulated up to 766 more steps per day compared to those living in areas of low walkability (Hajna *et al.*, 2015). Key attributes of a walkable neighbourhood may include: improved street connectivity, mixed land use (i.e., a range of complementary land uses such as residential development, shops, recreation facilities and parks and open space) and compact residential density.
- 4.2 Low-to-moderate quality evidence from high income countries (including one UK study) consistently indicates that improving walkability and access to recreational and non-recreational destinations (such as grocery stores, schools and amenities) may foster social engagement among older people (Beard & Petitot, 2010; McCormack & Sheill, 2011). Please also see evidence under “*increase access to facilities and amenities*” and “*enhance connectivity with safe efficient infrastructure*”.
- 4.3 **Improved infrastructure to support walking and cycling:** A range of systematic reviews have reported on evidence for an association between active travel to work or school, body mass index (BMI) and weight status. The evidence (predominantly US and UK based studies) is of moderate-to-high quality and shows either a positive association or no association but does not suggest a negative association (Faulkner *et al.*, 2009; Oja *et al.*, 2011; Xu *et al.*, 2013).
- 4.4 There is moderate quality evidence from high-income countries (mostly US) consistently reporting that provision of physical infrastructure such as dedicated

cycle routes and the instalment of greenway trails may increase cycling levels (Fraser & Lock, 2011; Gomez *et al.*, 2015; McCormack & Sheill, 2011). There is also a wealth of moderate-to-high quality evidence to suggest that investing in infrastructure to support walking may increase levels of physical activity among all age groups (Carlin *et al.*, 2015; D’Hease *et al.*, 2015; Grasser *et al.*, 2013; Larouche *et al.*, 2014; Mueller *et al.*, 2015; Wanner *et al.*, 2012).

5. Build complete and compact neighbourhoods

- 5.1 Compact Neighbourhoods: Low-to-moderate quality evidence from studies conducted in high-income countries suggests that living in a densely populated environment may increase level of physical activity levels (Durand *et al.*, 2011). Numerous moderate quality reviews from high-income countries report that mixed land use may also raise physical activity levels (Gomez *et al.*, 2015; McCormack & Sheill, 2011; WHO, 2007).
- 5.2 Evidence of moderate-to-high quality evidence indicates that exposure to residential greenness is associated with a reduced risk of mortality from cardiovascular disease (CVD) (Gascon *et al.*, 2016). A 10% increase in greenness was found to result in a small reduction in the risk of CVD mortality, although notably this reduction was not found to be statistically significant (risk ratio = 0.993, 95% CI = 0.985, 1.001).
- 5.3 Living in an area overlooking open public areas is associated with improved mental health outcomes (Annear *et al.*, 2014). These findings are supported by further review level evidence, drawn from the UK and other high and middle-income countries, in which access to green or open spaces has been shown to be associated with improved mental health outcomes (Clark *et al.*, 2007; Gascon *et al.*, 2016). However, caution is required when interpreting these findings as they are reliant on cross-sectional data and study quality is low-to-moderate.
- 5.4 This review found no conclusive evidence on the impacts of housing density on mental health outcomes. However, higher density housing developments have clear guidelines for dealing with issues such as pets, parking and parties (the three P’s). The impacts of housing density on mental health outcomes are context specific and the design of higher density housing needs to be fit for purpose (Haigh *et al.*, 2011).

5.5 Increased access to facilities and amenities: There is evidence of unknown quality that access to local amenities such as shops, schools and health centres may increase mobility and social participation among older adults (Laevsseur *et al.*, 2015).

5.6 Low-to-moderate quality evidence from studies conducted in high-income countries suggests that long distance trips, steep inclines and increased proximity to amenities via cycle paths may adversely affect cycling behaviour (Fraser & Lock, 2011). Two reviews, drawing upon low-to-moderate quality evidence from high-income countries (including the UK), indicate that the availability of open green spaces within the living environment is associated with increased active travel and physical activity (Fraser & Lock, 2011; Gomez *et al.*, 2015).

6. Enhance connectivity with safe efficient infrastructure

6.1 Improved street connectivity: There is evidence of moderate quality that street connectivity is positively associated with physical activity (McCormack & Sheill, 2011; WHO, 2007). Evidence of unknown quality from Europe and Asia demonstrates that adults living in neighbourhoods of high walkability accumulated up to 766 more steps per day compared to those living in areas of low walkability (Hajna *et al.*, 2015).

6.2 Public realm improvements: Low quality evidence from high income countries (including the UK) suggests that street lighting may prevent road traffic collisions (RTCs), injuries and fatalities among car occupants (Beyer & Ker, 2009). There is also moderate quality evidence to suggest that provision of good quality street lighting may increase pedestrian activity (McCormack & Sheill, 2011). General environmental improvements such as this may have the potential to reduce fear of crime (Lorenc *et al.*, 2013). However, this evidence is of low quality. There is consistent evidence of low quality, that installation of CCTV may be ineffective in reducing fear of crime (Lorenc *et al.*, 2013).



Neighbourhood Design

Quality of Evidence:

- ▲ Improved
- ▼ Reduced
- High Quality
- Medium Quality
- Low Quality
- NR (Not reported):

Methodological quality of the original research is unclear and should be treated with caution.

Greyed Out Text
Association between a health impact & health outcome not obtained as part of the umbrella review.

Best Available Evidence:

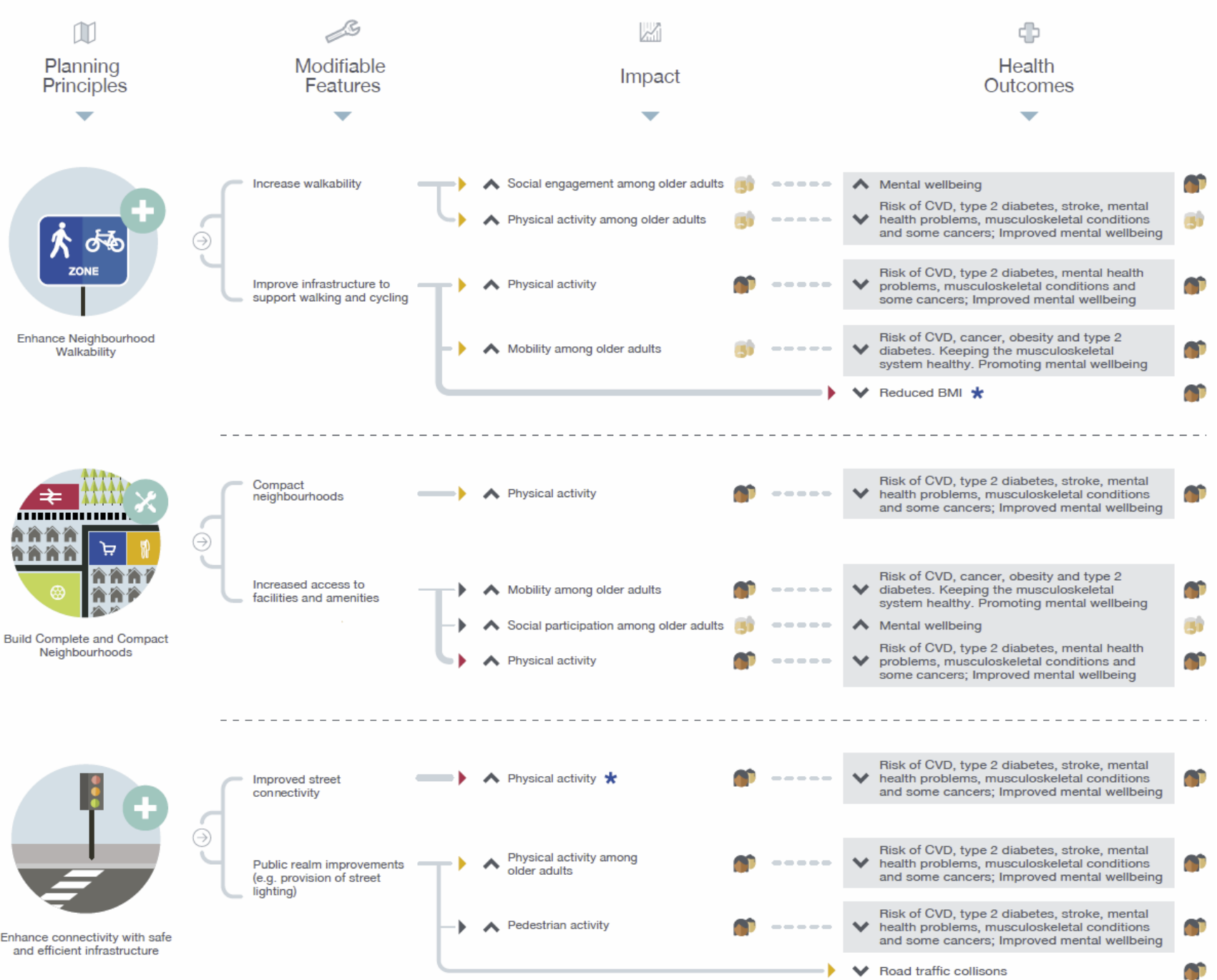
* In some instances, more than one piece of review-level evidence reporting on the same health impacts and/or outcomes was identified as part of this umbrella review. In such instances this table highlights findings of the review(s) which reported evidence of the best methodological quality.

Population Groups:

- General Population
- Older Adults
- Children & Adolescents

Disclaimer:

This diagram has been produced as part of a wider evidence resource, commissioned by Public Health England and developed by the University of the West of England. Please see the document Spatial planning for health: an evidence resource for planning and designing healthier places for further information.



Neighbourhood design bibliography

*Referenced in supporting evidence section

*Annear, M., Keeling, S., Wilkinson, T., Cushman, G., Gidlow, B., & Hopkins, H. (2014). Environmental influences on healthy and active ageing: A systematic review. *Ageing & Society*, 34 (4), 590-622.

*Beard, J.R., & Petitot, C. (2010). Ageing and urbanization: Can cities be designed to foster active ageing? *Public Health Reviews* [online]. 32 (2), 1.

*Berrigan, D., Pickle, L.W., & Dill, J., 2010. Associations between street connectivity and active transportation. *International Journal of Health Geographics*, 9 (1), 20.

*Beyer, F.R., & Ker, K. (2009). Street lighting for preventing road traffic injuries. *Cochrane Database of Systematic Reviews*, 1.

Bonell, C., Farah, J., Harden, A., Wells, H., Parry, W., Fletcher, A., Petticrew, M., Thomas, J., Whitehead, M., & Campbell, R. (2013). Systematic review of the effects of schools and school environment interventions on health: evidence mapping and synthesis. *Public Health Research* [online]. 1 (1).

Boothe, V.L., Boehmer, T.K., Wendel, A.M., & Yip, F.Y. (2014). Residential traffic exposure and childhood leukemia: a systematic review and meta-analysis. *American Journal of Preventive Medicine* [online]. 46 (4), 413-422.

Bowler, D.E., Buyung-Ali, L., Knight, T.M., & Pullin, A.S. (2010). Urban greening to cool towns and cities: A systematic review of the empirical evidence. *Landscape and Urban Planning* [online]. 97 (3), 147-155.

Cairns, J., Warren, J., Garthwaite, K., Greig, G., & Bambra, C. (2015) Go slow: an umbrella review of the effects of 20 mph zones and limits on health and health inequalities. *Journal of Public Health (Oxford, England)*. 37 (3), pp.515-520.

*Carlin, A., Murphy, M.H., & Gallagher, A.M. (2015). Do interventions to increase walking work? A systematic review of interventions in children and adolescents. *Sports Med*, 46 (5), 515-530.

Casey, R., Oppert, J., Weber, C., Charriere, H., Salze, P., Bardariotti, D., Banos, A., & Fischler, C. (2014). Determinants of childhood obesity: What can we learn from built environment studies? *Food Quality and Preference*, 31, 164-172.

*Clark, C., Myron, R., Stansfeld, S., & Candy, B. (2007). A systematic review of the evidence on the effect of the built and physical environment on mental health. *Journal of Public Mental Health* [online]. 6 (2), 14-27.

Chief Medical Officer. (2011). Start Active, Stay Active: A report on physical activity for health from the four home countries' Chief Medical Officers. 2011. Accessed 09 August 2016 from: www.gov.uk/government/publications/start-active-stay-active-a-report-on-physical-activity-from-the-four-home-countries-chief-medical-officers.

*D'Hease, S., Vanwollegam, G., Hinckson, E., De Bourdeauhuij, I., Deforche, B., Van Dyck, D., & Cardon, G. (2015). Cross-continental comparison of the association between the physical environment and active transportation in children: A systematic review. *IJBNPA*, 12 (145), DOI 10.1186/s12966-015-0308-z.

Davison, K.K., & Lawson, C.T. (2006). Do attributes in the physical environment influence children's physical activity? A review of the literature. *International Journal of Behavioral Nutrition and Physical Activity*, 3 (1), 19.

Dunton, G.F., Kaplan, J., Wolch, J., Jerrett, M., & Reynolds, K.D. (2009). Physical environmental correlates of childhood obesity: a systematic review. *Obesity reviews*, 10 (4), 393-402.

*Durand, C.P., Andalib, M., Dunton, G.F., Wolch, J., & Pentz, M.A. (2011). A systematic review of built environment factors related to physical activity and obesity risk:

implications for smart growth urban planning. *Obesity Reviews* [online]. 12 (5), e173-e182.

*Faulkner, G.E., Buliung, R.N., Flora, P.K., & Fusco, C. (2009). Active school transport, physical activity levels and body weight of children and youth: a systematic review. *Preventive Medicine*, 48 (1), 3-8.

*Fraser, S.D., & Lock, K. (2011). Cycling for transport and public health: a systematic review of the effect of the environment on cycling. *European Journal of Public Health* [online]. 21 (6), 738-743.

*Gascon, M., Triguero-Mas, M., Martinez, D., Dadvand, P., Rojas-Rueda, D., Plasencia, A., & Nieuwenhuijsen, M.J. (2016). Residential green spaces and mortality: A systematic review. *Environmental International*, 86, 60-67.

*Gomez, L.F., Sarmiento, R., Ordoñez, M.F., Pardo, C.F., de Sá, T.H., Mallarino, C.H., Miranda, J.J., Mosquera, J., Parra, D.C., & Reis, R. (2015). Urban environment interventions linked to the promotion of physical activity: A mixed methods study applied to the urban context of Latin America. *Social Science & Medicine* [online]. 131, 18-30.

*Grasser, G., Van Dyck, D., Titze, S., & Stronegger, W. (2013) Objectively measured walkability and active transport and weight-related outcomes in adults: a systematic review. *International Journal of Public Health*, 58 (4), 615-625.

Haigh, F. & Ng Chok, H., Harris, P. (2011) *Housing density and health: A review of the literature and Health Impact Assessments*. Centre for Health Equity Training, Research and Evaluation (CHETRE), University of New South Wales: Sydney.

*Hajna, S., Ross, N.A., Brazeau, A., Bélisle, P., Joseph, L., & Dasgupta, K. (2015) Associations between neighbourhood walkability and daily steps in adults: a systematic review and meta-analysis. *BMC Public Health* [online]. 15 (1), 1.

Hunter, R.F., Christian, H., Veitch, J., Astell-Burt, T., Hipp, J.A., & Schipperijn, J. (2015). The impact of interventions to promote physical activity in urban green space: a systematic review and recommendations for future research. *Social Science & Medicine*, 124, 246-256.

Kabisch, N., Qureshi, S., & Haase, D. (2015). Human-environment interactions in urban green spaces – A systematic review of contemporary issues and prospects for future research. *Environmental Impact Assessment Review*, 50, 25-34.

Kim, D. (2008). Blues from the neighbourhood? Neighbourhood characteristics and depression. *Epidemiol Rev*, 30, 101-117.

*Larouche, R., Saunders, T.J., Faulkner, G.E.J., Colley, R., & Tremblay, M. (2014). Associations between active school transport and physical activity, body composition, and cardiovascular fitness: a systematic review of 68 studies. *Journal of Physical Activity & Health*, 11 (1).

*Levasseur, M., Généreux, M., Bruneau, J., Vanasse, A., Chabot, É., Beaulac, C., & Bédard, M. (2015). Importance of proximity to resources, social support, transportation and neighborhood security for mobility and social participation in older adults: results from a scoping study. *BMC Public Health* [online]. 15 (1), 1.

*Lorenc, T., Petticrew, M., Whitehead, M., Neary, D., Clayton, S., Wright, K., Thomson, H., Cummins, S., Sowden, A., & Renton, A. (2013) Fear of crime and the environment: systematic review of UK qualitative evidence. *BMC Public Health* 13.1: 1.

*McCormack, G.R., & Shiell, A. (2011). In search of causality: a systematic review of the relationship between the built environment and physical activity among adults. *Int J Behav Nutr Phys Act* [online]. 8 (1), 125.

*Mueller, N., Rojas-Rueda, D., Cole-Hunter, T., de Nazelle, A., Dons, E., Gerike, R., Götschi, T., Panis, L.I., Kahlmeier, S., & Nieuwenhuijsen, M. (2015). Health impact assessment of active transportation: a systematic review. *Preventive Medicine*, 76, 103-114.

NICE. NG32: Older people: independence and mental wellbeing. National Institute for Health and Care Excellence, 2015. Available from: www.nice.org.uk

Papas, M.A., Alberg, A.J., Ewing, R., Helzlsouer, K.J., Gary, T.L., & Klassen, A.C. (2007). The built environment and obesity. *Epidemiol Rev*, 29 (1), 129-143.

Penkella, A.M., & Kohler, S. (2014). Urbanicity and mental health in Europe. *European Journal of Mental Health*, 9, 163-177.

Soon, I.S., Molodecky, N.A., Rabi, D.M., Ghali, W.A., Barkema, H.W., & Kaplan, G.G. (2012). The relationship between urban environment and the inflammatory bowel diseases: a systematic review and meta-analysis. *BMC Gastroenterol*, 24, 12:51.

Soril, L.J.J., Leggett, L.E., Lorenzetti, D.L., Silius, J., Robertson, D., Mansell, L., Holyroyd-Leduc, J., Noseworth, T.W., & Clement, F.M. (2014). Effective use of the built environment to manage behavioural and psychological symptoms of dementia: A systematic review. *PLoS ONE*, <https://doi.org/10.1371/journal.pone.0115425>.

NICE. PH41: Physical activity: walking and cycling. National Institute for Health and Care Excellence, 2012. Available from: www.nice.org.uk.

NICE. PH44: Physical Activity: Brief Advice for Adults in Primary Care. National Institute for Health and Care Excellence, 2013. Available from: www.nice.org.uk.

*Oja, P., Titze, S., Bauman, A., De Geus, B., Krenn, P., Reger-Nash, B., & Kohlberger, T. (2011). Health benefits of cycling: a systematic review. *Scandinavian Journal of Medicine & Science in Sports*, 21 (4), 496-509.

Pirkis, J., San Too, L., Spittal, M.J., Kryszynska, K., Robinson, J., & Cheung, Y.T.D. (2015). Interventions to reduce suicides at suicide hotspots: a systematic review and meta-analysis. *The Lancet Psychiatry* [online]. 2 (11), 994-1001.

Public Health England. (2015) PHE: Making the case: the impact of heat on health – now and in the future. Available at: www.gov.uk/government/publications/heatwave-plan-for-england.

Rothman, L., Buliung, R., Macarthur, C., To, T., & Howard, A. (2014). Walking and child pedestrian injury: a systematic review of built environment correlates of safe walking. *Injury Prevention: Journal of the International Society for Child and Adolescent Injury Prevention*, 20 (1), 41-49.

Sallis, J.F., Spoon, C., Cavill, N., Engelberg, J.K., Gebel, K., Parker, M., Thornton, C.M., Lou, D., Wilson, A.L., & Cutter, C.L. (2015). Co-benefits of designing communities for active living: an exploration of literature. *Int J Behav Nutr Phys Act* [online]. 12.

Thompson Coon, J., Boddy, K., Stein, K., Whear, R., Barton, J., & Depledge, M.H. (2011). Does participating in physical activity in outdoor natural environments have a greater effect on physical and mental wellbeing than physical activity indoors? A systematic review. *Environmental science & technology*, 45 (5), 1761-1772.

Vienneau, D., Schindler, C., Perez, L., Probst-Hensch, N., & Röösli, M. (2015). The relationship between transportation noise exposure and ischemic heart disease: a meta-analysis. *Environmental Research*, 138, 372-380.

*Wanner, M., Götschi, T., Martin-Diener, E., Kahlmeier, S., & Martin, B.W. (2012). Active transport, physical activity, and body weight in adults: a systematic review. *American Journal of Preventive Medicine*, 42 (5), 493-502.

*Xu, H., Wen, L.M., & Rissel, C. (2013). The relationships between active transport to work or school and cardiovascular health or body weight: a systematic review. *Asia-Pacific Journal of Public Health / Asia-Pacific Academic Consortium for Public Health*, 25 (4), 298-315.

Yen, I.H., Michael, Y.L., & Perdue, L. (2009). Neighborhood environment in studies of health of older adults: a systematic review. *American Journal of Preventive Medicine* [online]. 37 (5), 455-463.

*WHO Europe. (2007). *Tackling Obesity by Creating Healthy Residential Environments*. Accessed 19 April 2015 from http://www.euro.who.int/_data/assets/pdf_file/0012/98697/E90593.pdf.

Topic 2: Housing

A considerable amount of time is spent daily in the home. Adults who work and run businesses from their homes spend more time at home than anywhere else. The home can also provide an environment for children to play and interact with peers. Housing is a basic human right, yet the quality and affordability of houses can determine the health status of residents. It is estimated that 20% of the UK's housing stock does not meet decent home standard and that the cost to the NHS of poor quality housing is £2.5 billion per annum (BRE, 2010). Living in good quality and affordable housing is associated with numerous positive health outcomes for the general population and those from vulnerable groups, including: improved social outcomes among older adults, reduced injury among older adults and children and improved general physical and mental health.

Planning principles

1. *Improve quality of housing*

- In the UK, housing quality is assessed using the housing quality indicator (HQI) system¹. The HQI assesses housing quality according to a 10-item checklist: location; visual impact; open space; routes and movement; size; layout; noise/light and services; accessibility; sustainability; and, external environment (Housing and Communities Agency, 2011). This umbrella review identified evidence to support the importance of many of these factors in relation to housing and health.
- Energy efficient homes: There is a large body of mixed quality evidence to suggest that living in a warm and energy efficient property is associated with improved general health outcomes, reduced respiratory conditions, improved mental health, and reduced mortality.
- Removal of home hazards: Good quality housing is also associated with a reduced risk of unintentional injury or death. For example, improvements to residential lighting and interventions to reduce hazards in the home may lead to reduced fall-related injuries among older adults and wider positive outcomes such as improved social outcomes.

- Housing refurbishment/retrofitting: Evidence suggests that housing refurbishment, including damp proofing, re-roofing, and new window installation is associated with improvements in general health outcomes. Modifications to improve housing warmth and energy efficiency may help to reduce health inequalities among those from low-income groups, older adults and those living with chronic pre-existing conditions. Evidence also indicates that home security improvements have the potential to reduce fear of crime.
- Fuel poverty: No systematic review level evidence relating to the direct health impacts of living in fuel poverty was found that met the eligibility criteria for this review. However, in a report produced by the Marmot Review Team, fuel poverty was shown to be associated with excess winter deaths, increased prevalence of chronic conditions, and poorer mental health outcomes (Marmot Review Team, 2011).
- Daylight and ventilation: This review did not identify any eligible systematic review level evidence relating to daylight and ventilation and subsequent health outcomes. However, the association between poor indoor air quality and ill health, particularly CVD (second-hand tobacco smoke) respiratory symptoms (second-hand tobacco smoke, NO₂), sensory irritation (formaldehyde), lung cancer (second-hand smoke, PACs and radon) and other cancers (trichloroethylene and benzene) are well established (RCPRCPCH, 2016; WHO, 2010).
- The overall quality of evidence reviewed on housing is mixed, with the majority of reviews considered to be of moderate quality. Unfortunately, authors of many reviews did not report on evidence quality, making it difficult to draw clear causal links between good quality housing and health-related outcomes.

2. Increase provision of affordable and diverse housing

- Provision of diverse housing types: Housing diversity measures the range of housing types within a neighbourhood, suitable for different sections of society (e.g., young families, students, older adults). Provision of diverse forms and types of housing is associated with increased physical activity.
- Provision of mixed-use affordable housing: The provision of mixed land use and affordable housing is strongly associated with improved safety perceptions in the neighbourhood, particularly among individuals from low-income groups. However,

the impact of such housing provision on improving health outcomes and reducing health inequalities is unclear.

- Provision of affordable rental housing: A small body of poor quality evidence suggests that living in rental housing may have an adverse effect on the mental health of younger adolescents (12-14 years of age). However, there is no evidence to suggest an effect of affordable rental housing on the mental health status of older adolescents (15-19 years of age) and adults. The poor quality and limited number of studies identified in this review do not allow us to draw firm conclusions on this topic.
- Overall, evidence for the impact of increased provision of affordable housing on health-related outcomes remains unclear and requires further examination to determine causal associations.

3. *Increase provision of affordable housing for groups with specific needs*

- Provision of affordable housing for specific vulnerable groups: There is broad agreement in the literature that the provision of affordable housing for vulnerable groups (including adults with intellectual disability and adult substance users) is associated with improvements in social, behavioural and health-related outcomes.
- Provision of affordable housing for groups living with chronic conditions: There is strong, high quality evidence that provision of secure and affordable housing for those with chronic medical conditions, such as HIV/AIDS is associated with increased engagement with healthcare services, which has been shown to lead to improved health-related outcomes. Furthermore, provision of secure and affordable housing is also associated with reduced engagement in risky health-related behaviours. It is important to note that this review-level evidence was not drawn from studies conducted in the UK, and thus may not be transferable to a UK context.
- Provision of affordable housing for the homeless: The provision of affordable housing for the homeless has consistently associated with increased engagement with healthcare services, improved quality of life, increased employment and improvements in mental health status.

Supporting evidence

4. *Improve quality of housing*

- 4.1 Energy efficient homes: There is a wealth of mixed quality evidence from middle-and-high income countries (including the UK) to suggest that improvements in housing warmth and energy efficiency are related to improved health outcomes, including asthma, general and mental health outcomes for the population (including those living in poor housing with existing poor health), and general health improvements for those in low-income groups (notably older adults and those living with chronic conditions) (Gibson *et al.*, 2011; Krieger *et al.*, 2014; Thomson *et al.*, 2009; Thomson *et al.*, 2013; WHO 2005). Research suggests that such interventions may also have the ability to reduce health inequalities (Gibson *et al.*, 2011).
- 4.2 Low-to-moderate quality evidence from middle-and-high income countries indicates that poor housing insulation is associated with an increase in mortality (Garin *et al.*, 2014).
- 4.3 Removal of home hazards: There is a consistent body of moderate quality evidence that indicates that improved lighting is associated with improved social outcomes and reduced fall-related injuries among older adults (Bambra *et al.*, 2010; McClure *et al.*, 2008). However, the impact of such interventions on reducing health inequalities is unclear (Bambra *et al.*, 2010).
- 4.4 There is moderate quality evidence that home hazard reduction interventions are associated with reduce fall-related injuries among older adults (McClure *et al.*, 2008).
- 4.5 Housing refurbishment/retrofitting: There is moderate quality evidence from middle-and-high income countries (including the UK) that housing refurbishment, including damp proofing, re-roofing, installation of new windows is associated with improved health outcomes (Clark *et al.*, 2007; Gibson *et al.*, 2011, Thomson *et al.*, 2013). Such interventions may also have the ability to reduce health inequalities (Gibson *et al.*, 2011).
- 4.6 Evidence, predominantly from the UK, assessing the effectiveness of improvements in housing quality (including reduced condensation, dissatisfaction with housing and desire to be re-housed) indicates that poor housing quality is associated with

poor mental health outcomes. However, caution is required as the quality of the evidence is low-to-moderate (Clark *et al.*, 2007; WHO, 2005).

- 4.7 There is evidence to support the implementation of damp management interventions to improve asthma outcomes. However, the quality of evidence is unclear (Krieger *et al.*, 2014).
- 4.8 There is low-to-moderate quality evidence that working smoke alarms installed in the home can reduce death from residential fires by 40%-50% compared with homes that do not have working smoke alarms (DiGuseppi *et al.*, 2011). The appropriate installation of smoke alarms is required to prevent fire-related injury and death (WHO, 2005).
- 4.9 There is low quality evidence from five UK studies that home security improvements may reduce fear of crime (Lorenc, 2013).
- 4.10 There is low-to-moderate quality evidence that pre-set safe temperature hot water heaters can reduce scald burns among children (DiGuseppi *et al.*, 2011).
- 4.11 The prevalence of depression is negatively associated with housing quality, and the number of rooms in a house. Caution is required when interpreting these findings as although they are based on findings from middle-and-high income countries, the quality of the evidence is deemed to be of low-moderate quality (Garin *et al.*, 2014).
- 4.12 There is moderate quality evidence to suggest that active radon mitigation strategies for the home are effective in reducing exposure to radon in the air to fewer than 4 pCi/L (Sandel *et al.*, 2010).
- 4.13 One review found moderate quality evidence that residential lead hazard control is effective and ready for implementation in reducing environmental lead contamination (Sandel *et al.*, 2010).
- 4.14 Evidence for the effectiveness of garage sealing to reduce benzene and other VOC exposures is unclear (Sandel *et al.*, 2010). Further research in this area is required.
- 4.15 There is mixed, moderate quality evidence that housing shells are ineffective at preventing infiltration of small particulate matter, from air pollution and traffic (Sandel *et al.*, 2010).
- 4.16 Fuel poverty: No systematic review level evidence relating to the direct health impacts of living in fuel poverty was found that met the eligibility criteria for this review.

4.17 Daylight and ventilation: This review did not identify any eligible systematic review level evidence relating to daylight and ventilation and health outcomes.

5. Increase provision of affordable and diverse housing

Provision of diverse housing types: Low-to-moderate quality evidence from high income countries demonstrates that diverse housing types, increased housing density and increased access to open green space may increase physical activity (Durand, 2011). Please also see the *Neighbourhood Design* chapter.

5.1 Provision of mixed-use affordable housing: Moderate quality evidence from the US indicates that provision of mixed-use affordable housing (i.e., rent subsidies to create mixed-income or desegregated housing in low income neighbourhoods) may improve perceptions of neighbourhood safety and improve self-reported overall health among low income groups. The impact of such interventions on reducing health inequalities is unclear (Bambra *et al.*, 2010).

5.2 Provision of affordable rental housing: A review based on poor quality evidence suggests that the mental health of adolescents aged 12-14 may be adversely affected by living in affordable rental housing (Clark *et al.*, 2007). This evidence is based predominantly on research conducted in the UK. The provision of affordable rental housing tenure has not been found to be associated with mental health outcomes among adults and adolescents aged 15-19 (Clark *et al.*, 2007; Gibson *et al.*, 2011).

6. Increase provision of affordable housing for groups with specific needs

6.1 Provision of affordable housing for specific vulnerable groups: There is moderate quality evidence from middle-to-high income countries that provision of affordable housing for substance users is associated with decreased substance use and increased housing tenure among the homeless and housed individuals (Fitzpatrick-Lewis *et al.*, 2011; Reif *et al.*, 2014). Provision of abstinent housing¹ was found to be effective in supporting housing status, substance abuse relapse, engagement with health services, and improved psychiatric outcomes than non-abstinent housing or no housing.

- 6.2 There is evidence from the UK for the positive impact of the provision of dispersed housing ¹ for people with intellectual disability on quality of life outcomes, when compared with clustered housing (Mansell & Beadle-Brown, 2009). However, the quality of the available evidence is unclear.
- 6.3 A review of US evidence suggested that a programme to subsidise housing costs for low-income families was effective in achieving positive health outcomes. Families in receipt of housing vouchers in the US are less likely to suffer from overcrowding, malnutrition due to food insecurity, and concentrated poverty than low-income non-voucher holders (Lindberg *et al.*, 2010).
- 6.4 Provision of affordable housing for groups living with chronic conditions: There is support for an association between the provision of affordable, secure tenancy and improved health outcomes among inadequately housed people living with HIV/AIDS. Positive outcomes include engagement with health services, improved psychiatric outcomes, sustained viral suppression, and reduced engagement in risky sexual behaviours (Aidala *et al.*, 2016; Fitzpatrick-Lewis *et al.*, 2011; Leaver *et al.*, 2007).
- 6.5 There is moderate-to-high quality evidence that provision of housing assistance for inadequately housed people living with HIV/AIDS is associated with improved health outcomes (Aidala *et al.*, 2016).
- 6.6 Provision of affordable housing for the homeless: There is low quality evidence from the US indicating that provision of affordable, secure tenancy for the homeless is associated with short term housing improvement and increased employment (Bassuk *et al.*, 2014). There is moderate quality evidence reporting that provision of affordable, secure tenancy for the homeless living with severe and persistent mental illness can lead to improved mental health, healthcare utilisation and quality of life outcomes. However, the impact of such interventions for those who are housed but living in a precarious housing situation remains unclear (Kyle & Dunn, 2008; Nelson, Aubry & Lafrance, 2007).

¹ Dispersed housing refers to small group homes or supporting living apartments/houses scattered throughout residential neighbourhoods among the rest of the population.

² Abstemious housing is specialised housing that provides support for drug and alcohol dependent homeless people (Fitzpatrick, 2013)



Housing

Quality of Evidence:

- ⬆ Improved
- ⬇ Reduced
- ▬ High Quality
- ▬ Medium Quality
- ▬ Low Quality
- ▬ NR (Not reported):
Methodological quality of the original research is unclear and should be treated with caution.

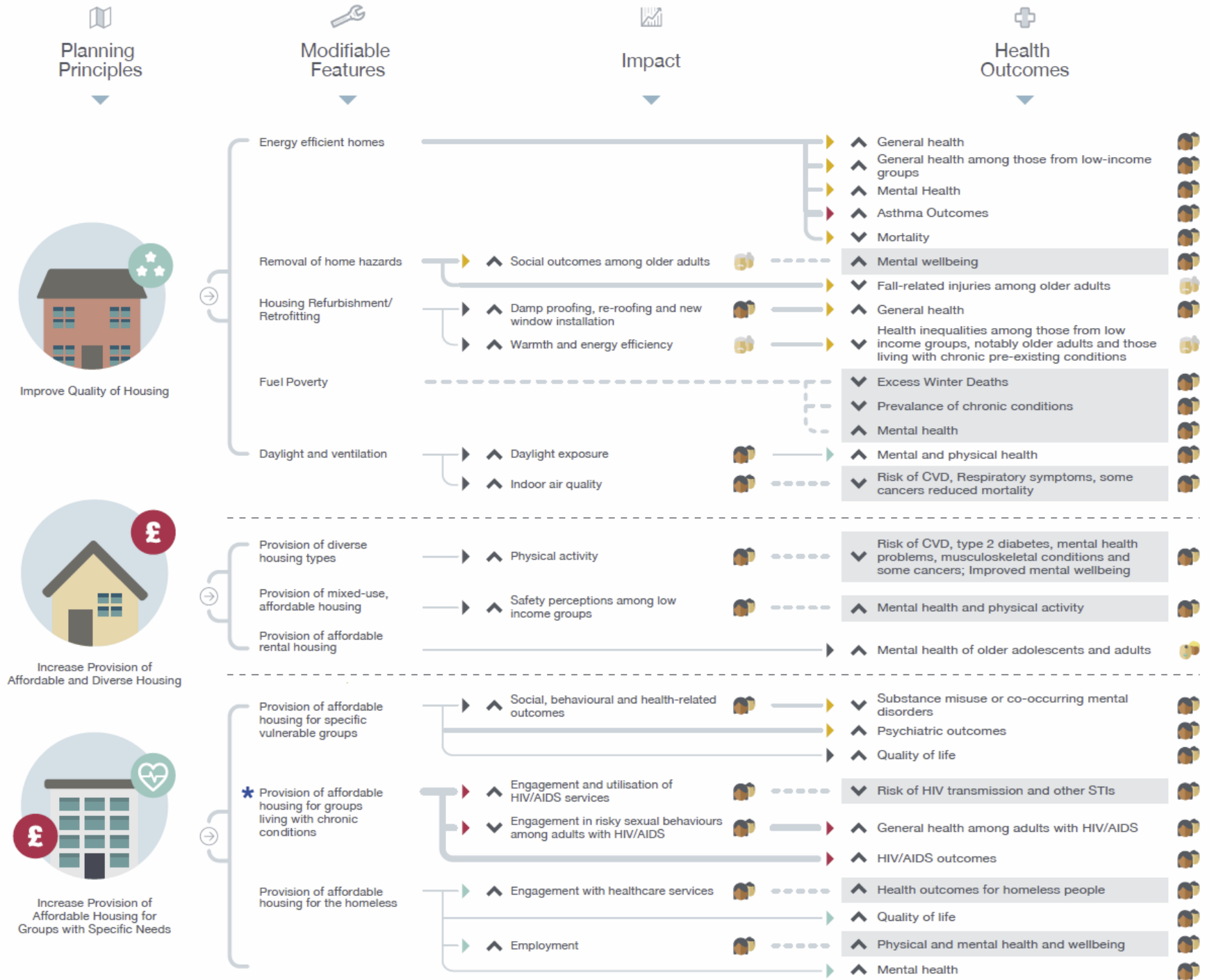
Greyed Out Text
Association between a health impact & health outcome not obtained as part of the umbrella review.

Best Available Evidence:
* In some instances, more than one piece of review-level evidence reporting on the same health impacts and/or outcomes was identified as part of this umbrella review. In such instances this table highlights findings of the review(s) which reported evidence of the best methodological quality.

Population Groups:

- 👤 General Population
- 👴 Older Adults
- 👦 Children & Adolescents

Disclaimer:
This diagram has been produced as part of a wider evidence resource, commissioned by Public Health England and developed by the University of the West of England. Please see the document Spatial planning for health: an evidence resource for planning and designing healthier places for further information.



Housing bibliography

*Referenced in supporting evidence section

*Aidala, A.A., Wilson, M.G., Shubert, V., Gogolishvili, D., Globerman, J., Rueda, S., Bozack, A.K., Caban, M., & Rourke, S.B. (2016). Housing status, medical care, and health outcomes among people living with HIV/AIDS: A systematic review. *AJPH Research*, 106 (1), e1-e22.

*Bambra, C., Gibson, M., Sowden, A., Wright, K., Whitehead, M., & Petticrew, M. (2010). Tackling the wider social determinants of health and health inequalities: Evidence from systematic reviews. *J Epidemiol Community Health*, 64, 284-291.

*Bassuk, E.L., DeCandia, C.J., Tsertsvadze, A., & Richard, M.K. (2014). The effectiveness of housing interventions and housing and service interventions on ending family homelessness: A systematic review. *American Journal of Orthopsychiatry*, 84 (5), 457-474.

BRE. (2010). *The cost of poor housing to the NHS*. Watford: BRE.

*Clark, C., Myron, R., Stansfield, S.A., & Candy, B. (2007). A systematic review of the evidence on the effect of the built and physical environment on mental health. *Journal of Public Mental Health*, 6 (2), 14-27.

Department for Communities and Local Government (DCLG). (2014). Affordable housing supply. [online] Available at: <https://www.gov.uk/government/collections/affordable-housing-supply> [Accessed 18 April 2016].

*Durand, C.P., Andalib, M., Dunton, G.F., Wolch, J., & Pentz, M.A. (2011). A systematic review of built environment factors related to physical activity and obesity risk: implications for smart growth urban planning. *Obesity Reviews* [online]. 12 (5), e173-e182.

*DiGuseppi, C., Jacobos, D.E., Phelan, K.J., Mickalide, A., & Ormandy, D. (2010). Housing interventions and control of injury-related structural deficiencies: A review of the evidence. *J Public Health Manag Pract*, 16 (5), S34-S43.

Fakoya, A., Lamba, H., Mackie, N., Nandwani, N., Brown, A., Bernard, E.J., Gilling-Smith, C., Lacey, C., Sherr, L., Claydon, P., Wallage, S., & Gazzard, B. (2008). British HIV Association, BASHH and FSRH guidelines for the management of the sexual and reproductive health of people living with HIV infection 2008. *HIV Medicine*, 9, 681-720.

*Fitzpatrick-Lewis, D., Ganann, R., Ciliska, S., Kouyoumdjan, F., & Hwang, S. (2011). Effectiveness of interventions to improve the health and housing status of homeless people: A rapid systematic review. *BMC Public Health*, 11:638.

*Fitzpatrick, K.M. ed., (2013). Poverty and Health: A Crisis Among America's Most Vulnerable [2 volumes]: A Crisis among America's Most Vulnerable. ABC-CLIO.

*Garin, N., Olaya, B., Miret, M., Ayuso-Matos, J.J., Power, M., Bucciarelli, P., & Haro, J.M. (2014). Built environment and elderly population health: A comprehensive review. *Clinical Practice & Epidemiology in Mental Health*, 10, 103-115.

*Gibson, M., Petticrew, M., Bambra, C., Sowden, A.J., Wright, K.E., & Whitehead, M. (2011). Housing and health inequalities: A synthesis of systematic reviews of interventions aimed at different pathways linking housing and health. *Health & Place*, 17, 175-184.

Health Development Agency. (2003). HIV prevention: A review of reviews assessing the effectiveness of interventions to reduce the risk of sexual transmission: Evidence briefing summary. Accessed 09 August 2016 from <http://pubs.cpha.ca/PDF/P28/22598.pdf>.

*Housing and Communities Agency. (2011). *Housing quality indicators*. [online] Available at: <https://www.gov.uk/guidance/housing-quality-indicators> [Accessed 18 April 2016].

*Krieger, J., Jacobs, D.E., Ashley, P.J., Baeder, A., Chew, G.L., Dearborn, D., Hynes, H.P., Miller, J.D., Morley, R., Rabito, F., & Zeldin, D.C. (2014). Housing interventions and control of asthma-related indoor biologic agents: A review of the evidence. *J Public Health Management, 16* (5), S11-S20.

*Kyle, T., & Dunn, J.R. (2008). Effects of housing circumstances on health, quality of life and healthcare use for people with severe mental illness: A review. *Health and Social Care, 16* (1), 1-15.

*Leaver, C.A., Burgh, G., Dunn, J.R., & Hwang, S.W. (2007). The effects of housing status on health-related outcomes in people living with HIV: A systematic review of the literature. *AIDS Behav, 11*, S85-S100.

*Lindberg, Ruth A., *et al* (2010). "Housing interventions at the neighborhood level and health: a review of the evidence. *Journal of Public Health Management and Practice, 16* (5), S44-S52.

*Lorenc, T., Petticrew, M., Whitehead, M., Neary, D., Clayton, S., Wright, K., Thomson, H., Cummins, S., Sowden, A., & Renton, A. (2013). Fear of crime and the environment: systematic review of UK qualitative evidence. *BMC Public Health 13.1*: 1.

*Mansell, J., & Beadle-Brown, J. (2009). Dispersed or clustered housing for adults with intellectual disability: A systematic review. *Journal of Intellectual & Developmental Disability, 34* (4), 313-323.

*Marmot Review Team. (2011). The health impacts of cold homes and fuel poverty. Accessed 05 April 2016 from:
https://www.foe.co.uk/sites/default/files/downloads/cold_homes_health.pdf.

*McClure, R.J., Turner, C., Peel, N., Spinks, A., Eakin, E., & Hughes, K. (2008). Population-based interventions for the prevention of fall-related injuries in older people. *Cochrane Database of Systematic Reviews, 1*, DOI: 10.1002/14651858.CD004441.pub2.

*Nelson, G., Aubry, T., & Lafrance, A. (2007). A review of the literature on the effectiveness of housing and support, assertive community treatment, and intensive case management interventions for persons with mental illness who have been homeless. *American Journal of Orthopsychiatry*, 77 (3), 350-361.

NHS. (2014). Healthy Urban Planning Checklist. Accessed 05 April 2016 from: <http://www.healthyurbandevlopment.nhs.uk/wp-content/uploads/2014/04/Healthy-Urban-Planning-Checklist-March-2014.pdf>.

Public Health England (2016) UK radon, Accessed 08 June 2016 from: <http://www.ukradon.org/information/risks>.

*Reif, S., George, P., Braude, L., Dougherty, R.H., Daniels, A.S., Ghose, S.S., & Delphin-Rittmon, M.E. (2014). Recovery housing: Assessing the evidence. *Psychiatric Services*, 65 (3), 295-300.

*Royal College of Physicians and Royal College of Paediatrics and Child Health. (2016). *Every Breath we Take: The lifelong impact of Air Pollution*. Accessed 09 August 2016 from <https://www.rcplondon.ac.uk/projects/outputs/every-breath-we-take-lifelong-impact-air-pollution>.

*Sandel, M., Baeder, A., Bradman, A., Hughes, J., Mitchell, C., Shaunessy, R., Takaro, T.K., & Jacobs, D.E. (2010). Housing interventions and control of health-related chemical agents: A review of the evidence. *J Public Health Management Practice*, 16 (5), S24-S33.

*Thomson, H., Thomas, S., Sellstrom, E., & Petticrew, M. (2009). The health impacts of housing improvement: A systematic review of intervention studies from 1887 to 2007. *AJPH*, 99, S681-S692.

*Thomson, H., Sellstrom, T.S., & Petticrew, M. (2013). Housing improvements for health and associated socio-economic outcomes. *Cochrane Database of Systematic Reviews*, 2. DOI: 0.1002/14651858.CD008657.pub2.

WHO Collaborating Centre for Healthy Urban Environments (2012). *Health inequalities and determinants in the physical urban environment: Evidence briefing*. Accessed 09 August 2016 from <http://www.apho.org.uk/resource/item.aspx?RID=118056>.

*World Health Organization (WHO). (2005). *Is housing improvement a potential health improvement strategy?* Accessed 09 August 2016 from http://www.euro.who.int/data/assets/pdf_file/0007/74680/E85725.pdf.

*World Health Organization. (2010). *WHO guidelines for indoor air quality: selected pollutants*. Accessed 09 August 2016 from http://www.euro.who.int/data/assets/pdf_file/0009/128169/e94535.pdf.

World Health Organization. (2016). Lead poisoning and health: Fact Sheet 379. Accessed 09 August 2016 from <http://www.who.int/mediacentre/factsheets/fs379/en/>.

Topic 3: Healthier food environment

The importance of eating a healthier and balanced diet is well established (PHE, 2016; WHO, 2015). A good diet can protect the body against numerous diseases and health conditions, including obesity, diabetes, cardiovascular diseases, and some cancers. Vulnerable groups, including those on a low income, children and young people, those who are overweight or obese, and those from minority ethnic groups, are less likely to achieve a healthier and balanced diet (Davies *et al.*, 2010; FPH, 2005). Evidence indicates that a poor diet is related to 30% life years lost in disability or early death (FPH, 2005). This presents a major challenge for public health. For further information on what constitutes a healthier balanced diet, please see the Eat Well Guide (<https://www.gov.uk/government/publications/the-eatwell-guide>) (PHE, 2016).

The food environment in which people live plays an important role in achieving a healthier diet. It is a complex system, comprising a person's proximity to food retail outlets, the physical presence of food affecting a person's diet, the distribution of food retail outlets, and the neighbourhood system that allows access to food (Swinburn *et al.*, 2015). It includes shops, restaurants, canteens, schools and other places where people buy food or drink, plus land used for local food production such as gardens and allotments. To date, there is relatively limited, good quality review level evidence clearly demonstrating the influence of the food environment on health and wellbeing outcomes. However, existing evidence indicates that making healthier foods more accessible and increase provision of low cost healthier food could be effective interventions for supermarkets and general catering settings (such as schools and workplaces). Evidence also indicates that schools should follow a whole school approach to promoting healthier diet, with nutrition integrated into the school culture (Davies *et al.*, 2010).

Planning principles

1. *Provision of healthier, affordable food for the general population*

- Increase access to healthier food for the general population: Research of moderate quality indicates that increased access to healthier, affordable food for the general

population (e.g., food in schools, neighbourhood retail provision) is associated with improved attitudes towards healthier eating and healthier food purchasing behaviour. It also indicates that improved dietary behaviours, such as increased fruit and vegetable consumption, are associated with increased access to healthier and affordable food. However, evidence for the impact of increased access to healthier and affordable food on health outcomes such as weight status is less consistent, with some reviews reporting positive effects and others not finding an effect. Caution must be taken when interpreting these findings as many are based on the findings from short term RCTs, meaning that the long-term effects are unknown.

- Decrease exposure to unhealthier food environments: Research from high income countries, including the UK indicates that increased access to unhealthier food retail outlets is associated with increased weight status in the general population, and increased obesity and unhealthier eating behaviours among children residing in low income areas.
- Increase access to healthier food in schools: A consistent body of evidence suggests that provision of healthier, affordable food in schools is associated with improved healthier food sales, dietary behaviours and nutritional outcomes. Evidence suggests that multi-component interventions, and taking an integrated, whole school approach, are effective in improving children's diet and food choices in schools.
- Access to retail outlets selling healthier food: Evidence from one review indicates that increased access to retail outlets selling healthier food is associated with improvements in dietary behaviours, and adult weight status. However, the review findings were based on evidence drawn chiefly from cross-sectional studies, meaning that the causal links cannot be confirmed.
- Access to unhealthier food in the workplace: No systematic review level evidence relating to access to unhealthier food in the workplace was found that met the eligibility criteria for this review and it is acknowledged that research in the area of workplace health is limited (Jones & Yates, 2013). However, a UK based empirical study found that exposure to takeaway food outlets was positively associated with consumption of takeaway food, particularly around the workplace (Burgoine *et al.*, 2014). Furthermore, evidence from numerous primary studies conducted in Northern Europe suggests that environmental strategies at worksites may help

consumers change dietary behaviour towards a healthier diet (Lassen *et al.*, 2012; Lassen *et al.*, 2011; Lassen *et al.*, 2004).

2. Enhance community food infrastructure

- Urban food growing: There is a small body of newly emerging evidence (predominantly based on findings from cross-sectional studies) for a positive association between urban agriculture and improved attitudes towards healthier food, increased opportunities for physical activity and social connectivity, and increased fruit and vegetable consumption. The overall evidence base for these associations is relatively small and requires further research to clarify causal links.
- Provision of and access to allotments and adequate garden space: No systematic review level evidence relating to the impact of provision of and access to allotments and adequate garden space on health outcomes was found that met the eligibility criteria for this review. However, a recent non-systematic literature review suggests that gardening in an allotment setting in the UK may result in numerous positive physical and mental health-related impacts and outcomes (Garden Organic & Sustain, 2014).

Supporting evidence

3. Provision of healthier, affordable food for the general population

- 3.1 Increase access to healthier food for the general population: One review of children's and young people's access to fruit and vegetables, containing evidence of low quality from middle-to-high income countries including the UK, reported mixed effects for the impact of increased access to affordable fruit and vegetables on food sales, fruit and vegetable consumption, attitudes towards consumption and general health measures (Gannan *et al.*, 2014). Despite the risk of bias associated with studies included in the review, it was reported that the most promising approach for improving the fruit and vegetable environment was through local school food policies.
- 3.2 Moderate quality evidence from North America indicates that increased availability of healthier, affordable food in public areas (e.g., schools, community centres, prisons, council buildings) of rural communities is associated with reduced dietary

fat intake (Calancie *et al.*, 2015), improved dietary behaviours, increased fruit and vegetable consumption and improved attitudes towards fruit and vegetables (Bambra *et al.*, 2010; Calancie *et al.*, 2015). The impact of increased availability of healthier and affordable food on reducing health inequalities remains unclear. An umbrella review reporting on studies conducted in Europe, Australasia, Japan and North America found one paper examining the impact of increased availability of healthier and affordable food (Bambra *et al.*, 2010), however, the original article did not report on socioeconomic position nor did it focus on disadvantaged groups.

3.3 Evidence from one review of RCTs (Wall *et al.*, 2006) included in a review of reviews (Bambra *et al.*, 2010) reported that provision of healthier, affordable food can have a positive effect on weight status (Bambra *et al.*, 2010). Despite the positive effects and strong RCT study design, the original review was based on short-term RCTs and did not identify any primary studies examining findings according to socioeconomic position (Wall *et al.*, 2006). Findings from a US review of evidence found that the relationship between provision of healthier, affordable food and weight status is unclear (Calancie *et al.*, 2015). Only one study in the review reported improved weight status. The quality of the studies in this review was not reported.

3.4 Decrease exposure to unhealthier food environments: There is low quality review level evidence, drawn mainly from cross-sectional studies, for an association between access to fast-food takeaway outlets and decreased fruit and vegetable consumption (Cobb *et al.*, 2015; Giskes *et al.*, 2010; Kent & Thompson, 2014). These reviews also suggest that increased access to fast-food takeaway outlets is associated with increased weight status in the general population (Cobb *et al.*, 2015; Giskes *et al.*, 2010; Kent & Thompson, 2014), and increased obesity and unhealthier eating among children residing in low-income areas (Cobb *et al.*, 2015; Kent & Thompson, 2014). Notably, when viewing the broader evidence base, findings are not always consistent. For example, other reviews based on evidence of unreported quality from North America and Australia, reported that they majority of original primary studies found a positive association between weight status, but other primary studies reporting a negative or null effect (Feng *et al.*, 2010; Gamba *et al.*, 2015). Overall, it is important to take caution when interpreting these findings as these reviews are based on evidence cross-sectional studies, from which it is not possible to draw causal links.

- 3.5 Increased access to healthier food in schools: Evidence for an impact of providing healthier, affordable food in schools on children's and young people's health outcomes is mixed, in terms of reported outcomes and quality of available evidence.
- 3.6 There is mixed evidence of the effectiveness of provision of healthier, affordable food in schools in improving dietary behaviours among children and young people. One review, that included evidence from the UK, found consistent evidence to demonstrate a positive association between changes to the school food environment and improvement in healthier eating behaviours (Driessen *et al.*, 2014). There is also moderate to high quality evidence that food environment changes in tertiary educational settings can have positive effects on nutrition-related outcomes of students (Roy *et al.*, 2015).
- 3.7 A moderate-quality review and meta-analysis of the effects of interventions to promote fruit and vegetable consumption found that computer-based game interventions increased children's consumption of fruit and vegetables (Delgado-Noguera *et al.*, 2011). Interventions providing free or subsidised fruit and vegetables in a school setting were found to have no effect on children's fruit and vegetable consumption in one review (Delgado-Noguera *et al.*, 2011), however, another review, deemed to be of high quality, reported that free or subsidised fruit and vegetables significantly increased children's fruit and vegetable consumption, although it did not impact upon energy, fat or sugar intake (Osei-Assibey *et al.*, 2012).
- 3.8 Evidence from a high-quality review of reviews suggests that multi-component interventions (though with no consistently clear cluster of activities), and taking an integrated, whole school approach, with nutrition being a central part of school culture and curriculum, are effective in improving children's diet and food choices in schools (Davies, 2010).
- 3.9 Moderate level evidence, from middle-to-high income countries including the UK, indicates that schools without snack bars or pouring rights contracts (where beverage manufacturers exclusively control beverage distribution) show significantly lower intake of sugar-sweetened drinks and energy-dense food among children. This finding is based on the reporting of one primary study (Sonntag *et al.*, 2015). However, another review, based on low quality evidence reported very little effect of the retail food environment on children's food purchases and consumption,

despite finding an association between exposure to food outlets and children's body weight (Williams *et al.*, 2014).

- 3.10 Access to retail outlets selling healthier food: Evidence suggests that improved supermarket access is associated with reduced body mass index (BMI) (Giskes *et al.*, 2010). However, the quality of this evidence is unknown as it was not reported by the review authors.
- 3.11 There are no consistent associations between supermarket shelf space and fruit and vegetable consumption (Giskes *et al.*, 2010). However, the proximity of fruit and vegetable outlets has been identified as important in encouraging healthier eating (Kent & Thompson, 2014).
- 3.12 Evidence for the association between convenience stores and BMI is unclear (Giskes *et al.*, 2010). However, provision of low-cost healthier foods in convenience stores is associated with significant increases in purchasing frequency of healthier food (including fruit and vegetables, low-fat milk, high fibre-cereals, and water). The quality of the available evidence was not assessed by the authors of the original review (Gittlesohn *et al.*, 2009).
- 3.13 Access to unhealthier food in the workplace: No systematic review level evidence relating to access to unhealthier food in the workplace was found that met the eligibility criteria for this review.

4. Enhance community food infrastructure

- 4.1 Urban food growing: Evidence, predominantly drawn from findings of cross-sectional studies, suggests that urban agriculture may increase opportunities for physical activity, social connections, and increased fruit and vegetable consumption (Kent & Thompson, 2014; McCormack *et al.*, 2010).
- 4.2 Attitudes towards buying, preparation and eating healthier food are also positively influenced by farmers' markets and community gardens (Kent & Thompson, 2014).
- 4.3 The overall evidence base for these associations is relatively small and requires further research to clarify causal links.



Healthier Foods

Quality of Evidence:

- ⬆ Improved
- ⬇ Reduced
- ▬▶ High Quality
- ▬▶ Medium Quality
- ▬▶ Low Quality
- ▬▶ NR (Not reported):
Methodological quality of the original research is unclear and should be treated with caution.

Greyed Out Text
Association between a health impact & health outcome not obtained as part of the umbrella review.

Best Available Evidence:

- * In some instances, more than one piece of review-level evidence reporting on the same health impacts and/or outcomes was identified as part of this umbrella review. In such instances this table highlights findings of the review(s) which reported evidence of the best methodological quality.

Population Groups:

- 👤 General Population
- 👴 Older Adults
- 👦 Children & Adolescents

Disclaimer:

This diagram has been produced as part of a wider evidence resource, commissioned by Public Health England and developed by the University of the West of England. Please see the document Spatial planning for health: an evidence resource for planning and designing healthier places for further information.

Planning Principles

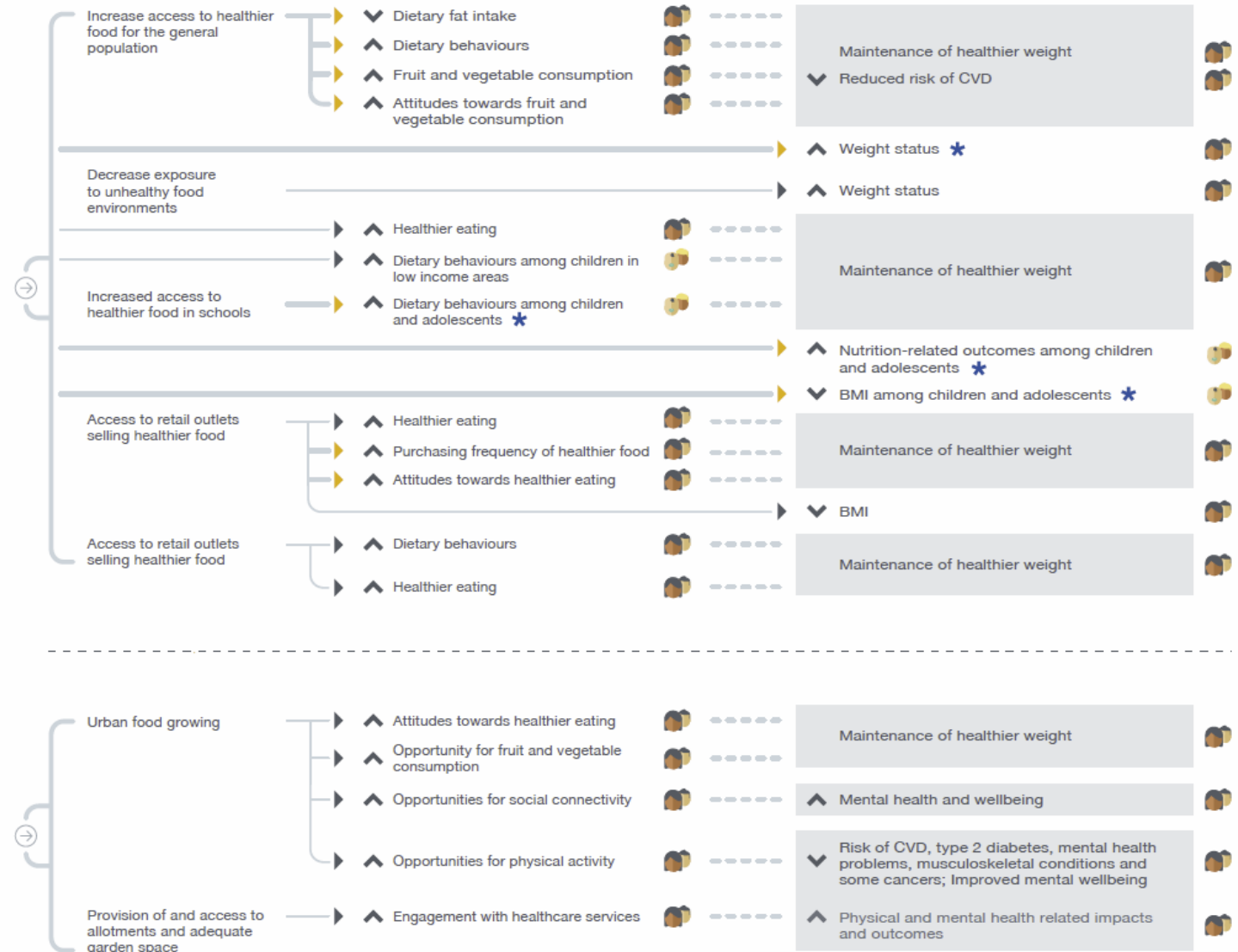


Provision of healthier, affordable food for the general population

Modifiable Features

Impact

Health Outcomes



Note: For further information on what constitutes a healthy balanced diet, please see the **Eat Well Guide**, available at: <https://www.gov.uk/government/publications/the-eatwell-guide>

Healthier food environment bibliography

*Referenced in supporting evidence section

*Bambra, C., Gibson, M., Sowden, A., Wright, K., Whitehead, M., & Petticrew, M. (2010). Tackling the wider social determinants of health and health inequalities: Evidence from systematic reviews. *J Epidemiol Community Health, 64*, 284-291.

Burgoine, T., Forouhi, N.G., Griffin, S.J., Wareham, N.J., & Monsivias, P. (2014). Associations between exposure to takeaway food outlets, takeaway food consumption, and body weight in Cambridgeshire, UK: population-based, cross-sectional study. *BMJ, 348*: g1464.

*Calancie, L., Jilcott Pitts, S.B., Khan, L.K., Fleischhacker, S., Evenson, K.R., Schreiner, M., Byker, C., Owens, C., McGuirt, J., Bambridge, E., Dean, W., Johnson, D., Kolodinsky, J., Pitch, E., Pinard, C., Quinn, E., Whetstone, L., & Ammerman, A. (2015). Nutrition-related policy and environmental strategies to prevent obesity in rural communities: A systematic review of the literature: 2002-2013. *Preventing Chronic Disease, 12*: e57.

Caspi, C.E., Sorensen, G., Subramanian, S.V., & Kawachi, I. (2012). The local food environment and diet: A systematic review. *Health Place, 18* (5), 1172-1187.

*Cobb, L.K., Appel, L.J., Fanco, M., Jones-Smith, J.C., Nur, A., & Anderson, C.A.M. (2015). The relationship of the local food environment with obesity: A systematic review of methods, study quality and results. *Obesity, 23* (7), 1331-1344.

*Davies, P., MacPherson, K., Faruque, D., & Froud, E. (2010). *Understanding the Effectiveness of Dietary and Food Choice Interventions: A Review of Reviews*. Oxford Evidentia, commissioned by Foods Standards Agency.

De Vet, E., de Ridder, D.T.D., & de Wit, J.B.F. (2010). Environmental correlates of physical activity and dietary behaviours among young people: A systematic review of reviews. *Obesity Reviews, 12*, e130-e142.

*Delgado-Noguera, M., Tort, S., Martinez-Zapata, M.J., & Bonfill, X. (2011). Primary school interventions to promote fruit and vegetable consumption: A systematic review and meta-analysis. *Preventive Medicine, 53*, 3-9.

*Driessen, C.E., Cameron, A.J., Thornton, L.E., Lai, S.K., & Barnett, L.M. (2014). Effect of changes to the school food environment on eating behaviours and/or body weight in children: A systematic review. *Obesity Reviews, 15*, 968-982.

*Feng, J., Glass, T.A., Curriero, F.C., Stewart, W.F., & Schwartz, B.S. (2010). The built environment and obesity: A systematic review of the epidemiologic evidence. *Health & Place, 16*, 175-190.

FPH. (2005). Food poverty and health: Briefing statement. Accessed 01 January 2017 from: http://www.fph.org.uk/uploads/bs_food_poverty.pdf.

*Gamba, R.J., Schuchter, J., Rutt, C., & Seto, E.Y.W. (2015). Measuring the food environment and its effects on obesity in the United States: A systematic review of methods and results. *J Community Health, 40*, 464-475.

Ganann, R., Fitzpatrick-Lewis, D., Ciliska, D., Peirson, L.J., Warren, R.L., Fieldhouse, P., Delgado-Noguera, M.F., Tort, S., Harris, S.P., Martinez-Zapata, M.J., & Wolfenden, L. (2014). Enhancing nutritional environments through access to fruit and vegetables in schools and homes among children and youth: A systematic review. *BMC Research Notes, 7*: 422.

Garden Organic & Sustain. (2014). The benefits of gardening and food growing for health and wellbeing. Accessed 05 April 2016 from: http://www.sustainweb.org/resources/files/reports/GrowingHealth_BenefitsReport.pdf.

*Giskes, K., van Lenthe, F., Avendano-Pabon, M., & Brug, J. (2010). A systematic review of environmental factors and obesogenic dietary intakes among adults: are we getting close to understanding obesogenic environments? *Obesity Reviews, 12*, e95-e106.

*Gittlesohn, J., Rowan, M., & Gadhoke, P. (2009). Interventions in small food stores to change the food environment, improve diet and reduce risk of chronic disease. *CDC – Preventing Chronic Disease*, 9: 110015.

Jaime, P.C., & Lock, K. (2009). Do school based food and nutrition policies improve diet and reduce obesity? *Preventive Medicine*, 48, 45-53.

*Jones, R., & Yates, G. (2013). The built environment and health: an evidence review. Accessed 06 April 2016 from: [http://www.gcph.co.uk/assets/0000/4174/BP_11 - Built environment and health - updated.pdf](http://www.gcph.co.uk/assets/0000/4174/BP_11_-_Built_environment_and_health_-_updated.pdf).

*Kent, J.L., & Thompson, S. (2014). The three domains of urban planning for health and well-being. *Journal of Planning Literature*, 1-18.

Lassen, A., Thorsen, A.V., Trolle, E., Elsig, M., & Ovesen, L. (2004). Successful strategies to increase the consumption of fruits and vegetables: results from the Danish '6 a day' Work-site Canteen Model Study. *Public Health Nutrition*, 7 (2), 263-270.

Lassen, A.D., Thorsen, A.V., Sommer, H.M., Fagt, S., Trolle, E., Biloft-Jensen, A., & Tetens, I. (2011). Improving the diet of employees at blue-collar worksites: results from the 'Food at Work' intervention study. *Public Health Nutrition*, 14 (6), 965-974.

Lassen, A.D., Ernst, L., Poulsen, S., Andersen, K.K., Hansen, G., Biloft-Jensen, A., & Tetens, I. (2012). Effectiveness of a Canteen Take Away concept in promoting healthy eating patterns among employees. *Public Health Nutrition*, 15 (3), 452-458.

*McCormack, L.A., Laska, M.N., Larson, N.I., & Story, M. (2010). Review of the nutritional implications of farmers' markets and community gardens: A call for evaluation and research efforts. *Journal of the American Dietetic Association*, 110, 399-408.

National Institute for Health and Care Excellence. (2015). Preventing excess weight gain (NG 7). London: NICE.

National Institute for Health and Care Excellence. (2010). Cardiovascular disease prevention (PH 25). London: NICE.

National Institute for Health and Care Excellence. (2016). Community engagement: improving health and wellbeing and reducing health inequalities (NG 44). London: NICE.

*Osei-Assibey, G., Dick, S., Macdiarmid, J., Semple, S., Reilly, J.J., Ellaway, A., Cowie, H., & McNeill, G. (2012). The influence of the food environment on overweight and obesity in young children: A systematic review. *BMJ Open*, 2: e001538.

PHE. (2016). The Eatwell Guide. Accessed 15 March 2017 from:
<https://www.gov.uk/government/publications/the-eatwell-guide>.

*Roy, R., Kelly, B., Rangan, A., & Allman-Farinelli, M. (2015). Food environment interventions to improve the dietary behaviour of young adults in tertiary education settings: A systematic review. *Journal of the Academy of Nutrition and Dietetics*, 115 (10), 1647-1681.

*Sonntag, D., Schneider, S., Mdege, N., Ali, S., & Schmidt, B. (2015). Beyond food promotion: A systematic review on the influence of the food industry on obesity-related dietary behaviour among children. *Nutrients*, 7, 8565-8576.

*Swinburn, B., Kraak, V., Rutter, H., *et al.*, (2015). Strengthening of accountability systems to create healthy food environments and reduce global obesity. *The Lancet*, 285 (9986), 2534-2545.

*Wall, J., Mhurchu, C.N., Blakely, T., Rodgers, A., & Wilton, J. (2006). Effectiveness of monetary incentives in modifying dietary behaviour: A review of randomised controlled trials. *Nutrition Reviews*, 64 (12), 518-531.

*WHO. (2015). Healthy diet. Fact sheet No.394. Accessed 15 March 2017 from:
<http://www.who.int/mediacentre/factsheets/fs394/en/>.

*Williams, J., Scarborough, P., Matthews, A., Cowburn, G., Foster, C., Roberts, N., & Rayner, M. (2014). A systematic review of the influence of the retail food environment around schools on obesity-related outcomes. *Obesity Reviews*, 15, 359-374.

Topic 4: Natural and sustainable environment

For the purposes of this review the 'natural and sustainable environment' is comprised of neighbourhood ecosystems and co-benefits between the environment and health.

Planning principles

1. *Reduce exposure to environmental hazards*

- Improve air quality: Recent review level evidence indicates that living in an area with clean air is associated with positive changes in people's health behaviours. For example, improved air quality is associated with increased physical activity among older adults. Additional findings indicate that stagnant weather can reduce air quality and thus negatively affect health by trapping warm and cold air, leading to smog. The overall quality of this evidence was not reported, and therefore caution is required when drawing conclusions from such findings.
- Exposure to air pollution: There is a wealth of consistent evidence demonstrating adverse effects of exposure to air pollutants on health outcomes across all population groups. For example, poor air quality is linked with an increased risk of developing chronic conditions (e.g., COPD and type II diabetes), neonatal complications and poor birth outcomes, cancer, worsened respiratory outcomes and childhood mortality, among others. Notably, there is consistent evidence for the adverse health effects associated with exposure to particulate matter (organic and inorganic particles, such as dust, pollen, soot, smoke, and liquid droplets).
- Excessive noise: Exposure to excessive noise is associated with poorer mental health outcomes, particularly among older adults and children. It is also linked with higher anxiety levels among adults.
- Impact of flooding: No review level evidence relating to flooding and its impact on health outcomes was found as a result of our search strategy. However, there is review level evidence to demonstrate that flooding can affect people's physical and mental health, with affected communities reporting higher symptoms of stress, mental illness and increased risk of chronic disease (Alderman *et al.*, 2012). Moreover, there is a review of the literature undertaken to describe the risk of carbon monoxide poisoning throughout flooding/disaster situations (Waite *et al.*,

2014), and one demonstrating secondary stressors that increase the risk of mental health problems (Stanke *et al.*, 2012).

2. Access to and engagement with the natural environment

- Provision of access and engagement with the natural environment: Access to, and engagement with, the natural environment is associated with numerous positive health outcomes, including improved physical and mental health and reduced risk of cardiovascular disease, risk of mortality and other chronic conditions.
- Increased availability of open, green space is associated with a reduced risk of obesity among adolescents. Evidence of unreported quality from middle and high-income countries (including the UK) indicates that exposure to heavy traffic, temporary hazards, and rubbish are each associated with poorer physical health outcomes among older adults, including cardiovascular disease mortality, incidence of falls and reduced longevity (Annear *et al.*, 2014).
- There is consistent evidence that having access to and engaging with the natural environment can increase active travel and improve physical activity.
- None of the reviews identified as part of this review reported on the impact of access to or engagement with the natural environment on reducing health inequalities. However, evidence from empirical studies suggest that living in close proximity to green space, such as parks and other open spaces can improve health, regardless of social class (Mitchell & Popham, 2008).
- Aesthetic park improvements: Attempts to improve the physical appearance of parks are associated with increased visitation and physical activity among children and older adults. Evidence also suggests that improving the appearance of parks may increase usage and increase physical activity among children and older adults. Overall, findings were consistent across several reviews of moderate quality. However, evidence on the impact of interventions to improve school play areas remains contested.
- There is further low-quality evidence from America and Australia that improving the quality of urban green spaces is significantly associated with an increase in visitation and levels of physical activity.

- Participation in physical activity in an outdoor setting: Evidence indicates that physical activity participation in a natural setting is associated with more improved mental health outcomes than physical activity participation in an indoor setting.
- Urban versus rural settings: Living in a hillside area, living in an area with high rainfall, and living in a rural environment are all associated with improved physical health outcomes among older adults.

3. *Adaptation to climate change*

- Neighbourhood 'greening' (Prioritisation of neighbourhood tree planting): There is low-to-moderate quality evidence from studies conducted globally (including the UK) that "greening" (i.e., planting of trees) has a cooling effect on the environment. An urban park is about 1°C cooler than a non-green site.
- Tackle Climate Change: Our review search strategy found that no review level evidence on the impact of heat and cold extremes on health, which are likely to increase in frequency due to climate change. However, the UK's Climate Change Risk Assessment (CCC, 2017) lists risks to health due to extreme temperatures specific for the UK. Rising temperatures suggest there will be increasingly more heatwaves in the UK, but excess deaths from cold weather will remain challenging due to an increasingly aging population (Hajat *et al.* 2014).

Supporting evidence

4. *Reduce exposure to environmental hazards*

4.1 Improved air quality: Systematic review level evidence, drawing upon evidence from high and middle-income countries but of unknown quality, indicates that living in an area with clean air is associated with increased physical activity among older adults (Annear *et al.*, 2014).

4.2 Exposure to air pollution: Moderate-to-high quality evidence from studies conducted in Canada demonstrates that exposure to air pollution can adversely affect human health (Rodriguez-Villamizar *et al.*, 2015). There is also evidence of unknown quality (from studies conducted in United States) for an association between air pollution and prevalence of poor cognitive function (Peters *et al.*, 2015).

- 4.3 There is evidence from high and middle-income countries but of unknown quality that short term exposure to outdoor air pollution is associated with an increased risk of COPD mortality in Europe (6% increase), USA (1% increase) and China (1% increase), respectively. Chronic exposure to air pollution can also increase risk of COPD by 10% (Song, Christiani, & Ren, 2014).
- 4.4 There is consistent evidence from studies conducted in middle and high-income countries, including the UK, that exposure to particulate matter and other gaseous pollutants can adversely affect birth weight and increase risk of preterm delivery (Koranteng, Vargas, & Buka, 2007; Bonzizni *et al.*, 2009, Steib *et al.*, 2012).
- 4.5 Evidence from studies conducted predominantly in the UK and US indicate that exposure to NO₂ is significantly associated with congenital coarctation of the aorta (Chen *et al.*, 2014). Exposure to 10ppb nitrogen dioxide and 1ppb sulfur (sulphur) dioxide also increases the risk of congenital coarctation of the aorta (OR = 1.17, 95% CI = 1.00, 1.36 and OR = 1.07, 95% CI = 1.01, 1.13, respectively) (Vrijheid *et al.*, 2011).
- 4.6 Other neonatal complications and poor birth outcomes associated with exposure to NO₂ include a significant increase in miscarriage among IVF patients (Frutos *et al.*, 2015) and an increased risk of hypertensive disorders of pregnancy and preeclampsia (OR per 10 ppb = 1.16, 95% CI = 1.03, 1.30 and 1.10, 95% CI = 1.03, 1.17, respectively) during the pregnancy period (Hu *et al.*, 2014). This evidence is drawn from studies conducted in higher and middle-income countries.
- 4.7 Women are also at increased risk of hypertensive disorders of pregnancy when exposed to CO and O₃ during the first semester (OR per 1 ppm = 1.79, 95% CI = 1.31, 2.45 and 1.09, 95% CI = 1.05, 1.13, respectively) (Hu *et al.*, 2014). This evidence is drawn from studies conducted in high and middle-income countries.
- 4.8 Low-to-moderate quality evidence indicates that exposure of pregnant women to insecticides and herbicides increases the risk of childhood leukaemia by 105% and 61%, respectively. Exposure of children to pesticides and herbicides can also increase risk of childhood leukaemia (Turner, Wigle, & Krewski, 2011). This finding comes from studies conducted in high-income countries.
- 4.9 There is evidence of unknown quality (from studies conducted in Canada) to indicate that exposure to air pollution is associated with infant mortality and adverse respiratory health effects in children (Koranteng *et al.*, 2007).

- 4.10 There is evidence of unreported quality from the UK indicating that levels of nitrogen oxide (NO₂) in air pollution caused by traffic near the home, are associated with repeat asthma-related hospital admissions (CABE, 2009).
- 4.11 Evidence of unreported quality from high and middle-income countries indicates that exposure to PM_{2.5} is associated with a 10-11% increased risk of type II diabetes mellitus (95% CI = 1.02%, 1.18%) (Balti *et al.*, 2009; Eze *et al.*, 2015). The effects are more pronounced among females (1.14% increased risk, 95% CI = 1.03%, 1.26%) per 10 µg/m³ increment PM_{2.5} (Eze *et al.*, 2015). Research also suggests that exposure to NO₂ is associated with type II diabetes mellitus 1.08% (95% CI = 1.00%, 1.17%), particularly among females, 1.15% (95% CI = 1.05%, 1.27%) (Eze *et al.*, 2015). These findings are supported by review level evidence from Europe, Asia and America indicating that exposure to air pollution, particularly gaseous pollutants can increase risk of diabetes (Janghorbani, Momeni, & Mansourian, 2014).
- 4.12 Evidence of unreported quality from high and middle-income countries including the UK indicates that exposure to PM_{2.5} increases the meta-relative risk for lung cancer by 9% (RR 95% CI = 1.04, 1.14). For exposure to PM₁₀ the meta-relative risk is increased by 8% (RR 95% CI = 1.00%, 1.17%) (Hamra *et al.*, 2014). Exposure to NO_x is also associated with an increased meta-relative risk of 3% for lung cancer (RR 95% CI = 1.01%, 1.05%) (Hamra *et al.*, 2015).
- 4.13 There is moderate quality evidence that a 10 µg/m³ increment in PM_{2.5} is associated with a 4% increase in the risk of death, although this was not statistically significant (RR 95% CI = 0.52%, 1.56%).
- 4.14 Moderate-high quality evidence from studies conducted predominantly in Europe and North-America suggest that a 10 µg/cm³ increase in PM_{2.5} and PM₁₀ increases the risk of myocardial infarction by 2% (OR = 1.022, 95% CI = 1.015, 1.030) and 0.5 % (OR=1.005; 95% CI= 1.001-1.008), respectively (Luo *et al.*, 2015).
- 4.15 Moderate quality evidence from UK, China and USA suggests that exposure to PM_{2.5} and PM₁₀ is negatively associated with sperm quality, with poorer outcomes identified in relation to sperm concentration, count, morphology and motility (Deng *et al.*, 2016). Further evidence of unreported quality indicates that air pollution can reduce sperm motility by 39.4% (±5.52%) (Najafi *et al.*, 2015).
- 4.16 There is moderate-high quality evidence from studies conducted majorly in US and some parts of Europe that exposure to particulate matter, particularly PM_{2.5},

- increases the likelihood of out-of-hospital cardiac arrest by 2.4% to 7%, per interquartile increase in average particulate matter exposure (Teng *et al.*, 2014).
- 4.17 There is evidence of unknown quality from Europe and North-America that 10 $\mu\text{g}/\text{cm}^3$ increase in $\text{PM}_{2.5}$ and PM_{10} leads to a corresponding increase of 16.79 μm and 4.15 μm in carotid intima-media thickness respectively (Luo *et al.*, 2015).
- 4.18 Poor quality evidence suggests that 10 $\mu\text{g}/\text{cm}^3$ increase in $\text{PM}_{2.5}$ increases the risk of lower acute respiratory infection (Odds ratio = 1.12). This finding comes from studies conducted predominantly in Europe (Mehta *et al.*, 2013).
- 4.19 There is evidence of unknown quality to suggest that 10 $\mu\text{g}/\text{m}^3$ increase in PM_{10} can increase the incidence of stroke by 6% (95% CI = 1.018, 1.105) and mortality from stroke by 8% (95% CI = 0.992, 1.177). The hazard ratio associated with a 5 $\mu\text{g}/\text{m}^3$ increase in $\text{PM}_{2.5}$ in Europe and North America combined is as high as 1.064 (95% CI = 1.021, 1.109) and 1.125 (95% CI = 1.007, 1.256) for stroke events and mortality, respectively (Scheers *et al.*, 2015). Further evidence suggests an association between stroke hospital admission and an increase in concentration of carbon monoxide (Relative Risk (RR) = 1.015 per 1ppm), sulphur dioxide (RR=1.019 per 10ppb) and nitrogen dioxide (RR = 1.014 per 10ppb) (Shah *et al.*, 2015)
- 4.20 There is evidence of unknown quality to suggest that a 10 $\mu\text{g}/\text{m}^3$ increase in PM_{10} can increase risk of post-neonatal mortality for all causes by 5% and post-neonatal mortality caused by respiratory disease by 22%. (Lacasana, Esplugues, & Ballester, 2005)
- 4.21 **Excessive noise:** One review of evidence from high and middle-income countries including the UK identifies poorer mental health outcomes among older adults in relation to exposure to excessive noise (Annear *et al.*, 2014). These findings are supported by low-to-moderate quality evidence drawn mainly from the UK for a relationship between chronic noise and mental health outcomes among children, and higher anxiety levels among adults exposed to road traffic noise (Clark *et al.*, 2007). Limited evidence from European studies also suggests an association between a 10dB Lden increase in transportation noise and 6% higher risk of ischemic heart disease (Vienneau *et al.*, 2015).
- 4.22 **Impact of flooding:** In a changing climate, there is an increased risk of flooding which will affect physical and mental health. There is a narrative review of literature that describes the risks of Carbon Monoxide (CO) poisoning posed by the different

phases of flooding including the impact on physical health (Waite *et al.*, 2014). Two systematic reviews of epidemiological evidence report that flooding has adverse and long-term effects on mental health and wellbeing (Ahern *et al.*, 2005; Stanke *et al.*, 2012). This evidence relates to common mental disorders (i.e. anxiety and depression) and measurable posttraumatic stress disorder (PTSD) in the UK.

4.23 Exposure to water pollution: No review level evidence relating to exposure to water pollution and health outcomes was found that met the eligibility criteria for this review.

5. Access to and engagement with the natural environment

5.1 Provision of access and engagement with the natural environment: Evidence of unreported quality from high to middle income countries including the UK indicates that exposure to heavy traffic, temporary hazards, and rubbish are each associated with poorer physical health outcomes among older adults, including cardiovascular disease mortality, incidence of falls and reduced longevity (Annear *et al.*, 2014).

5.2 Moderate-to-high quality evidence also indicates that exposure to residential greenness is associated with a reduced risk of mortality from cardiovascular disease (CVD). A 10% increase in greenness was found to result in a small reduction in the risk of CVD mortality, although notably this reduction was not found to be statistically significant (risk ratio = 0.993, 95% CI = 0.985, 1.001). The review findings drawn from evidence from the UK and other high and middle-income countries found no indication that residential greenness is associated with lung cancer mortality (Gascon *et al.*, 2016).

5.3 Low quality evidence from high and middle-income countries indicates that the availability of open green spaces within the living environment is associated with opportunity and motivation to engage in physical activity (Calogiuri & Chroni, 2014; Lee & Maheswaran, 2010), and higher levels of physical activity (Calogiuri & Chroni, 2014).

5.4 Living in an area overlooking open public areas is associated with improved mental health outcomes (Annear *et al.*, 2014). These findings are supported by further review level evidence, drawn from the UK and other high and middle-income countries, demonstrating that access to green or open spaces is associated with improved mental health outcomes (Clark *et al.*, 2007; Gascon *et al.*, 2015). However,

caution is required when interpreting these findings as they are reliant on cross-sectional data and study quality is low-to-moderate.

- 5.5 None of the reviews identified reported on the impact of access to or engagement with the natural environment on reducing health inequalities. However, evidence from empirical studies suggest that living in close proximity to green space, such as parks and other open spaces can improve health, regardless of social class (Mitchell & Popham, 2008).
- 5.6 Aesthetic park improvements: There is moderate quality evidence that aesthetic improvement of parks may increase visitation and raise physical activity levels among children and adults (McCormack, 2011; WHO, 2007). This is supported by low quality evidence from America and Australia that improving the quality of urban green spaces can significantly increase visitation and levels of physical activity (Hunter *et al.*, 2015).
- 5.7 Participation in physical activity in an outdoor setting: There is evidence of unreported quality from high income countries including the UK to suggest that access to recreational infrastructure, such as parks and playgrounds, may have the potential to increase physical activity among children and reduce obesity among adolescents (Davison & Lawson, 2006; Dunton *et al.*, 2009).
- 5.8 Moderate quality evidence from the US and some parts of Europe demonstrates that exercise in the natural environment can have positive effect on mental wellbeing compared to indoor exercise. However, caution is required when interpreting as the finding is based on self-reported measures of mental health (Thompson Coon *et al.*, 2011).
- 5.9 Rural settings: Proximity to open spaces, living in a hillside area, living in an area with high rainfall and living in a rural environment are all associated with improved physical health outcomes among older adults (Annear *et al.*, 2014).
- 5.10 Urban settings: Evidence for the impact of human-environment interactions in urban green spaces is unclear. Findings from one review of empirical studies of unreported quality conducted in the UK and other high and middle-income countries suggest that urban green spaces generally have a positive impact on health outcomes (Kabisch, Qureshi, & Haase, 2015).

6. *Adaptation to climate change*

- 6.1 Prioritisation of neighbourhood tree planting: There is low to moderate quality evidence from studies conducted around the world (including UK) that greening (planting of trees) has a cooling effect on the environment. An urban park is about 1°C cooler than a non-green site (Bowler, 2010).
- 6.2 No review level evidence relating to the urban heat island effect (i.e., a man-made area that is significantly warmer than surrounding countryside) and health outcomes was found through this review.
- 6.3 Tackle Climate Change: This umbrella review did not identify any systematic review level evidence for the impact of climate change on health impacts and outcomes. However, empirical level data indicates that climate change and extreme events negatively affect human health during and after heatwaves, flooding and cold snaps, and are considered likely to increase in frequency and intensity. The UK experiences a substantial annual mortality burden associated with current weather patterns, with the fraction of deaths attributable to cold exposure currently being much larger than for the UK during the 2020s, 2050s and 2080s. Rising temperatures suggest there will be increasingly more heatwaves in the UK, but excess deaths from cold weather will remain challenging due to an increasingly aging population. The number of heat-related deaths in the UK are projected to increase by around two and a half times by the 2050s (median estimate), due to climate change, population growth and ageing, from a current annual baseline of around 2,000 heat-related deaths per year (CCC, 2017).
- 6.4 Stagnant weather can also cause warm and cold air to become trapped, leading to smog which can lead to negative health consequences (CABE, 2009). The evidence is drawn from the UK but the quality of the evidence is unreported, meaning that caution is required when interpreting these statements.



Natural & Sustainable Environments

Quality of Evidence:

- ▲ Improved
- ▼ Reduced
- ▬▶ High Quality
- ▬▶ Medium Quality
- ▬▶ Low Quality
- ▬▶ NR (Not reported):

Methodological quality of the original research is unclear and should be treated with caution.

Greyed Out Text

Association between a health impact & health outcome not obtained as part of the umbrella review.

Best Available Evidence:

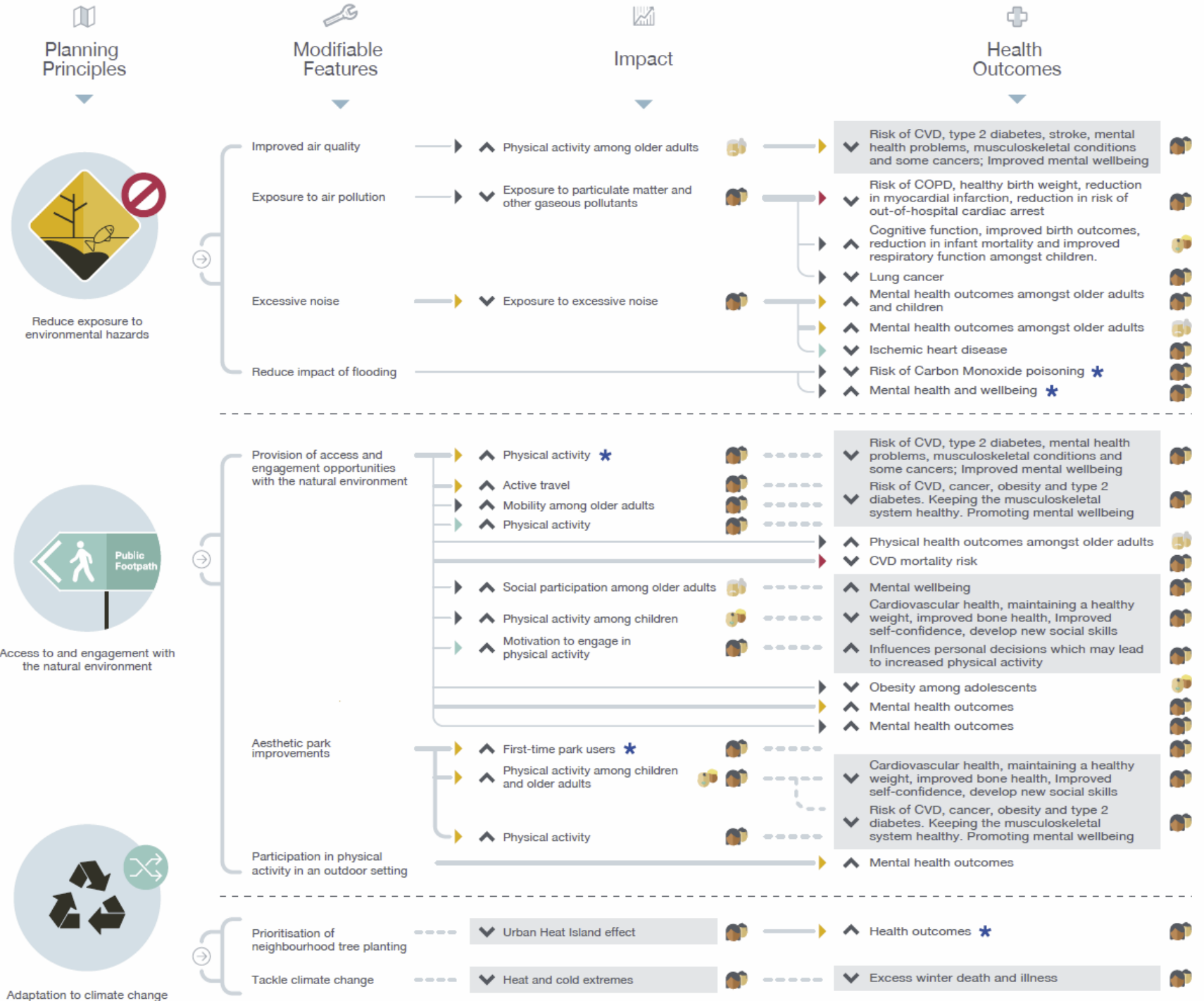
- * In some instances, more than one piece of review-level evidence reporting on the same health impacts and/or outcomes was identified as part of this umbrella review. In such instances this table highlights findings of the review(s) which reported evidence of the best methodological quality.

Population Groups:

- 👤 General Population
- 👴 Older Adults
- 👦 Children & Adolescents

Disclaimer:

This diagram has been produced as part of a wider evidence resource, commissioned by Public Health England and developed by the University of the West of England. Please see the document Spatial planning for health: an evidence resource for planning and designing healthier places for further information.



Natural and sustainable environment bibliography

*Referenced in supporting evidence section

*Ahern, M., Kovats, R.S., Wilkinson, P., Few, R., & Matthies, F. (2005). Global health impacts of floods: Epidemiologic evidence. *Epidemiologic Reviews*, 27, 36-46.

*Alderman, K., Turner, L.R., & Tong, S. (2012). Floods and human health: A systematic review. *Environment International*, 47, 37-47.

*Annear, M., Keeling, S., Wilkinson, T., Cushman, G., Gidlow, B., & Hopkins, H. (2014). Environmental influences on healthy and active ageing: A systematic review. *Ageing and Society*, 34, 590-622.

Atkinson, R.W., Kang, S., Mills, I.C., & Walton, H.A. (2014). Epidemiological time series studies of PM2.5 and daily mortality and hospital admissions: A systematic review and meta-analysis. *Thorax*, 0, 1-6.

*Balti, E.V., Echouffo-Tcheugui, J.B., Yako, Y.Y., & Kengne, A.P. (2014). Air pollution and risk of type 2 diabetes mellitus: A systematic review and meta-analysis. *Diabetes Research and Clinical Practice*, 106, 161-172.

Bambra, C., Gibson, M., Sowden, A., Wright, K., Whitehead, M., & Petticrew, M. (2010). Tackling the wider social determinants of health and health inequalities: evidence from systematic reviews. *J Epidemiol Community Health*, 64, 284-291.

Beard, J.R., & Petitot, C. (2010). Ageing and urbanization: Can cities be designed to foster active ageing? *Public Health Reviews* [online], 32 (2), 1.

*Bonzini, M., Carugno, M., Grillo, P., Mensi, C., Bertazzi, P.A., & Pesatori, A.C., (2009). Impact of ambient air pollution on birth outcomes: systematic review of the current evidences. *La Medicina del lavoro*, 101 (5), 341-363.

Boothe, V.L., Boehmer, T.K., Wendel, A.M., & Yip, F.Y. (2014). Residential traffic exposure and childhood leukaemia: a systematic review and meta-analysis. *American Journal of Preventive Medicine* [online]. 46 (4), 413-422.

*Bowler, D.E., Buyung-Ali, L., Knight, T.M., & Pullin, A.S. (2010). Urban greening to cool towns and cities: A systematic review of the empirical evidence. *Landscape and Urban Planning* [online], 97 (3), 147-155.

*CABE. (2009). *Future health: Sustainable places for health and wellbeing*. CABE: London, UK. Accessed 09 August 2016 from <http://webarchive.nationalarchives.gov.uk/20110118095356/http://www.cabe.org.uk/files/future-health.pdf>.

*Calogiuri, G., & Chroni, S. (2014). The impact of the natural environment on the promotion of active living: An integrative systematic review. *BMC Public Health*, 14:873.

Committee on Climate Change (CCC). (2017). *UK Climate change risk assessment 2017. Synthesis report: priorities for the next five years*. Accessed 18 May 2017 from <https://www.theccc.org.uk/wp-content/uploads/2016/07/UK-CCRA-2017-Synthesis-Report-Committee-on-Climate-Change.pdf>.

*Chen, E.K-C., Zmirou-Navier, D., Padila, C., & Deguen, S. (2014). Effects of air pollution on the risk of congenital anomalies: A systematic review and meta-analysis. *Int J Environ Res Public Health*, 11, 7642-7668.

*Clark, C., Myron, R., Stansfield, S.A., & Candy, B. (2007). A systematic review of the evidence on the effect of the built and physical environment on mental health. *Journal of Public Mental Health*, 6 (2), 14-27.

*Davison, K.K., & Lawson, C.T. (2006). Do attributes in the physical environment influence children's physical activity? A review of the literature. *International journal of behavioral nutrition and physical activity*, 3 (1), 19.

Deng, Z., Chen, F., Zhang, M., Lan, L., Qiao, Z., Cui, Y., An, J., Wang, N., Fan, Z., Zhao, X., & Li, X. (2016). Association between air pollution and sperm quality: A systematic review and meta-analysis. *Environmental Pollution*, *208*, 663-669.

DiGiuseppi, C., Jacobos, D.E., Phelan, K.J., Mickalide, A., & Ormandy, D. (2010). Housing interventions and control of injury-related structural deficiencies: A review of the evidence. *J Public Health Manag Pract*, *16* (5), S34-S43.

*Dunton, G.F., Kaplan, J., Wolch, J., Jerrett, M., & Reynolds, K.D. (2009). Physical environmental correlates of childhood obesity: a systematic review. *Obesity reviews*, *10* (4), 393-402.

*Eze, I.C., Hemkens, L.G., Bucher, H.C., Hoffman, B., Schindler, C., Kunzli, N., Schikowski, T., & Probst-Hensch, N.M. (2015). Association between ambient air pollution and diabetes mellitus in Europe and North America: Systematic review and meta-analysis. *Environmental Health Perspectives*, *123*, 381-389.

Faulkner, G.E., Buliung, R.N., Flora, P.K., & Fusco, C. (2009). Active school transport, physical activity levels and body weight of children and youth: a systematic review. *Preventive Medicine*, *48* (1), 3-8.

Favarato, G., Ross Anderson, H., Atkinson, R., Fuller, G., Mills, I., & Walton, H. (2014). Traffic-related pollution and asthma prevalence in children. Quantification of associations with nitrogen dioxide. *Air Qual Atmos Health*, *7* (4), 459-466.

*Frutos, V., Gonzalez-Comadran, M., Sola, I., Jacquemin, B., Carreras, R., & Checa Vizcalino, M.A. (2015). Impact of air pollution on fertility: A systematic review. *Gynaecological Endocrinology*, *31* (1), 7-13.

Gascon, M., Triguero-Mas, M., Martinez, D., Dadvand, P., Forus, J., Plasencia, A., & Nieuwenhuijsen, M.J. (2015). Mental health benefits of long-term exposure to residential green and blue spaces: A systematic review. *J Environ Res Public Health*, *12*, 4354-4379.

*Gascon, M., Triguero-Mas, M., Martinez, D., Dadvand, P., Rojas-Rueda, D., Plasencia, A., & Nieuwenhuijsen, M.J. (2016). Residential green spaces and mortality: A systematic review. *Environmental International*, 86, 60-67.

Hajat, S., Vardoulakis, S., Heaviside, C. & Eggen, B., 2014: Climate change effects on human health: projections of temperature-related mortality for the UK during the 2020s, 2050s and 2080s. In: *J Epidemiol Community Health*.

Hajna, S., Ross, N.A., Brazeau, A., Bélisle, P., Joseph, L., & Dasgupta, K. (2015) Associations between neighbourhood walkability and daily steps in adults: a systematic review and meta-analysis. *BMC Public Health* [online], 15 (1), 1.

*Hamra, G.B., Guha, N., Cohen, A., Laden, F., Raaschou-Nielsen, O., Samet, J.M., Vineis, P., Forastiere, F., Saldiva, P., Yorfuji, T., & Loomis, D. (2014). Outdoor particulate matter exposure and lung cancer: A systematic review and meta-analysis. *Environmental Health Perspectives*, 122 (9), 906-911.

*Hamra, G.B., Laden, F., Cohen, A.J., Raaschou-Nielsen, O., Brauer, M., & Loomis, D. (2015). Lung cancer and exposure to nitrogen dioxide and traffic: A systematic review. *Environmental Health Perspectives*, 123 (11), 1107-1112.

*Hu, H., Ha, S., Roth, J., Kearney, G., Talbott, E.O., & Xu, X. (2014). Ambient air pollution and hypertensive disorders of pregnancy: A systematic review and meta-analysis. *Atmospheric Environment*, 97, 336-345.

Hunter, R.F., Christian, H., Veitch, J., Astell-Burt, T., Hipp, J.A., & Schipperijn, J. (2015). The impact of interventions to promote physical activity in urban green space: a systematic review and recommendations for future research. *Social Science & Medicine*, 124, 246-256.

Intergovernmental Panel on Climate Change. (2014). *Climate Change 2014: Impacts, Adaptation, and Vulnerability*. Accessed 09 August 2016 from <http://ipcc-wg2.gov/AR5/report/>.

Jafta, N., Jeena, P.M., Barregard, L., & Naidoo, R.N. (2015). Childhood tuberculosis and exposure to indoor air pollution: a systematic review and meta-analysis. *The International Journal of Tuberculosis and Lung Disease*, 19 (5), 596-602.

*Janghorbani, M., Momeni, F., & Mansourian, M. (2014). Systematic review and meta-analysis of air pollution exposure and risk of diabetes. *European Journal of Epidemiology*, 29 (4), 231-242.

*Kabisch, N., Qureshi, S., & Haase, D. (2015). Human-environment interactions in urban green spaces – A systematic review of contemporary issues and prospects for future research. *Environmental Impact Assessment Review*, 50, 25-34.

*Koranteng, S., Vargas, A.R.O., & Buka, I. (2007). Ambient air pollution and children's health: A systematic review of Canadian epidemiological studies. *Paediatrics & Child Health*, 12 (3), 225-233.

*Lacasaña, M., Esplugues, A., & Ballester, F. (2005) Exposure to ambient air pollution and prenatal and early childhood health effects. *European Journal of Epidemiology* [online], 20 (2), 183-199.

*Lee, A.C.K., & Maheswaran, R. (2010). The health benefits of urban green spaces: A review of the evidence. *Journal of Public Health*, 33 (2), 212-222.

Luo, C., Zhu, X., Yao, C., Hou, L., Zhang, J., Cao, J., & Wang, A. (2015). Short-term exposure to particulate air pollution and risk of myocardial infarction: a systematic review and meta-analysis. *Environmental Science and Pollution Research*, 22 (19), 14651-14662.

Lui, X., Lian, H., Ruan, Y., Liang, R., Zhao, X., Routledge, M., & Fan, Z. (2015). Association of exposure to particulate matter and carotid intima-media thickness: A systematic review and meta-analysis. *Int J Environ Res Public Health*, 12 (10), 12924-12940.

Mackenbach, J.D., Rutter, H., Compernelle, S., Glonti, K., Oppert, J., Charreire, H., De Bourdeaudhuij, I., Brug, J., Nijpels, G., & Lakerveld, J. (2014). Obesogenic environments: a systematic review of the association between the physical environment and adult weight status, the SPOTLIGHT project. *BMC Public Health, 14*: 233.

Menichini, F., & Mudu, P. (2010). Drug consumption and air pollution: An overview. *Pharmacoepidemiol Drug Saf, 19* (12), 1300-1315.

McClure, R.J., Turner, C., Peel, N., Spinks, A., Eakin, E., & Hughes, K. (2008). Population-based interventions for the prevention of fall-related injuries in older people. *Cochrane Database of Systematic Reviews, 1*, DOI: 10.1002/14651858.CD004441.pub2.

*McCormack, G.R., & Shiell, A. (2011). In search of causality: a systematic review of the relationship between the built environment and physical activity among adults. *Int J Behav Nutr Phys Act* [online], *8* (1), 125.

*Mehta, S., Shin, H., Burnett, R., North, T., & Cohen, A.J. (2013). Ambient particulate air pollution and acute lower respiratory infections: a systematic review and implications for estimating the global burden of disease. *Air Quality, Atmosphere & Health, 6* (1), 69-83.

Mitchell, R., & Popham, F. (2008). Effect of exposure to natural environment on health inequalities: An observational population study. *The Lancet, 372* (9650), 1655-1660. C.f. Fair Society, Healthy Lives, p80.

*Najafi, T.F., Roudsari, R.L., Namvar, F., Ghanbarabadi, V.G., Talasaz, Z.H., & Esmaeli, M. (2015). Air Pollution and Quality of Sperm: A Meta-Analysis. *Iranian Red Crescent Medical Journal, 17* (4).

National Institute for Health and Care Excellence (2015) NICE NG32 Older people: independence and mental wellbeing. December 2015. Available from <https://www.nice.org.uk/>.

National Institute for Health and Care Excellence. (2012). NICE PH41 Physical activity: walking and cycling. November 2012. Available from <https://www.nice.org.uk/>.

National Institute for Health and Care Excellence. (2013). NICE PH44 Physical activity: brief advice for adults in primary care. May 2013. Available from <https://www.nice.org.uk/>.

National Institute for Health and Care Excellence. (2013). NG6: Excess winter deaths and illnesses associated with cold homes

Oja, P., Titze, S., Bauman, A., De Geus, B., Krenn, P., Reger-Nash, B., & Kohlberger, T. (2011). Health benefits of cycling: a systematic review. *Scandinavian Journal of Medicine & Science in Sports*, 21 (4), 496-509.

Pedersen, M., Stayner, L., Slama, R., Figueras, F., Nieuwenhuijsen, M.J., Dadvand, P. (2014). Ambient air pollution and pregnancy-induced hypertensive disorders: A systematic review and meta-analysis. *Hypertension*, 64 (3), 494-500.

*Peters, R., Peters, J., Booth, A., & Mudway, I. (2015). Is air pollution associated with increased risk of cognitive decline? A systematic review. *Age Ageing*, 44 (5), 755-760.

*Rodriguez-Villamizar, L.A., Magico, A., Osornio-Vargas, A., & Rowe, B.H. (2015). The effects of outdoor air pollution on the respiratory health of Canadian children: A systematic review of epidemiological studies. *Canadian Respiratory Journal*, 22 (5), 282-292.

*Sandel, M., Baeder, A., Bradman, A., Hughes, J., Mitchell, C., Shaunessy, R., Takaro, T.K., & Jacobs, D.E. (2010). Housing interventions and control of health-related chemical agents: A review of the evidence. *J Public Health Management Practice*, 16 (5), S24-S33.

*Scheers, H., Jacobs, L., Casas, L., Nemery, B., & Nawrot, T.S. (2015). Long-Term Exposure to Particulate Matter Air Pollution Is a Risk Factor for Stroke Meta-Analytical Evidence. *Stroke*, 46 (11), 3058-3066.

*Shah, A.S., Lee, K.K., McAllister, D.A., Hunter, A., Nair, H., Whiteley, W., Langrish, J.P., Newby, D.E., & Mills, N.L. (2015). Short term exposure to air pollution and stroke: systematic review and meta-analysis. *BMJ*, *350*:h1295.

*Song, Q., Christiani, D.C., & Ren, J. (2014). The global contribution of outdoor air pollution to the incidence, prevalence, mortality and hospital admission for chronic obstructive pulmonary disease: a systematic review and meta-analysis. *International Journal of Environmental Research and Public Health*, *11* (11), 11822-11832.

*Stanke, C., Murray, V., Amlot, R., Nurse, J., & Williams, R. (2012). The effects of flooding on mental health: Outcomes and recommendations from a review of the literature. *PLoS Current Disasters*, doi: 10.1371/4f9f1fa9c3cae.

*Stieb, D.M., Chen, L., Eshoul, M., & Judek, S. (2012). Ambient air pollution, birth weight and preterm birth: a systematic review and meta-analysis. *Environmental Research* [online], *117*, 100-111.

*Teng, T.H.K., Williams, T.A., Bremner, A., Tohira, H., Franklin, P., Tonkin, A., Jacobs, I., & Finn, J. (2014). A systematic review of air pollution and incidence of out-of-hospital cardiac arrest. *Journal of epidemiology and community health*, *68* (1), 37-43.

*Thompson Coon, J., Boddy, K., Stein, K., Whear, R., Barton, J., & Depledge, M.H. (2011). Does participating in physical activity in outdoor natural environments have a greater effect on physical and mental wellbeing than physical activity indoors? A systematic review. *Environmental science & technology*, *45* (5), 1761-1772.

*Turner, M.C., Wigle, D.T., & Krewski, D. (2011). Residential pesticides and childhood leukemia: a systematic review and meta-analysis. *Ciencia & saude coletiva*, *16* (3), 1915-1931.

Van Cauwenberg, J., De Bourdeaudhuij, I., De Meester, F., Van Dyck, D., Salmon, J., Clarys, P., & Deforche, B. (2011). Relationship between the physical environment and physical activity in older adults: a systematic review. *Health & Place*, *17* (2), 458-469.

Van Holle, V., Deforche, B., Van Cauwenberg, J., Goubert, L., Maes, L., Van de Weghe, N., & De Bourdeaudhuij, I. (2012). Relationship between the physical environment and different domains of physical activity in European adults: a systematic review. *BMC Public Health*, 12 (1), 1.

*Vienneau, D., Schindler, C., Perez, L., Probst-Hensch, N., & Rössli, M. (2015). The relationship between transportation noise exposure and ischemic heart disease: a meta-analysis. *Environmental Research*, 138, 372-380.

Vrijheid, M., Martinez, D., Manzanares, S., Dadvand, P., Schembari, A., Rankin, J., & Nieuwenhuijsen, M. (2011). Ambient air pollution and risk of congenital anomalies: a systematic review and meta-analysis. *Environmental Health Perspectives*, 119 (5), 598.

Waite T. *et al* (2014) Carbon Monoxide Poisoning and Flooding: Changes in Risk Before, During and After Flooding Require Appropriate Public Health Interventions Version 1. PLoS Curr. 2014 July 3; 6: ecurrents.dis.2b2eb9e15f9b982784938803584487f1.

*WHO Europe. (2007). *Tackling Obesity by Creating Healthy Residential Environments*. Accessed 19 April 2016 from http://www.euro.who.int/_data/assets/pdf_file/0012/98697/E90593.pdf.

Xu, H., Wen, L.M., & Rissel, C. (2013). The relationships between active transport to work or school and cardiovascular health or body weight: a systematic review. *Asia-Pacific Journal of Public Health / Asia-Pacific Academic Consortium for Public Health*, 25 (4), 298-315.

Topic 5: Transport

Transportation plays an important role in supporting daily activities. Active travel (i.e., cycling, walking and use of public transport) has the potential to increase physical activity levels and improve physical and mental wellbeing. Prioritisation of active travel may also reduce over reliance on motorised transport which may contribute to improved air quality and a reduction in road injuries.

Planning principles

1. *Provision of active travel infrastructure*

- Increase infrastructure for walking and cycling: There is a wealth of high quality evidence from a variety of high and middle-income countries to show that investing in walking and cycling infrastructure is associated with increased physical activity levels and improved mobility among all age groups. There is moderate to high quality evidence indicating that prioritising active travel, through investment in cycling infrastructure, is associated with numerous health gains. For example, the implementation of new cycle lanes is associated with improved cardiovascular outcomes and improved weight status among children, adults and older adults.
- The overall quality of the evidence reviewed was mixed, although the majority of studies were categorised as high quality.

2. *Provision of Public Transport*

- Encourage use of public transport: Evidence suggests that combining public transport with other forms of active travel such as walking and cycling may improve cardiovascular fitness. Provision of high quality public transport is associated with higher levels of active travel among children.
- Reduce exposure to environmental hazards: Active travel in areas with low pollution levels is associated with increased physical activity among older adults. Although not drawn from systematic review level evidence, findings from an empirical study suggest that production of lower-emission motor vehicles (cars, motorcycles, and trucks) and an increase in active travel are needed to meet targets for reduction of

greenhouse-gas emissions. The perception of air pollution appears to constitute a barrier to participating in outdoor physical activity and active transport.

3. *Prioritise active travel and road safety*

- Prioritise pedestrians and cyclists: Attempts to prioritise road use for pedestrians and cyclists through changes to physical infrastructure are associated with positive behavioural and health outcomes. For instance, the separation of cycling and pedestrian infrastructure from road traffic has been shown to encourage active travel.
- Traffic calming measures: Traffic calming measures, including speed humps, speed tables, cushions and roundabouts, are associated with increased walking behaviour and a reduced risk of pedestrian injury. For example, one review found that a 1 mph reduction in speed can lower the risk of road traffic collision by 5%. Findings from another review highlight that implementation of 20 mph zones and limits was associated with reduced road traffic collisions. However, the impact of such measures on reducing health inequalities is not yet known. A recent report by the Royal Society for the Prevention of Accidents (ROSPA) suggests that traffic calming measures are effective when used in 20 mph zones (ROSPA, 2015). This umbrella review found no review level evidence that met our review's eligibility criteria relating to the effectiveness of home zones in improving road safety. However, there are reports in the grey literature that home zones can effectively reduce traffic speed to 10mph -15 mph, and thus may reduce risk of road traffic collisions (Department for Transport, 2005).
- Public realm improvements: Improvements to street lighting are associated with increased physical activity participation among older adults and reduced incidence of road traffic collisions.

4. *Enable mobility for all ages and activities*

- Access to recreational space: There is moderate quality evidence that built environment strategies to promote physical activity may have a positive impact upon engagement in physical activity behaviours. For example, increasing access to playgrounds and recreational facilities is associated with increased walking among

adolescents. Please also see “*Neighbourhood Design*” and “*Natural and Sustainable Environment*”.

- Organisational travel plans: Evidence for the effectiveness of organisational travel plans on health and physical activity is inconsistent. In the review by Hosking *et al.* (2010), only one RCT found that organisational travel plans were effective in improving health related quality of life and increasing amount of time spent walking.
- Active travel to school or work: Evidence from high quality studies affirms a positive association between active travel to school or work and cardiovascular outcomes.
- Active travel in rural settings: No review level evidence was found as part of this review relating to the impact of living in a rural setting on health. However, a recent report by Active Living Research (2015) suggests that active travel is difficult to achieve in rural areas where residents live far away from local amenities and social services. This finding comes from a study that has not been quality assessed by the authors of this report.
- Mobility for mentally and physically impaired: No review level evidence was found as part of this review relating to the impact of improved mobility on the health outcomes among the mentally and physically impaired. However, an empirical study by Lezzoni *et al.*, (2001) reported that addressing mobility issues among mentally and physically impaired individuals can improve quality of life.

Supporting evidence

5. Provision of active travel infrastructure

5.1 Increase infrastructure for walking: There is moderate-to-high quality evidence to suggest that investing in infrastructure to support walking is associated with increased levels of physical activity among children, adults and older adults (Carlin *et al.*, 2015; D’Hease *et al.*, 2015; Grasser *et al.*, 2013; Larouche *et al.*, 2014; Mueller *et al.*, 2015; Wanner *et al.*, 2012).

5.2 Increase infrastructure for cycling: There is moderate-to-high quality evidence from studies conducted mainly in Europe (including UK) and America suggesting that prioritising cycling infrastructure is associated with raised physical activity levels among children, adults and older adults (D’Hease *et al.*, 2015; Larouche *et al.*, 2014; Mueller *et al.*, 2015; Wanner *et al.*, 2012). Low-to-moderate quality evidence

suggests that the provision and proximity of cycle paths is positively associated with cycling rates (Fraser & Lock, 2011). Furthermore, low-to-moderate quality evidence suggests that long trip distance, steep inclines and distance of services from cycle paths can adversely affect cycling behaviour (Fraser & Lock, 2011).

6. Provision of Public Transport

6.1 Encourage use of public transport: There is evidence that active travel (to work or school - combining walking, cycling or public transportation) has the potential to improve cardiovascular health. This finding was consistent in 15 out of 16 empirical studies included in Xu, Wen & Rissel's (2013) review.

6.2 There is evidence of unknown quality that provision of high quality public transport is associated with an increase active travel among children (Davison & Lawson, 2006).

6.3 Reduced exposure to environmental hazards: Moderate quality evidence from middle and high-income countries (excluding the UK) suggests that a reduction in pollution is associated with increased physical activity participation among older adults (Annear *et al.*, 2014).

6.4 There is moderate quality evidence from Europe (UK inclusive), America and Asia to indicate that the health gains from active travel policies outweigh the adverse effects of traffic incidents. However, in terms of air pollution, there is limited evidence that active commuters are at lower risk of suffering from the consequences of air pollution than passive commuters (Fraser & Lock, 2011; Mueller *et al.*, 2015).

6.5 Moderate quality evidence from high income countries (including the UK) demonstrates that perceived or objective danger may adversely affect cycling behaviour (Fraser & Lock, 2011).

7. Prioritise active travel and road safety

7.1 Prioritise pedestrians and cyclists: Low-to-moderate quality evidence from studies conducted predominantly in high income countries (including UK) demonstrate that separation of cycling from other traffic may promote cycling (Fraser & Lock, 2011). Moderate-to-high quality evidence demonstrates a consistent positive association between walkability indexes (land use mix, residential density and street connectivity) and active travel among children and adults (Davison & Lawson, 2006;

Grasser *et al.*, 2013). Findings are based on studies conducted in middle and high-income countries, including the UK.

- 7.2 Traffic calming measures: There is moderate quality evidence from middle and high-income countries that traffic calming is associated with increased walking behaviour and reduced risk of pedestrian injury (Rothman *et al.*, 2013).
- 7.3 There is high quality UK based evidence that 20 mph zones and limits are effective in reducing the incidence of road traffic collisions and injuries, however, there is not yet evidence for a direct impact of 20 mph zones or limits on reducing health inequalities (Cairns *et al.*, 2015).
- 7.4 A small body of evidence suggests an association between a 10dB Lden increase in transportation noise and 6% higher risk of ischemic heart disease (Vienneau *et al.*, 2015). This finding is based on studies conducted across Europe.
- 7.5 Moderate quality evidence suggests that there is no clear association between the use of porous asphalt and road safety (Elvik & Greibe, 2005).
- 7.6 Public realm improvements: Moderate quality evidence from high income countries (including UK) demonstrates that perceived or objective danger may adversely affect cycling behaviour (Fraser & Lock, 2011). Low quality evidence from high income countries (including the UK) suggests that street lighting may prevent RTCs, injuries and fatalities among car occupants (Beyer & Ker, 2009).

8. Enable mobility for all ages and activities

- 8.1 Access to recreational space: There is low-to-moderate quality evidence from middle and high-income countries to indicate that traffic calming, access to recreational facilities such as playgrounds can increase safe walking among adolescents. The evidence is less consistent for children (Rothman *et al.*, 2013).
- 8.2 There is review level evidence, drawn from the UK and other high and middle-income countries, demonstrating that access to green or open spaces is associated with improved mental health outcomes (Clark *et al.*, 2007; Gascon *et al.*, 2015). However, caution is required when interpreting these findings as they are reliant on cross-sectional data and study quality is low-to-moderate.
- 8.3 Active travel to school or work: There is moderate to high quality evidence from high income countries (including the UK and other European countries) that walking and cycling to school or work may improve cardiovascular health and reduce

cardiovascular risk factors (Oja *et al.*, 2011; Xu *et al.*, 2013). There is inconsistent moderate to high quality evidence for an association between active travel to work or school, body mass index (BMI) and weight status. The evidence (predominantly US and UK based studies) shows either a positive association or no association but does not suggest a negative association (Faulkner *et al.*, 2009; Oja *et al.*, 2011; Xu *et al.*, 2013).

8.4 Active travel and mental health: No review level evidence was found as part of this review for the impact of active travel on mental health outcomes. Nevertheless, empirical studies conducted mainly in North America have found that people living on a street with little traffic knew most of their neighbours and had many friends on the street compared to people that live in a similar street but just with heavy traffic. In addition, other empirical studies have found that children on busier streets were less likely to be allowed to play in the streets which can have a detrimental impact on their mental and physical development. These findings come from studies that have not been quality assessed by the reviewers of this report.

8.5 Active travel in rural settings: No review level evidence was found as part of this review relating to the impact of living in a rural setting on health outcomes. However, a recent report by Active Living Research (2015) suggests that active travel is difficult to achieve in rural areas where residents live far away from local amenities and social services. This finding comes from a study that has not been quality assessed by the reviewers of this report.

8.6 Mobility for mentally and physically impaired: No review level evidence was found as part of this review relating to the impact of improved mobility on the health outcomes among the mentally and physically impaired. However, Lezzoni *et al.*, (2001) reported that addressing mobility issues among mentally and physically impaired individuals can improve quality of life.



Transport

Quality of Evidence:

- ⬆ Improved
- ⬇ Reduced
- ▶ High Quality
- ▶ Medium Quality
- ▶ Low Quality
- ▶ NR (Not reported):

Methodological quality of the original research is unclear and should be treated with caution.

Greyed Out Text
Association between a health impact & health outcome not obtained as part of the umbrella review.

Best Available Evidence:

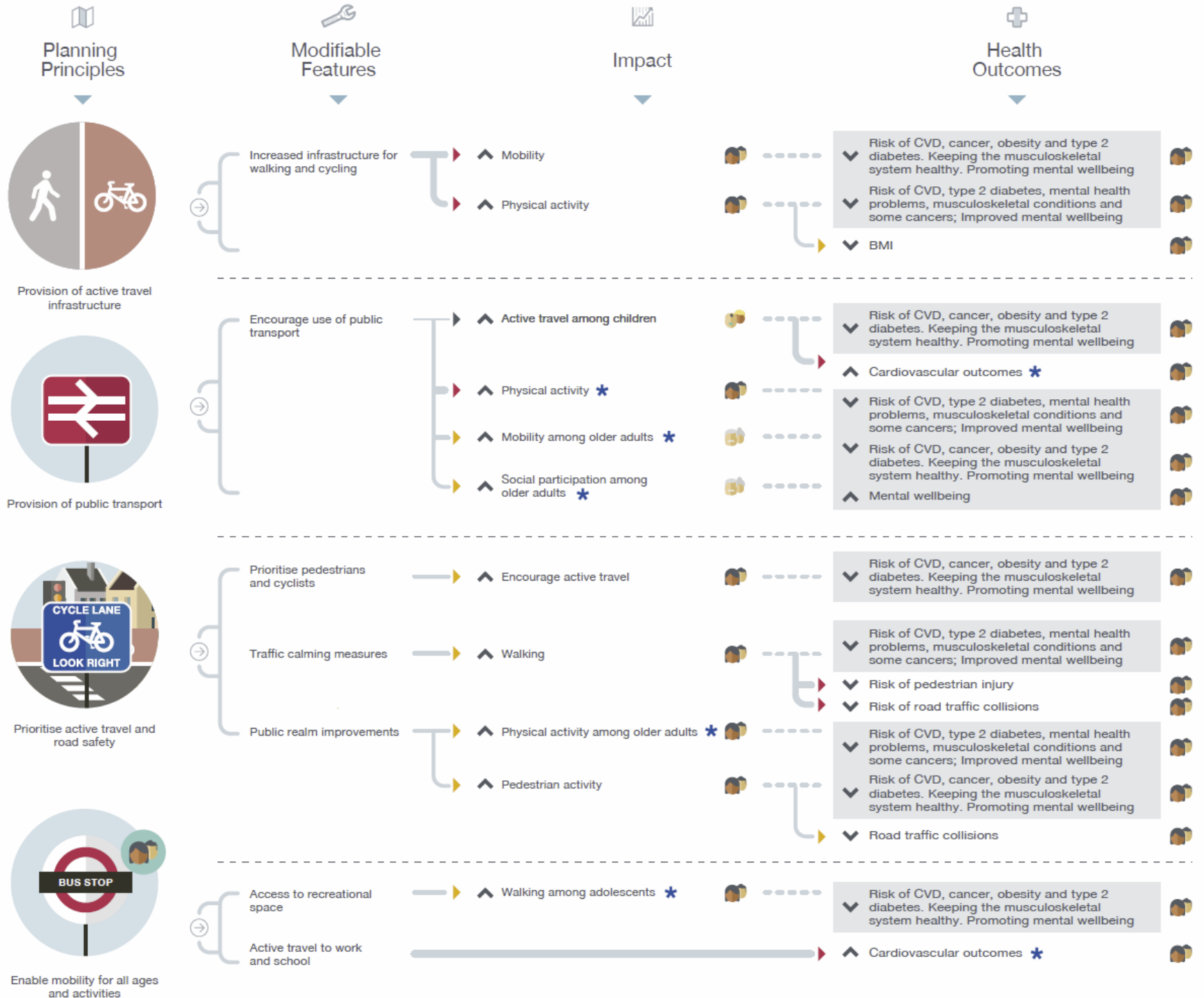
* In some instances, more than one piece of review-level evidence reporting on the same health impacts and/or outcomes was identified as part of this umbrella review. In such instances this table highlights findings of the review(s) which reported evidence of the best methodological quality.

Population Groups:

- 👤 General Population
- 👴 Older Adults
- 👦 Children & Adolescents

Disclaimer:

This diagram has been produced as part of a wider evidence resource, commissioned by Public Health England and developed by the University of the West of England. Please see the document Spatial planning for health: an evidence resource for planning and designing healthier places for further information.



Transport bibliography

*Referenced in supporting evidence section

*Active Living Research (2015). Promoting Active Living in Rural Communities.

Accessed 09 August 2016 from:

http://activelivingresearch.org/sites/default/files/ALR_Brief_RuralCommunities_Sept2015.pdf.

Aeron-Thomas, A., & Hass, S. (2005). Red-light cameras for the prevention of road traffic crashes. *Cochrane Database of Systematic Reviews*, DOI:

10.1002/14651858.CD003862.pub2.

*Annear, M., Keeling, S., Wilkinson, T., Cushman, G., Gidlow, B., & Hopkins, H. (2014).

Environmental influences on healthy and active ageing: A systematic review. *Ageing & Society*, 34 (4), 590-622.

Appleyard, D., Gerson, M.S., & Lintell, M. (1981). *Livable streets*. Berkely: University of California Press, 1981. (recently reissued in a 2nd edition: 2012, Editor B. Appleyard)

Baker, P.R., Francis, D.P., Soares, J., Weightman, A.L., & Foster, C. (2011). Community wide interventions for increasing physical activity. *Sao Paulo Medical Journal*. 129 (6), 436-437.

*Beyer, F.R., & Ker, K. (2009). Street lighting for preventing road traffic injuries.

Cochrane Database of Systematic Reviews. 1.

Bunn, F., Collier, T., Frost, C., Ker, K., Roberts, I., & Wentz, R. (2003). Traffic calming for the prevention of road traffic injuries: systematic review and meta-analysis. *Injury Prevention: Journal of the International Society for Child and Adolescent Injury Prevention*, 9 (3), 200-204.

*Cairns, J., Warren, J., Garthwaite, K., Greig, G., & Bambra, C. (2015) Go slow: an umbrella review of the effects of 20 mph zones and limits on health and health inequalities. *Journal of Public Health (Oxford, England)*. 37 (3), pp.515-520.

*Carlin, A., Murphy, M.H., & Gallagher, A.M. (2015). Do interventions to increase walking work? A systematic review of interventions in children and adolescents. *Sports Med*, 46 (5), 515-530.

Chief Medical Officer. (2012). *Annual Report of the Chief Medical Officer: Surveillance Volume 2012*. Accessed 09 August 2016 from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/298297/cmo-report-2012.pdf.

Chillon, P., Evenson, K.R., Vaughn, A., & Ward, D.S. (2011). A systematic review of interventions for promoting active transportation to school. *The International Journal of Behavioral Nutrition and Physical Activity*, 8, 10.

*Clark, C., Myron, R., Stansfeld, S., & Candy, B. (2007). A systematic review of the evidence on the effect of the built and physical environment on mental health. *Journal of Public Mental Health* [online]. 6 (2), 14-27.

*Davison, K.K., & Lawson, C.T. (2006). Do attributes in the physical environment influence children's physical activity? A review of the literature. *The International Journal of Behavioral Nutrition and Physical Activity*, 3, 19.

*Department for Transport. (2005). *Home zones: Challenging the future of our streets*. Accessed 09 August 2016 from <http://www.rudi.net/files/homezones.pdf>

*D'Haese, S., Vanwolleghem, G., Hinckson, E., De Bourdeaudhuij, I., Deforche, B., Van Dyck, D., & Cardon, G. (2015). Cross-continental comparison of the association between the physical environment and active transportation in children: a systematic review. *International Journal of Behavioral Nutrition and Physical Activity*, 12, 145.

*Elvik, R., & Greibe, P. (2005). Road safety effects of porous asphalt: a systematic review of evaluation studies. *Accident Analysis & Prevention*, 37 (3), 515-522.

*Faulkner, G.E., Buliung, R.N., Flora, P.K., & Fusco, C. (2009). Active school transport, physical activity levels and body weight of children and youth: a systematic review. *Preventive Medicine*, 48 (1), 3-8.

*Fraser, S.D., & Lock, K. (2011). Cycling for transport and public health: a systematic review of the effect of the environment on cycling. *European Journal of Public Health*, 21 (6), 738-743.

*Gascon, M., Triguero-Mas, M., Martinez, D., Dadvand, P., Forus, J., Plasencia, A., & Nieuwenhuijsen, M.J. (2015). Mental health benefits of long-term exposure to residential green and blue spaces: A systematic review. *J Environ Res Public Health*, 12, 4354-4379.

*Grasser, G., Van Dyck, D., Titze, S., & Stronegger, W. (2013) Objectively measured walkability and active transport and weight-related outcomes in adults: a systematic review. *International Journal of Public Health*, 58 (4), 615-625.

Hanson, S., & Jones, A. (2015). Is there evidence that walking groups have health benefits? A systematic review and meta-analysis. *British Journal of Sports Medicine*, 49 (11), 710-715.

*Hosking, J., Macmillan, A., Connor, J., Bullen, C., & Ameratunga, S. (2010). Organisational travel plans for improving health. *Cochrane Database Syst Rev*, 3.

Høyen, A. (2014) Speed cameras, section control, and kangaroo jumps—a meta-analysis. *Accident Analysis & Prevention*, 73, 200-208.

Ker, K., Roberts, I., Collier, T., Beyer, F., Bunn, F., & Frost, C. (2005). Post-licence driver education for the prevention of road traffic crashes: a systematic review of randomised controlled trials. *Accident Analysis & Prevention*, 37 (2), 305-313.

*Larouche, R., Saunders, T.J., Faulkner, G.E.J., Colley, R., & Tremblay, M. (2014). Associations between active school transport and physical activity, body composition, and cardiovascular fitness: a systematic review of 68 studies. *Journal of Physical Activity & Health*, 11 (1).

Lezzoni, L.I., McCarthy, E.P., Davis, R.B. & Siebens, H. (2001). Mobility difficulties are not only a problem of old age. *Journal of General Internal Medicine*, 16 (4), 235-243.

Mayne, S., Auchincloss, A. & Michael, Y. (2015). Impact of policy and built environment changes on obesity-related outcomes: a systematic review of naturally occurring experiments. *Obesity Reviews*, 16 (5), 362-375.

McGrath, L.J., Hopkins, W.G., & Hinckson, E.A. (2015). Associations of Objectively Measured Built-Environment Attributes with Youth Moderate–Vigorous Physical Activity: A Systematic Review and Meta-Analysis. *Sports Medicine*, 45 (6), 841-865.

Mindell, J.S., & Karlsen, S. (2012) A review of the evidence on community severance and its impacts on health. *Journal of Urban Health*, 89, 232-246.

*Mueller, N., Rojas-Rueda, D., Cole-Hunter, T., de Nazelle, A., Dons, E., Gerike, R., Götschi, T., Panis, L.I., Kahlmeier, S., & Nieuwenhuijsen, M. (2015). Health impact assessment of active transportation: a systematic review. *Preventive Medicine*, 76, 103-114.

National Institute for Health and Care Excellence. (2012). NICE PH41 *Physical activity: walking and cycling*. November 2012. Available from <https://www.nice.org.uk/>.

National Institute for Health and Care Excellence. (2013). NICE PH44 *Physical activity: brief advice for adults in primary care*. May 2013. Available from <https://www.nice.org.uk/>.

National Institute for Health and Care Excellence. (2015). NICE NG32 *Older people: independence and mental wellbeing*. December 2015. Available from <https://www.nice.org.uk/>.

Oja, P., Titze, S., Bauman, A., De Geus, B., Krenn, P., Reger-Nash, B., & Kohlberger, T. (2011). Health benefits of cycling: a systematic review. *Scandinavian Journal of Medicine & Science in Sports*, 21 (4), 496-509.

Pilkington, P., & Kinra, S. (2005). Effectiveness of speed cameras in preventing road traffic collisions and related casualties: A systematic review. *BMJ*, 330, doi: <https://doi.org/10.1136/bmj.38324.646574.AE>.

Porchia, B.R., Baldasseroni, A., Dellisanti, C., Lorini, C., Bonaccorsi, G. (2014). Effectiveness of two interventions in preventing traffic accidents: A systematic review. *Ann Ig*, 26, 63-75.

*Rothman, L., Buliung, R., Macarthur, C., To, T., & Howard, A. (2014). Walking and child pedestrian injury: a systematic review of built environment correlates of safe walking. *Injury Prevention: Journal of the International Society for Child and Adolescent Injury Prevention*, 20 (1), 41-49.

ROSPA. (2015). *20 mph zones and Speed Limits*. Accessed 09 August 2016 from: <http://www.rospa.com/rospaweb/docs/advice-services/road-safety/drivers/20-mph-zone-factsheet.pdf>

*Vienneau, D., Schindler, C., Perez, L., Probst-Hensch, N., & Rösli, M. (2015). The relationship between transportation noise exposure and ischemic heart disease: a meta-analysis. *Environmental Research*, 138, 372-380.

Wanner, M., Götschi, T., Martin-Diener, E., Kahlmeier, S., & Martin, B.W. (2012). Active transport, physical activity, and body weight in adults: a systematic review. *American Journal of Preventive Medicine*, 42 (5), 493-502.

Wilson, C., Willis, C., Hendrikz, J., Le Brocque, R., & Bellamy, N. (2010). Speed cameras for the prevention of road traffic injuries and deaths (review). *Cochrane Database of Systematic Reviews*, 6 (10).

*Xu, H., Wen, L.M., & Rissel, C. (2013). The relationships between active transport to work or school and cardiovascular health or body weight: a systematic review. *Asia-Pacific Journal of Public Health / Asia-Pacific Academic Consortium for Public Health*, 25 (4), 298-315.

5. Discussion

Summary of findings

This umbrella review presents an overview of the evidence for the relationship between the built and natural environment and health. Evidence pertaining to five key aspects of the built and natural environment (neighbourhood design, housing, healthier food, natural and sustainable environment, and transport) was collated, quality assessed and summarised to illustrate statistical associations between the built and natural environment and health, strength of the evidence, and recommendations for those working in the public health or planning professions.

Across all areas of the built and natural environment explored as part of this review, evidence was identified demonstrating an inextricable association between the built and natural environment and health. In the case of neighbourhood design, improving neighbourhood walkability (i.e., an area that is supportive of walking) and infrastructure designed to promote walking and cycling was found to be associated with numerous positive health outcomes, including increased physical activity levels and improved social engagement among older adults. Furthermore, areas of mixed land use (i.e., neighbourhoods that include green spaces), diverse housing types and high quality public transport were found to be associated with increased physical activity levels, reduced risk of pedestrian injury and road traffic collisions, and increased social participation among older adults, among other positive health outcomes.

An examination of evidence for the influence of housing on health revealed that housing features such as energy efficient homes, housing refurbishment, and removal of home hazards, and the availability of affordable housing was associated with a variety of positive health outcomes including improved social outcomes, reduced injury, and improved general physical and mental health. Among vulnerable groups (for example, substance users, homeless, disabled), provision of affordable housing was associated with improved quality of life, mental health and clinical health-related outcomes.

Evidence for the impact of the food environment on health revealed that provision of healthier and affordable food could be effective in improving dietary attitudes and behaviours, and reducing dietary fat intake and BMI in public service settings (for example, schools, community settings, council offices). Research also indicates that multi-component interventions that take an integrated, whole school approach may be most effective in improving children's diet and food choices in schools. Urban food growing was found to be associated with improved attitudes towards healthy eating, increased opportunities for social connectivity and increased opportunities for physical activity.

In terms of the natural and sustainable environment, there is a wealth of evidence that improvement to air quality, prioritisation of neighbourhood tree planting, and provision of open and green spaces is associated with increased physical activity, increased environmental cooling, and improved general physical health outcomes (for example, reduced cardiovascular disease (CVD) mortality risk). In addition, provision of infrastructure to support walking and cycling and increased access to buildings and facilities is associated with increased physical activity and improved social engagement among older adults. This section of the review also highlights the consequences of flooding. The review found that flooding was associated with a number of health-related issues including carbon monoxide poisoning and poorer mental health outcomes.

In the case of transport, evidence was found to demonstrate that infrastructure for walking and cycling, installation of traffic calming measures, and public realm improvements (for example, enhanced street lighting) was associated with increased mobility, physical activity levels, reduced BMI and reduced risk of injury, among other positive outcomes. Furthermore, the provision of open and green space, high quality public transport and improved air quality was associated with numerous positive health outcomes including increased physical activity, improved cardiovascular outcomes, and improved social participation, among others.

However, despite the evidence identified and reviewed, the findings need to be interpreted with caution. The majority of review level evidence examined was reliant on

short-term, cross-sectional empirical studies. As such, in many cases it is impossible to identify the causal link between the aspect of the built environment and the health impact(s) and/or health outcome(s). In the most part, this review has identified that numerous aspects of the built environment and health are ***related***, but not necessarily ***causal***. However, the available evidence is suggestive that modification to certain aspects of the built and natural environment may have the potential to impact positively upon specific health behaviours and health outcomes. The findings of this review reiterate the findings of a previous umbrella review, that the influence of built and natural environment characteristics on health inequalities outcomes remains unclear.

What is already known on this subject

- The natural and built environment plays a key role in shaping the social and economic determinants of health.
- Although the linkages between the environment and health have long been established, there is often insufficient evidence to ascertain causality.

What this umbrella review adds

- This study systematically assessed evidence from recent systematic reviews on the association between the built and natural environment and health. The collation of evidence provides readers with an insight into the research that has been conducted in this field.
- By adopting a systematic approach to evidence gathering and quality appraisal of available evidence, this study was able to identify gaps in the evidence and make recommendations for further research.
- The diagrams, on each of the five aspects of the built environment examined as part of this review, provide logical evidence-based messages to aid communication among planners and public health professionals.

Implications for policy and practice

The environment in which people live has an impact on health and wellbeing. In addition to direct health benefits, enhancement of the built and natural environment can impact on people's attitudes, behaviours and perceptions of their environment. For instance, reducing air pollution is associated with improved perceptions of safety, the promotion of outdoor physical activity, and improved social interaction.

Findings from this review strengthen the argument for an upstream shift to address key built and natural environment obstacles to enable people to increase control over, and improve, their health. Communication between built environment and health professionals is essential. The findings highlight the importance of local evidence-based action to ensure settings and place based approaches provide opportunities for people to make healthier lifestyle choices. Incorporating health needs and impact into the conceptualisation, design and planning of infrastructural projects, may assist policy makers, planners and built environment professionals in the development of sustainable communities.

Strengths and limitations of the available evidence

Although this review identified substantial evidence for associations between the built and natural environment and health, the utility of this evidence is limited due to the generally weak scientific rigour of the original empirical studies contributing to the evidence reviews included in this umbrella review. In a complex system such as the built and natural environment, it is not always possible to undertake an experimental approach (such as randomised controlled trials) that can in other circumstances offer the best way of assessing causality. In such cases, determination of what is sufficient quality of evidence in order to take action is still a matter for debate. Wherever possible, experimental approaches should be undertaken in order to develop the evidence base in this field, as they do often offer the highest quality of evidence regarding causality.

The findings of this review are also limited in their inability to draw firm conclusions about the impact of the built and natural environment on health inequalities. This is due

to the fact that despite the wealth of research exploring the relationships between the built environment and health, work focussed specifically on health inequalities is extremely limited. Where evidence was identified as part of this review it has been reported in the results section; however, in the most part the available evidence is insufficient to draw conclusions and thus there is a strong case for examining health inequalities in more depth in future public health research.

Finally, it is important to acknowledge that although the primary target audience of this review is public health professionals working in local authority settings in the UK, much of the existing good quality evidence comes from other high and middle-income countries. This is potentially problematic as the planning principles followed in the UK are somewhat different to the principles adhered to elsewhere (e.g., USA); this may mean that findings from other countries are not as applicable in a UK context. However, in response to this, we have highlighted UK-centric evidence in the results section where possible.

Strengths and limitations of this umbrella review

This review summarises a broad spectrum of research linking health and the built and natural environment. Careful attention was given to rate the quality of each included study. A key strength of this review is therefore the robustness of methodology and rigour of quality appraisal. The quality of included studies was assessed on two separately quality matrices; the 7-item Methodological Quality Checklist (MQC) and the quality rating ascribed by the authors of each evidence review included in our umbrella review. Evidence reviews deemed to be of very low quality were excluded from the final analysis. Thus, health and built environment professionals are guided in their understanding of the influence of the built and natural environment on health outcomes, based on the best available, current and systematically retrieved, evidence.

It is important to note that the decision to focus purely on review level evidence has its drawbacks. For example, despite an extensive search of the literature it was soon realised that evidence for certain built environment areas/issues does not yet exist or has yet to be systematically reviewed. Notably, this does not mean that the built

environment area/issue does not exist or is not important. In response to this, where 'gaps' in the evidence were identified we contacted experts in the field of the built environment and health and searched for references to relevant empirical studies. Therefore, we are confident in our identification of 'gaps' in the evidence and we support the case for further good quality research to determine causal links between the built environment and health more comprehensively. For example, additional work could broaden the scope of the review to include identification and assessment of individual empirical studies, although it is acknowledged that this would represent a significant undertaking.

This work focused on the findings from quantitative systematic review level evidence alone. We acknowledge that this does limit the findings to some extent as we have not included evidence from qualitative systematic reviews. However, this work is chiefly designed for public health professionals, and quantitative evidence is still considered by the public health profession to be the most appropriate approach for determining causality. The inclusion of qualitative evidence reviews was beyond the remit of this umbrella review, but future large-scale reviews may benefit from the inclusion of qualitative review level evidence to explore the relationship between health and the built environment from a more in-depth perspective and for a deeper understanding of the issues.

Appendix A: Umbrella review methods

Search strategy

In line with the umbrella review methodology, we conducted a rapid structured systematic search for existing quantitative systematic reviews to provide us with an overview of the evidence base. Due to the limited time scale of the project, we searched for published reviews between January 2005 and February 2016. Databases searched include:

- Cochrane Database of Systematic Reviews
- EPPI CENTRE
- MEDLINE
- PsycINFO
- SafetyLit
- Transport Research Information Service (TRIS)
- Applied Social Sciences Index and Abstracts (ASSIA).

To identify relevant stakeholder documentation (i.e., non-systematic review level evidence) we searched the websites of stakeholder organisations known to have an interest in the built environment and health. In line with a recent umbrella review (Bambra *et al.* 2010), potential stakeholder documentation was only eligible for inclusion in our review if the document was developed or endorsed by a respected stakeholder organisation. The websites of the following stakeholder organisations were searched:

- Public Health England (PHE)
- National Institute for Health and Care Excellence (NICE)
- World Health Organisation (WHO)
- European Commission (EC)
- Royal Society for the Prevention of Accidents (ROSPA)
- Royal Town Planning Institute (RTPI)

- Design Council (which incorporates the work of CABI)
- Royal Institute of British Architects (RIBA)
- Spatial Planning and Health Group (SPAHG)
- Centers for Disease Control and Prevention (CDC)
- Department for Transport (DfT)
- UK Health Forum
- Landscape Institute
- Town and Country Planning Association (TCPA)
- Royal Institute of British Architects (RIBA)
- HACT Ideas and innovations in housing

In addition to this, we also searched Google Scholar, reference lists of included papers, and contacted experts working in the built environment and health fields to identify any further potentially eligible documents.

The search terms used were adapted from recent systematic reviews of the built environment and health (Durand *et al.*, 2011; Mackenbach *et al.*, 2014; Renalds, Smith & Hale, 2010) and are divided into three word groups relating to 'built environment characteristics', 'health outcomes' and 'study type' (see Table 1 for details).

Table 1. Search terms

Built environment characteristics	Built environment OR neighbourhood design OR housing OR healthy food OR natural and sustainable environment OR transport* OR smart growth OR urban planning OR urban environment OR physical environment OR spatial planning OR food availability OR food environment OR open space OR outdoor* OR countryside OR nature OR allotment OR air quality OR air pollution OR construction facility OR design OR planning OR land use mix or residential OR walkability OR traffic OR green space OR social mix OR housing mix OR salutogenic environments OR liveable environments OR urban design OR cycle networks OR cycle provision OR pedestrian provision OR car-free developments OR home zones
	AND
Health outcomes	Health outcome OR health OR health gain* OR injury preven* OR accident OR physical health OR mental health OR emotional health OR blood pressure OR physical activity OR diet OR activ* OR exercise OR nutrition OR energy intake OR obes* or overweight OR fruit and vegetable OR cardiovascular OR CVD OR suicide OR violence OR disorder OR road safety OR wellbeing OR well-being OR disability OR sedent* OR moderate-to-vigorous physical activity OR MVPA or weight status OR walking OR cycling or road traffic collision OR RTC or RTA or alcohol
	AND
Study type**	Systematic review OR meta-analys*

Note. *=Truncation; **=This word grouping only applied to the search for existing systematic reviews in electronic databases. Search terms words for ‘Built environment characteristics’ alone were searched on the websites of relevant stakeholder organisations.

Inclusion and exclusion criteria

Existing quantitative systematic reviews and stakeholder reviews were eligible for inclusion in this umbrella review. Qualitative systematic reviews were excluded as we wished to focus on the best available evidence on causal links from the perspective of the public health hierarchy of evidence (see Figure 2). The findings of this umbrella evidence review are for public health professionals, and quantitative evidence is still considered by the public health profession to be the most appropriate approach for determining causality.

Figure 2. Public health hierarchy of evidence

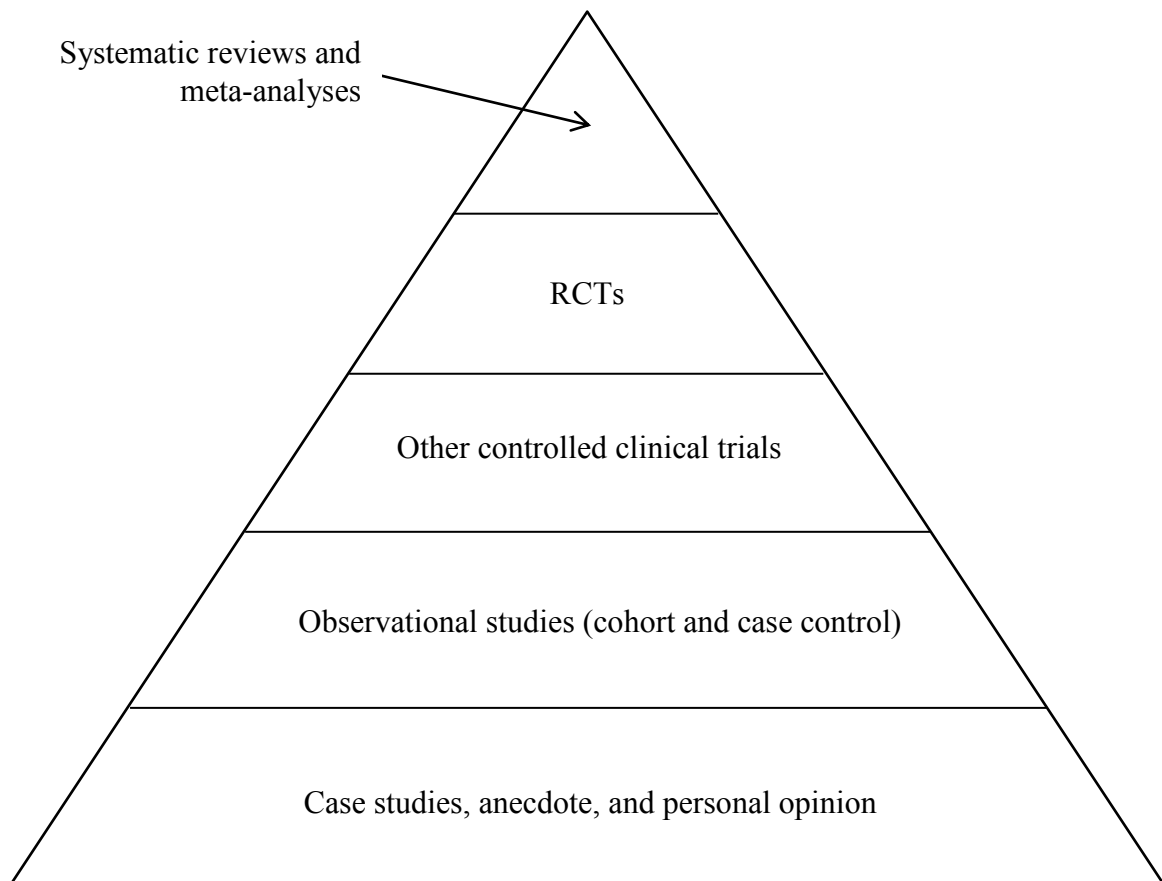


Figure adapted from Greenhalgh *et al.*, (2014).

We also excluded primary empirical studies as the umbrella review aimed to provide an overview of the built environment and health evidence base as opposed to examining the results from individual studies. In line with previous umbrella reviews (Bambra *et*

al., 2010; Cairns *et al.*, 2015; Horodyska *et al.*, 2015), existing systematic reviews were required to meet the Database of Abstracts of Reviews of Effects (DARE) criteria: (1) inclusion of a defined research question and (2) a search strategy including at least one named database, in conjunction with either reference checking, hand searching, citation searching or contact with authors in the field.

Papers that did not report on at least one of the five built environment topics and their association with health outcomes were excluded from this review. If a paper presented separate findings on more than one of the five built environment categories covered by this review or more than one health outcome, these were assessed separately. All health outcomes (physical and mental health) were considered for inclusion in this review.

We included existing systematic reviews and stakeholder documentation relating to adults and children from high and middle-income countries (Europe, North America, Australasia, and Japan). Searches were limited to English-language publications.

Potentially eligible papers were initially screened for inclusion by the project researcher according to the relevance of title and abstract. A sample of search results was independently assessed for inclusion by the project manager to check the validity of inclusion and exclusion decisions. There were no cases of disagreement between the researcher and project manager.

Data extraction

Descriptive data from each included paper were extracted (e.g., author, year of publication, population of interest, health outcome(s), quality of available evidence, and key findings).

Data extraction was conducted by the project researcher and the project manager. A sample was then independently assessed, with the project researcher and the project manager reviewing each other's work. There were no cases of disagreement between the researcher and project manager.

Quality assessment

1) *Quality of review level evidence*

The Methodological Quality Checklist (MQC) (Bambra *et al.*, 2009), a 7-item appraisal tool, was used to assess the quality and strength of each systematic review included in analyses (see Box 1). Each review was rated from 0-7, with those scoring 4 or more deemed moderate to high quality evidence and included in our umbrella review.

Reviews scoring 3 or fewer were excluded from the final analyses. The checklist was used to highlight variations in the reviews and assess the reliability and validity of the reviews. The MQC has been used in previous umbrella reviews of the built environment and health (Bambra *et al.*, 2009; Cislak *et al.*, 2012; Horodyska *et al.*, 2015).

At the time of writing there was no recognised measure for assessing the quality of stakeholder organisation documentation. For the purposes of this umbrella review we assessed the quality of stakeholder documentation using an adapted version of the MQC, the Methodological Quality Checklist for Stakeholder Documents and Position Papers (MQC-SP), developed for a recent umbrella review of diet and physical activity interventions and policies (Horodyska *et al.* 2015). In accordance with the MQC-SP, stakeholder organisation documentation scoring 4 or more were considered to be moderate to high quality evidence and were included in our umbrella review. However, documentation scoring 3 or fewer was excluded from the final analyses (see Box 1).

Quality assessment was conducted by the project researcher and the project manager. A sample was then independently assessed, with the project researcher and the project manager reviewing each other's work. There were no cases of disagreement between the researcher and project manager.

Box 1. Quality assessment checklists

Methodological Quality Checklist (MQC)	Methodological Quality Checklist for Stakeholder Documents and Position Papers (MQC-SP)
Is there a well-defined question?	Is there a major stakeholder involved?
Is there a defined search strategy?	Is there a well-defined aim?
Are inclusion/exclusion criteria stated?	Is there a robust methodology?
Are the primary study designs and number of studies clearly stated?	Quality evaluation on analysed material applied?
Have the primary studies been quality assessed?	Have the included materials been appropriately synthesised?
Have the studies been appropriately synthesised?	Has more than one stakeholder been involved at the process?
Has more than one author been involved at each stage of the review process?	

2) Quality of empirical evidence informing each review

For the purposes of this review, the quality rating of the empirical primary studies informing each review was based on the rating allocated by the original authors of each review. In some reviews, a quality rating was not provided by the original authors. In such instances, a quality rating code of 'not reported' was allocated to a review to indicate that the quality of evidence was unclear as it has not been assessed and/or reported. The quality of the evidence in each review was therefore grouped into one of four categories:

- High quality
- Medium quality
- Low quality
- Not reported

Synthesis of the data

1) Generation of 'planning principles'

To synthesise evidence generated from each individual review, findings were initially grouped according to modifiable feature. Modifiable features are defined as features of the built environment that, if altered in some way, may impact upon people's behaviours or lifestyles, and/or health outcomes. For example, with regard to housing, we identified that improved residential lighting (a modifiable feature) is associated with improved social outcomes (behavioural impact) and reduced fall-related injuries among older adults (health outcome).

Each modifiable feature was then categorised into one of a series of planning principles related to the five topic areas under review. For example, the modifiable feature 'improved residential lighting' was grouped into the overarching planning principle 'improve quality of housing'.

In some cases, we identified 'gaps' in the evidence (i.e., areas/issues for which there was no review level evidence that met our inclusion criteria for this umbrella review). It is important to note that although for some built environment areas/issues no review level evidence was found and/or no evidence has yet been systematically reviewed, this does not mean that the built environment area/issue does not exist or is not important. In response to this, when we identified a 'gap' in the review level evidence, we searched for references to relevant empirical studies. Notably, however, caution is advised when viewing these studies as they were hand-picked examples and they were not subject to the same quality assessment procedures as the review level evidence.

The terminology used to describe each planning principle was discussed and agreed by the research project team and with wider advisory and stakeholder groups to ensure that both public health and built environment practitioners could interpret and use the evidence in their own disciplinary context.

2) Supporting evidence

Each of the planning principles was based on evidence identified as part of this umbrella review. In the interests of transparency and to demonstrate how each of the planning principles was identified from the original evidence base, we summarised the evidence, including references and reported on the quality of the available evidence in the form of supporting evidence statements.

Built environment and health diagrams

Following data synthesis, the findings from the umbrella review of five built environment topic areas were converted into five diagrams designed to illustrate the strength and quality of evidence between the built environment and health. The aim of the diagrams is to provide a one page resource to enable public health and planning professionals to identify positive actions in the planning sphere that may improve health and wellbeing. For this reason, when constructing the diagrams for each category we focused on planning principles and modifiable features within the built environment that may have a 'positive' impact on health impacts/outcomes (e.g., reduced exposure to environmental hazards and improved air quality). This means that 'negative' findings (e.g., increase exposure to air pollution is associated with poorer respiratory outcomes) are not included within the diagrams as they do not fit within our 'positive' framework. However, it is important to note that any 'negative' evidence has been included within the overall findings of the review.

The diagrams are designed to be read from left to right, with users moving from **Planning Principles** (agreed good planning principles) to **Modifiable Features** (positive actions that can be taken within each planning principle in order to try and improve health and wellbeing), to **Impact** (changes in behaviour and other areas that might affect health outcomes), and finally to **Health Outcomes** (measurable health impacts). Strength of evidence is indicated by thickness of arrow, and evidence relating to specific population groups is highlighted.

In some instances, the evidence suggested that changes to a modifiable feature can lead to an impact, which then, in turn leads directly to a health outcome. However, in the most part, the available evidence for a causal relationship between an impact and direct health outcomes was unclear and/or unexplored in the literature. As such, we have not inferred potential causal relationships between impacts and health outcomes. We only report instances where a causal link between impacts and health outcomes has been clearly reported in the available review level evidence.

Although the diagrams are designed to be suitable for both public health and planning professionals, the primary target audience are public health professionals working in local authority settings. Detailed evidence tables enable users to quickly interrogate the evidence summarised in the diagrams.

The diagrams and detailed evidence provided are flexible in that they can be used for an overview of the evidence on the built environment and health, or as a standalone resource focused on one of the five areas of the built environment specifically addressed in this umbrella review.

References

Bambra, C., Gibson, M., Sowden, A., Wright, K., Whitehead, M., & Petticrew, M. (2009). Working for health? Evidence from systematic reviews on the effects of health and health inequalities of organisational changes to the psychosocial work environment. *Prev Med*, *48*, 454-461.

Bambra, C., Gibson, M., Sowden, A., Wright, K., Whitehead, M., & Petticrew, M. (2010). Tackling the wider social determinants of health and health inequalities: evidence from systematic reviews. *J Epidemiol Community Health*, *64*, 284-291.

Becker, I., & Oxman, A. (2008). Overviews of reviews. In: Higgins, J., Green, S., (eds). *Cochrane Handbook for Systematic Reviews of Interventions*. Chichester: John Wiley & Sons Ltd, 607-632.

Cislak, A., Safron, M., Pratt, M., Gaspar, T., & Luszczynska, A. (2012). Family-related predictors of body weight and weight-related behaviours among children and adolescents: A systematic umbrella review. *Child Care Health Dev*, 38 (3), 321-331.

Chow, C.K., Lock, K., Teo, K., Subramanian, S.V., McKee, M., & Yusuf, S. (2008). Environmental and societal influences acting on cardiovascular risk factors and disease at a population level: A review. *Int J Epidemiol*, 38 (6), 1580-1594.

Durand, C.P., Andalib, M., Dunton, G.F., Wolch, J., & Pentz, M.A. (2011). A systematic review of built environment factors related to physical activity and obesity risk: implications for smart growth urban planning. *Obesity Reviews*, 12, 173-182.

Greenhalgh, T. (2014). *How to read a paper: The basics of evidence-based medicine, 5th Edition*. BMJ Books.

Horodyska, K., Luszczynska, A., van den Berg, M., Hendriksen, M., Roos, G., De Bourdeaudhuij, & Brug, J. (2015). Good practice characteristics of diet and physical activity interventions and policies: an umbrella review. *BMC Public Health*, 15:19.

Ioannidis, J.P. (2009). Integration of evidence from multiple meta-analyses: a primer on umbrella reviews, treatment networks and multiple treatments meta-analyses. *CMAJ*, 181, 486-493.

Joanna Briggs Institute. (2014). *Joanna Briggs Institute Reviewers Manual 2014*. [Accessed online 6 January 2016 from [http://joannabriggs.org/assets/docs/sumari/ReviewersManual-methodology-JBI Umbrella%20Reviews-2014.pdf](http://joannabriggs.org/assets/docs/sumari/ReviewersManual-methodology-JBI%20Umbrella%20Reviews-2014.pdf)].

Khangura, S., Konnyu, K., Cushman, R., Grimshaw, J., & Moher, M. (2012). Evidence summaries: the evolution of a rapid review approach. *Systematic Reviews*, 1:10.

Mackenbach, J.D., Rutter, H., Compennolle, S., Glonti, K., Oppert, J., Charreire, H., De Bourdeaudhuij, I., Brug, J., Nijpels, G., & Lakerveld, J. (2014). Obesogenic environments:

a systematic review of the association between the physical environment and adult weight status, the SPOTLIGHT project. *BMC Public Health*, 14: 233.

Renalds, A., Smith, T.H., & Hale, P.J. (2010). A systematic review of built environment and health. *Fam Community Health*, 33, 68-78.

Theodoratou, E., Tzoulaki, I., Zgaga, L., & Ioannidis, J.P. (2014). Vitamin D and multiple health outcomes: umbrella review of systematic reviews and meta-analyses of observational studies and randomised controlled trials. *BMJ*, 348:g2305.

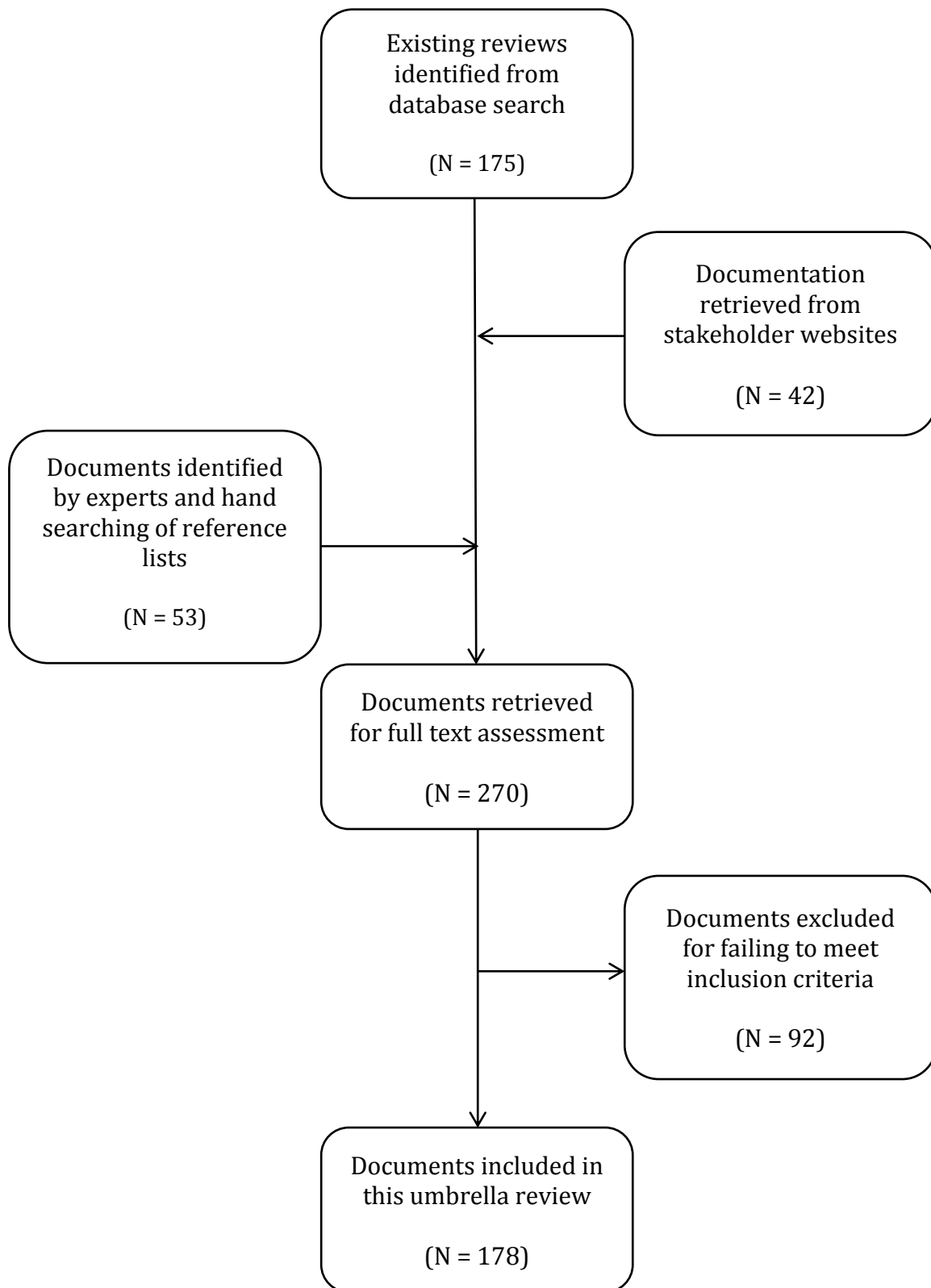
Appendix B: Umbrella review results

A total of 270 evidence reviews were compiled from the comprehensive database search, the stakeholder website search, reference lists of included papers, and feedback from experts working in built environment or public health fields (see Figure 3 for umbrella review flowchart).

In all, 178 studies met the inclusion criteria with the following studies grouped according to topic area:

- Neighbourhood design (N = 44)
- Housing (N = 21)
- Healthier food environment (N = 20)
- Natural and sustainable environment (N = 63)
- Transport (N = 30)

Figure 3. Umbrella review flowchart



Appendix C. Detailed evidence: Neighbourhood design

Table 2. Quality assessment of systematic review evidence

First author	Research question ^a	Search strategy ^b	Inclusion/exclusion criteria ^c	Study details ^d	Quality assessment ^e	Synthesis ^f	Independent review ^g	Score (0-7)
Annear	N	Y	Y	N	Y	Y	Y	5
Beard	Y	Y	Y	N	Y	Y	N	5
Beyer	Y	Y	Y	Y	Y	Y	N	6
Bonell	Y	Y	Y	Y	Y	Y	Y	7
Boothe	Y	N	Y	Y	Y	Y	Y	6
Bowler	Y	Y	Y	N	N	Y	N	4
Cairns	Y	Y	Y	Y	Y	Y	Y	7
Casey	Y	Y	Y	Y	N	Y	Unclear	5
Clark	Y	Y	N	N	Y	Y	Y	5
D'Haese	Y	Y	Y	Y	Y	Y	Y	7
Davison	Y	Y	Y	N	Unclear	Y	Y	5
Dunton	Y	N	Y	Y	N	Y	Unclear	4
Durand	Y	Y	Y	Y	N	N	Y	5
Faulkner	Y	Y	Y	Y	N	Y	Unclear	5
Fraser	Y	Y	Y	Y	Y	Y	N	6
Gascon	Y	Y	Y	Y	Y	Y	Y	7
Gomez	Y	Y	Y	Y	Y	Y	N	6
Grasser	Y	Y	Y	Unclear	Y	Y	Y	6
Hahn	Y	Y	Y	Y	Y	Y	Y	7
Hajna	Y	N	Y	Y	N	Y	N	4
Hunter	Y	Y	Y	Y	Y	Unclear	Y	6
Kabisch	Y	Y	Y	N	N	Y	N	4
Kim	Y	N	Y	Y	N	Y	N	4
Larouche	Y	Y	Y	Y	Y	Y	Y	7
Leavsseur	Y	Y	Y	Y	N	N	Y	5
Lorenc	Y	Y	Y	Y	Y	Y	Y	7
McCormack	Y	Y	Y	Y	N	Y	N	5
Mueller	Y	Y	Y	Y	N	Y	Y	6
Papas	Y	Y	Y	Y	N	Y	Unclear	5
Penkella	Y	Y	Y	Y	N	N	N	4

Rothman	Y	Y	Y	Y	Y	Y	Y	7
Schüle	Y	Y	Y	Y	N	Y	N	5
Soon	Y	Y	Y	Y	Y	Y	N	6
Soril	Y	Y	Y	Y	Y	Y	Y	7
Thompson Coon	Y	Y	Y	Y	Y	Y	Y	7
Vienneau	Y	Y	Y	Y	N	Y	Unclear	5
Yen	N	Y	Y	Y	Y	Y	N	5

Note. (a) = Is there a well-defined question? – The question should define at least the participants, the intervention, the outcomes and the study designs; (b) = Is there a defined search strategy? – The search strategy should include at least one named database combined with reference checking, hand searching, citation, follow-up or expert contact; (c) = Are inclusion / exclusion criteria stated? – The review should make the grounds for study inclusion and exclusion transparent in terms of participants, intervention, outcomes and study design; (d) = Are the primary study designs and number of studies clearly stated? – The review should outline the designs of included studies and make it clear which and how many studies are in the final synthesis; (e) = Have the primary studies been quality assessed? – The review should clearly describe the quality assessment process, which quality appraisal tool is used, and the relative quality of each included study; (f) = Have the studies been appropriately synthesised? – The review should use meta-analysis or narrative synthesis, whichever is most suitable given the heterogeneity of studies and their methodological quality. If studies are very heterogeneous, narrative synthesis is appropriate; (g) = Has more than one author been involved at each stage of the review process? – To minimise bias, the review should have at least two reviewers involved in each stage (study selection, data extraction, quality appraisal, synthesis) of the review.

Table 3. Quality assessment of stakeholder documentation

First author / title	Stakeholder involvement ^a	Well-defined aim ^b	Robust methodology ^c	Quality assessment ^d	Synthesis ^e	Independent review ^f	Score
Design Council – CABE, Urban Green Nation 2010	Y	Y	Unclear	Unclear	Unclear	N	2
Design Council – CABE, Community Green 2010	Y	Y	Unclear	N	Unclear	N	2
RIBA City Health Check, 2013	Y	N	Unclear	N	N	N	0
RTPI / Promoting healthy cities	Y	N	Unclear	Unclear	Unclear	N	1
Sport England / Active design	Y	Y	Unclear	N	Unclear	Y	3
WHO Soc Dets of Health – the urban dimension & the role of Las. 2012	Y	Y	Y	Y	Y	Unclear	5
WHO Tackling Obesity healthy residential environments 2007	Y	Y	Y	Unclear	Y	Y	5

Note. (a) = Is there a major stakeholder involved? – The document is developed/endorsed by (1) a nationwide or international organisation which is issuing recommendations or guidelines which are used in clinical practice; or (2) an interdisciplinary or cross-country consortium aiming at providing progress in the discipline or practice for a respective health outcome; (b) = Is there a well-defined aim? – The document specifies the aim of the paper, target population(s), type of actions and their breadth and the respective health outcome; (c) = Is there a robust methodology? – The methods should list the sources used to obtain comprehensive and heterogeneous data, such as literature review and analysis of several examples of published and unpublished documents; (d) = Quality assessment of analysed materials applied? – The document refers to the quality assessment of the included material and/or refers to quality assessment measures or methods; (e) = Has the included material been appropriately synthesised? – The synthesis of analysed material addresses the heterogeneity of the analysed data; provides specific conclusions; conclusions are supported by analysed material; the key constructs are clearly operationalised; (f) = Has more than one organisation/stakeholder been involved in the process? – To minimise bias, conclusions were based on involvement and consensus achievement by at least two stakeholder/multiple researchers from different organisations.

Table 4. Description of systematic reviews and stakeholder documentation included within this umbrella review

First author, year of publication	Type of paper^a	Number of original studies	Design of original studies^b	Population	Health outcome(s)	Location(s)	Synthesis method	Quality of the evidence^c
Annear, 2014	1	83	C-S, L, RCT, Qual	Older adults	Physical and mental health, and activity participation	HICs	Narrative	Poor/moderate
Beard, 2010	1	51	C-S, L	Older adults	Large range of physical and mental health outcomes	unclear	Narrative	Poor/moderate
Beyer, 2009	1	17	cBA	General	RTCs, Injuries, road traffic speed	USA-10, UK-4, Australia-2, Germany-1	Meta-analysis	Low
Bonell, 2013	1	10	RCT, Q	School communities	Physical and mental HWB, health behaviours, health promotion outcomes	US, UK	Narrative	Moderate
Boothe, 2014	1	9	Case-C, and unclear	children	Childhood cancer, leukaemia	HICs	Narrative and meta-analysis	Moderate
Bowler 2010	1	47	Unclear (mostly observational)	Whole population	Air temperature (climate change mitigation)	Worldwide (3 UK studies)	Narrative plus meta-analysis	Poor / moderate
Cairns, 2014	1	5	S-R	All ages	Health and socio-economic status outcomes	UK-4	Narrative	Moderate-high
Casey, 2014	1	25	C-S, L	Boys and girls	Weight status and childhood obesity	USA, Australia	Narrative	N/R
Clark, 2007	1	99	C-S, Qual (n=1), reviews	Adults, children, older adults	Mental health	HICs	Narrative	Poor/moderate
D'Haese, 2015	1	68	C-S, C-C	6-12 year	Walkability	North America,	Narrative	High

						Europe.		
Davison, 2006	1	33	C-S, L	Children age 3-18 years	Physical activity	USA, UK, Portugal, Canada, Australia,	Narrative	N/R
Dunton, 2009	1	15	C-S	Children and Adolescents	Obesity	USA, Canada	Semi-quantitative procedure	N/R
Durand, 2011	1	44	C-S, L, quasi-L	Adults, children	Physical activity, obesity	HICs	Narrative	Poor/moderate
Faulkner, 2009	1	13	C-S	Children	Physical activity, body weight	USA, Philippines, Australia, UK-4, Denmark-2, New Zealand-1	Narrative	N/R
Fraser, 2011	1	21	C-S, L, Qual	Adults, children	Cycling prevalence	HICs (mostly US)	Narrative	Moderate - low
Gascon, 2015	1	12	Eco, C, CS	Adults and children	Mortality-related outcomes	UK, US, Oceania, Canada, Lithuania	Narrative	Moderate/High
Gomez, 2015	1	8	C-S, L, C-C, RCT, CR-CS	Adults, children	Physical activity	HICs, Latin America	Narrative	Moderate
Grasser, 2013	1	34	Unclear	Health white adults >19 years	Walking, cycling, weight-related measures	N/R	Narrative	Moderate-high
Hahn, 2005	1	43	Time-series, C-S, C-C	Adults, children	violent crimes, suicide, unintentional firearm injury	US	Narrative	Low
Hajna, 2015	1	6	unclear	adults	Walking	Europe, Asia	Narrative and meta-analysis	Unclear
Hunter, 2014	1	12	Q-11, RCT-1	General	Physical activity	USA-9, Australia-3	Narrative	Low

Kabisch, 2015	1	30	N/R	Any	Any health and wellbeing	UK, USA, Sweden, Canada, Germany, Netherlands	Narrative	N/R
Kim, 2008	1	28	RCT, Q, C-S, L	Adults	depression	North America	Narrative	Unclear
Larouche, 2014	1	73	C-S, RCT, C-C	N/R	Physical activity, cardiovascular fitness	UK, USA, Sweden, Denmark, Portugal, Philippines	Narrative	Moderate
Leavasseur, 2015	1	50	C-S, Qual.	Older adults	Mobility & social participation	HICs	Narrative	Unclear
Lorenc, 2013	1	47	Cba, uBA	General population	Perception of fear and crime	UK-36, USA-10, Netherlands-1	Narrative	Low
McCormack 2011	1	33	C-S, Q	Mainly adults	Physical activity	HICs (mostly US, 1 UK)	Narrative	Moderate
Mueller, 2015	1	30	HIA, CBA	N/R	Known health impact	USA, Netherlands, Spain, UK, Australia, Norway	Narrative	N/R
Oja, 2011	1	16	C-S, Case-C, C-C, RCT	General population	Cardiorespiratory fitness, cardiovascular risk factors, all-cause mortality	Germany, Australia, Denmark, UK, China, USA	Narrative	Low-4 Moderate-5 Strong-7
Papas, 2007	1	20	CS, L	Children and adults	Obesity	US, Australia and Europe	Narrative	N/R
Penkella, 2014	1	11	C-S	Adults, children	Mental health	Europe	Narrative	Poor
Rothman, 2015	1	85		Children age 0-12	Safe walking, child pedestrian injury	Western Europe, Australia,	Narrative	Low to moderate

						Japan, North America, New Zealand		
Schüle, 2015	1	33	CS	Adults, students and life births	Physical activity, overweight, health behaviour, child health	USA-14, Belgium-3, Australia-1, Canada-5, Germany-2, Sweden-1, Britain-1	Qualitative synthesis	N/R
Soon, 2012	1	40	C-C, L	Not specified	Crohn's Disease, ulcerative colitis	Worldwide	Narrative and meta-analysis	Low
Soril, 2014	1	5	Comparative cohort	Residents with dementia in long-term care settings	Management of behavioural and psychological symptoms of dementia	Australia-3, Canada-1, UK-1, USA-1	Narrative	Low-moderate
Thompson Coon, 2011	1	11	RCT, L	General population, mean age 25.22	Mental health	USA, Australia, Switzerland	Narrative	Moderate
Vienneau, 2015	1	10	Case-C, Cohort,	Male and female	Ischemic heart disease	Europe	Meta-analysis	N/R
Xu, 2013	1	19	C-S, S-R,C-S	Children and adults	Body weight, cardiovascular health, cancer, mental health and injury	Unclear	Narrative	Mixed (low, moderate and high)
Yen, 2009	1	33	C-S, L	Older adults	Large range of physical and mental health outcomes	HICs (mostly US)	Narrative	Moderate

Note. (a) 1 = systematic reviews, 2 = stakeholder documentation; (b) RCT = Randomized controlled trial, CR-CS = Controlled repeat cross-sectional, Q = Quasi-experimental, C-C = Controlled-cohort, C-T= Controlled trial; C-S=Cross-sectional, Case-C=case control, uBA= uncontrolled before and after Study, cBA= uncontrolled before and after Study, S-R=Systematic review, HIA= Health Impact Assessment, CBA= Cost Benefit Analysis (c) high, moderate, low based on authors assessment of study quality Qual = qualitative, B-A = before after.

Table 5. Main findings from systematic reviews and stakeholder documentation included within this umbrella review

First author, year of publication	Main findings	Quality of the review ^a
Annear, 2014	Environmental conditions associated with the health and activity participation of older adults include perceptions of local safety and security, traffic conditions, pollution and environmental hazards, noise and lighting levels, access to natural areas and public green space, neighbourhood stability, social capital or neighbourliness.	5
Beard, 2010	While evidence is building to support environmental determinants of older people's health, few of these studies can yet point to specific pathways that may be amenable to intervention. Strategies to foster social engagement of older people through improving access to buildings and public transport, improving walkability, creating destinations that encourage older people to leave their homes, and developing innovative technology such as web-based networking and videoconferencing appear justified.	5
Beyer, 2009	A review of 17 controlled before-after studies on the effectiveness of street lighting in preventing crashes found positive evidence (low quality) for the effectiveness of street lighting in preventing road traffic crashes, injuries and fatalities	6
Bonell, 2013	The main findings with regards to the physical school environment was that there is not currently strong evidence for the effects of interventions to improve school play areas, despite a consistent suggestion that these interventions have potential and may be more effective for younger children during longer breaks.	7
Boothe, 2014	A positive and significant association between childhood leukaemia and high residential traffic exposure during the postnatal period was observed; no association was found for traffic exposure during the prenatal period.	6
Bowler 2010	Findings broadly support the hypothesis that greening (particularly trees) can cool the environment, at least at a local scale. The review was however not able to demonstrate exactly how green infrastructure should be designed in terms of the abundance, type and distribution of greening. On average, an urban park would be around 1 °C cooler than a non-green site, and larger parks are cooler. However, this evidence is mostly based on observational data of existing green spaces.	4
Cairns, 2014	Authors performed an umbrella review of 5 systematic reviews to assess the link between 20 mph zones and health/ health inequalities. 4 of the 5 systematic reviews included were of good quality while the fifth was of moderate quality. Evidence strongly supports that 20 mph zones are effective in reducing accidents and injuries. However, no direct evidence of impact of 20 mph limits on health inequalities	7
Casey, 2014	25 studies were reviewed to evaluate the relationship between built environment features and weight status among youths. 8 out of 10 papers (including 1 longitudinal study) reported that neighbourhood walkability was inversely associated with overweight. Access to recreational facility was also inversely linked with obesity and overweight.	5
Clark, 2007	Consistent association found between urban birth and schizophrenia, as well as an association between rural residence in adulthood and suicide rates for males, but not females. Some evidence for an effect of chronic noise exposure on mental health in adults. The evidence for an effect of poor housing on mental health was weak.	5

D'Hease, 2015	A review of 65 studies to determine the environmental characteristics and different contexts of active transports in 6 -12 year olds across different countries. Active transport (walking or cycling) to school was positively associated with walkability (land use mix, residential density and street connectivity). Walking to school was positively associated with walkability, density and accessibility. Association between traffic safety and all forms of active transportation to school was positive. No convincing evidence was found for associations between the physical environment and active transportation during leisure.	7
Davison, 2006	Presence of recreational infrastructure was associated with physical activity among children. However, findings were less consistent.	5
Dunton, 2009	15 studies were reviewed to examine the association between the built environment and obesity in children. Access to equipment and facilities, neighbourhood pattern and urban sprawl were associated with obesity in adolescents. Association between the environment and obesity in children differed by demographic characteristics of children. Children from low-socioeconomic status families were reported to have lower BMI than children from high income families	4
Durand, 2011	Evidence from predominantly cross-sectional research (high risk of bias) suggests that communities which have diverse housing types, mixed land use, increased housing density, development which is directed toward existing communities, and increased levels of or access to natural space and critical environmental areas may show increases in walking and physical activity among residents who are exposed to these characteristics.	5
Faulkner, 2009	This article reviewed 13 studies to assess the association between active school transport and weight related outcomes among children and youth. 11 out of 13 studies found that active school commuters were more physically active than passive commuters. However, evidence of association between active transport to school and body weight in children was inconclusive as only 1 study out of 10 showed a positive association between active school transport and reduction in body weight. Over-reliance on cross-sectional studies	5
Fraser, 2011	The environmental factors identified as being positively associated with cycling included presence of dedicated cycle routes or paths, separation of cycling from other traffic, high population density, short trip distance, proximity of a cycle path or green space and for children projects promoting 'safe routes to school'. Negative environmental factors were perceived and objective traffic danger, long trip distance, steep inclines and distance from cycle paths.	6
Gascon, 2015	This review explored the relationship between exposure to green and blue spaces and mental health outcomes. 28 studies were eligible and subsequently reviewed. 22 studies evaluated the mental health benefits of surrounding greenness. Among studies of children, 1 (in 4) was associated with reduced emotional and behavioural problems. Overall, however, due to the limited available evidence, the causal relationship was deemed inadequate. For adults, most studies observed a reduced risk of poor mental health with increasing surrounding greenness. Overall, the evidence was classed as limited. Evidence for access to green spaces for studies of adults and children was considered inadequate, as was evidence on the influences of the quality of green and blue spaces.	7
Gomez, 2015	Attributes of urban environments that are associated with increased physical activity include the availability	6

	of public transportation, land-use mix, bicycle infrastructure, short distance of trips, availability of public recreational facilities, and traffic safety. Promising evidence was also found regarding the policies to increase public spaces for recreational physical activity. In Latin American cities, the Ciclovía and BRT projects seem to promote PA.	
Grasser, 2013	34 studies were reviewed to explore the association between GIS based measures of walkability and active transport. Population density, intersection density and walkability indexes were associated with measures of physical activity for transport but the association was inconsistent for weight-related outcomes.	6
Hahn, 2005	The evidence about the effectiveness of firearms laws in preventing violence was insufficient to determine the effectiveness of any of the firearms laws reviewed singly or in combination.	7
Hajna, 2015	Adults living in high compared to low walkable neighbourhoods accumulated 766 more steps per day (95 % credible interval 250, 1271). This accounts for approximately 8 % of recommended daily steps.	4
Hunter, 2014	12 studies were included in review of intervention to promote physical activity in urban green space. Built environment only interventions were effective (4/9 studies) in encouraging use and increasing physical activity in urban green space. However, the evidence was stronger (3/3) for interventions that combined physical activity initiatives with improvement in built environment. Improving the quality of urban green space significantly increased visitation and level of physical activity	6
Kabisch, 2015	This review explored human-environment interactions in urban green spaces. The reporting of the impact of green spaces on health and wellbeing is limited in this review, with no information provided on study designs and specific populations under investigation. Thirty papers were assessed the impact, with authors summarising that results from studies are often contradictory and based on self-reported outcomes. Generally urban green spaces were found to have a positive impact on health outcomes, but there were findings that did not identify a link between green space availability and general health.	4
Kim, 2008	Few studies of physical neighbourhood conditions and depression. Evidence of harmful effects of neighbourhood social disorder, and protective effects for neighbourhood SES.	4
Larouche, 2014	Moderate quality evidence to show that active school transport interventions leads to increase in physical activity. 54/68 studies were cross-sectional. The evidence for the effectiveness of active school transport for cardiovascular fitness is inconsistent and weak	7
Leavsseur, 2015	Mobility and social participation were both positively associated with proximity to resources and recreational facilities. Having access to a car or driver's license, public transportation and neighbourhood security were negatively associated with poor user-friendliness of the walking environment and neighbourhood insecurity.	5
Lorenc, 2013	47 studies were reviewed to examine the effectiveness of a variety of environmental interventions to reduce the fear of crime. Home security improvement and none-crime related environmental improvements (cleaning and repainting of bus station, installation of gym equipment's in parks) were effective in reducing indications of fear and crime. The effectiveness of light improvement and CCTV interventions on perception of crime was minimal.	7
McCormack 2011	Land use mix, composite walkability and neighbourhood type were consistently associated with higher	5

	physical activity levels even after controlling for neighbourhood self-selection. The built environment was found to be more supportive of walking and cycling than of physical activity more generally. Evidence from quasi-experimental studies suggests changes in the built environment can precede changes in physical activity (increased cyclist activity after the instalment of cycling infrastructure, increased walking, cycling, and other physical activity after instalment of a greenway trail, increased pedestrian activity following instalment of street lighting and increased first time park user following park upgrades).	
Mueller, 2015	Studies included in this review applied different HIA methodologies, yet findings suggest that active transport can provide considerable net health benefit regardless of geographical context. Increase in physical activity levels from active transport policies or intervention was shown to exceed any the adverse effect of traffic incidents and air pollution	6
Oja, 2011	Cross-sectional and longitudinal evidence showed association between cycling and cardiovascular fitness in youth. 6 studies found consistent dose-response gradient between amount of time spent on cycling and health gain. High strength of association for the link between cycling and cardiorespiratory fitness in adults (2 high quality RCTs and 1 high quality CCT), moderate association between cycling and reduction in cardiovascular risk factors, inconclusive for all course mortality, cancer risk, overweight and obesity	7
Papas, 2007	There was a statistically significant association between distance to a recreational facility and increased risk of obesity among adults	5
Penkella, 2014	Associations were observed between living in a European City environment mood and anxiety disorders, psychotic disorders, and substance abuse. However, which elements of the urban environment are significant could not be determined, causality cannot be inferred, and urbanicity was inconsistently defined.	4
Pirkis, 2015	The key approaches that are currently used as interventions at suicide hotspots (namely, restricting access to means, encouraging help-seeking, and increasing likelihood of intervention by third party) seem to be effective in averting suicides at these sites.	
Rothman, 2015	85 studies investigating built environment correlates of walking and pedestrian injury among children were reviewed. Traffic calming and presence of recreational facilities/playgrounds showed consistent association with more walking time and lower risk of pedestrian injuries. Other built environment features such as land mix use were associated with higher amount of time spent walking but also higher risks of injuries. Evidence in many of these areas were inconsistent. 94% of 'walking' studies were cross-sectional while 60% of pedestrian injury studies were cross-sectional.	7
Schüle, 2015	Majority of the studies (22/33) found an association between neighbourhood socioeconomic position and improved health of residents. No assessment of the quality of individual studies included in review. There was an over-reliance on cross-sectional studies	5
Soon, 2012	Living in urban environments may increase the risk of developing inflammatory bowel disease. Though, the strengths of association varied due to heterogeneity between studies. NB: Socioeconomic factors not controlled for in studies.	6
Soril, 2014	5 low to moderate studies were included in the systematic review to determine the effectiveness of built environment interventions in managing behavioural and psychological symptoms of dementia. 1(out of 2) study reported improvements in behavioural symptoms following change/redesign of existing physical	7

	space. The two studies that examined relocation to a novel living environment reported decreased or no difference in the severity and/or frequency of BPSD post-intervention. None of the studies suggest worsening of psychological or behavioural condition following a built environment intervention. However, built environment interventions were broad, evidence of the effectiveness of individual interventions was inconclusive.	
Sport England 2015	Active Design is a key guidance document intended to help unify health, design and planning by promoting the right conditions and environments for individuals and communities to lead active and healthy lifestyles. Ten principles of active design are outlined. Practical case studies and pointers to best practice are given.	3
Thompson Coon, 2011	The review found positive effects on self-reported mental wellbeing following exercise in natural environment compared to indoor exercise	7
Vienneau, 2015	10 studies were examined to evaluate the association between transportation noise exposure and risk of ischaemic heart disease. Meta-analysis revealed a 6% increase in ischemic heart disease per 10dB Lden increase in noise exposure	5
WHO Soc Dets of Health – the urban dimension & the role of LAs. 2012	<p>This WHO report draws upon the SDOH Commission Report and the Marmot Review to identify key principles of healthy cities; those of most relevance to this review are given below:</p> <ul style="list-style-type: none"> - promoting safe and sustainable places and communities, undertaking health equity impact assessment in urban planning and place shaping to inform new design and the regeneration of existing neighbourhoods; - Place shaping, incorporating good services, availability of high-quality housing, access to employment and a sense of safety and community, leading to high levels of social capital and personal and collective psychosocial well-being. <p>Also see in particular section 1.5.4: Neighbourhoods and facilities: Urban land-use patterns are one of the main influences on the levels of physical activity, especially among lower-income groups who get much of their physical activity through daily living activity and travel rather than recreation. Access to local facilities such as shops, schools, health centres and places of informal recreation are important for health and well-being, both for the physical activity taken in getting there and the social interaction on the way there or at the facilities. This is especially important for people who get much of their physical activity from walking rather than recreation. However, disadvantaged areas disproportionately experience the deteriorating features of an urban environment such as dilapidation, vandalism, graffiti and litter, leading to a sense of insecurity on streets and in parks and play areas. This means that people in these areas use these facilities less than elsewhere, and children are less likely to be let out to play. This leads to reduced physical activity and exacerbates health problems such as obesity. A secondary analysis of a cross-sectional survey of 12 cities in Europe found that respondents from areas with high levels of litter and graffiti were 50% less likely than respondents from areas with low levels to be physically active and 50% more likely to be overweight.</p>	5
WHO Tackling Obesity healthy residential environments 2007	<p><i>All population groups</i> Several factors in the residential environment positively affect physical activity behaviour, active living and the risk of overweight and obesity in all population groups:</p>	5

	<ul style="list-style-type: none"> • Perceived safety, including road safety and safety from or no fear of crime; • Aesthetically pleasing environments that are well-maintained and interesting to look at; • Short distances that enable people to get to and from places on foot or by bicycle, and to use public transport without spending too much time covering long distances; mixed land use, density and street connectivity facilitate short distances; • Accessibility to physical activity facilities and active transport opportunities (walking, cycling) and access to public transport. <p><i>Children and adolescents</i> For physical activity among children and adolescents, important residential environment factors are:</p> <ul style="list-style-type: none"> • Access to indoor and outdoor facilities for sports and play close to the home (e.g. parks, playgrounds, green spaces, sports clubs, sports facilities on school yards and kindergartens); • Perceiving the neighbourhood surroundings as interesting and friendly; and being able to safely walk or cycle to school and other destinations. <p><i>Older people</i> For physical activity among older people, important residential environment factors are:</p> <ul style="list-style-type: none"> • Convenient, walkable distances from the home to public facilities (businesses, stores, shopping malls); • An activity-friendly, pleasant neighbourhood with opportunities for safe walking for recreation and active transport (e.g. well-maintained pavements); and recreational facilities (parks, walking and cycle trails) in the vicinity of the dwelling. <p>There are a number of local community interventions addressing these factors, but only a few are adequately evaluated.</p>	
Xu, 2013	Active transport to work/school (walking, cycling or public transportation) showed significant association with improved cardiovascular health, this finding was consistent in 15 out of 16 studies. 3 out of 4 cross-sectional studies found that active travel to and from school was associated with lower BMI. 1 longitudinal study and 1 systematic review found strong evidence of inverse relationship between active transport and BMI. The evidence was mixed in two other systematic reviews and 1 narrative review. No strong evidence on active transport and mental health	7
Yen, 2009	Neighbourhood SES is consistently associated with health in older adults; The positive association between physical environment, perceived or objective, and physical activity behaviour was fairly consistent.	5

Note. (a) = total scores for MQC (systematic reviews): 1-3 = low quality, 4-5 = moderate quality, 6-7 = high quality or MQC-SP (for stakeholder documentation): 1-3 = low quality, 4-5 = moderate quality, 6 = high quality.

Appendix D. Detailed evidence: Housing

Table 6. Quality assessment of systematic reviews

First author	Research question ^a	Search strategy ^b	Inclusion/exclusion criteria ^c	Study details ^d	Quality assessment ^e	Synthesis ^f	Independent review ^g	Score
Aidala	Y	Y	Y	Y	Y	Y	Y	7
Bambra	Y	Y	Y	Y	Y	Y	Y	7
Bassuk	Y	Y	Y	Y	Y	Y	Y	7
Clark	Y	Y	N	N	Y	Y	N	4
DiGuseppi	Y	Y	Y	N	N	Y	N	4
Fitzpatrick-Lewis	Y	Y	Y	Y	Y	Y	Y	7
Garin	Y	Y	Y	Y	N	Y	N	5
Gibson	Y	Y	Y	Y	Y	Y	N	6
Krieger	Y	Y	Y	N	N	Y	N	4
Kyle	Y	Y	Y	Y	Y	Y	N	6
Leaver	Y	Y	Y	Y	Y	Y	Y	7
Lindberg	Y	Y	Y	N	N	Y	N	4
Lorenc	Y	Y	Y	Y	Y	Y	Y	7
Mansell	Y	Y	Y	Y	N	Y	N	5
McClure	Y	Y	Y	Y	Y	Y	Y	7
Nelson	Y	Y	Y	Y	N	Y	N	5
Reif	Y	Y	Y	Y	Y	Y	N	6
Sandel	Y	Y	Y	N	N	Y	N	4
Thomson 2009	Y	Y	Y	Y	Y	Y	Y	7
Thomson 2013	Y	Y	Y	Y	Y	Y	Y	7

Note. (a) = Is there a well-defined question? – The question should define at least the participants, the intervention, the outcomes and the study designs; (b) = Is there a defined search strategy? – The search strategy should include at least one named database combined with reference checking, hand searching, citation, follow-up or expert contact; (c) = Are inclusion / exclusion criteria stated? – The review should make the grounds for study inclusion and exclusion transparent in terms of participants, intervention, outcomes and study design; (d) = Are the primary study designs and number of studies clearly stated? – The review should outline the designs of included studies and make it clear which and how many studies are in the final synthesis; (e) = Have the primary studies been quality assessed? – The review should clearly describe the quality assessment process, which quality appraisal tool is used, and the relative quality of each included study; (f) = Have the studies been appropriately synthesised? – The review should use meta-analysis or narrative synthesis, whichever is most suitable given the heterogeneity of studies and their methodological quality. If studies are very heterogeneous, narrative synthesis is appropriate; (g) = Has more than one author been involved at each stage of the review process? – To minimise bias, the review should have at least two reviewers involved in each stage (study selection, data extraction, quality appraisal, synthesis) of the review.

Table 7. Quality assessment of stakeholder documentation

First author	Stakeholder involvement ^a	Well-defined aim ^b	Robust methodology ^c	Quality assessment ^d	Synthesis ^e	Independent review ^f	Score
WHO	Y	Y	Y	Y	Y	N	5

Note. (a) = Is there a major stakeholder involved? – The document is developed/endorsed by (1) a nationwide or international organisation which is issuing recommendations or guidelines which are used in clinical practice; or (2) an interdisciplinary or cross-country consortium aiming at providing progress in the discipline or practice for a respective health outcome; (b) = Is there a well-defined aim? – The document specifies the aim of the paper, target population(s), type of actions and their breadth and the respective health outcome; (c) = Is there a robust methodology? – The methods should list the sources used to obtain comprehensive and heterogeneous data, such as literature review and analysis of several examples of published and unpublished documents; (d) = Quality assessment of analysed materials applied? – The document refers to the quality assessment of the included material and/or refers to quality assessment measures or methods; (e) = Has the included material been appropriately synthesised? – The synthesis of analysed material addresses the heterogeneity of the analysed data; provides specific conclusions; conclusions are supported by analysed material; the key constructs are clearly operationalised; (f) = Has more than one organisation/stakeholder been involved in the process? – To minimise bias, conclusions were based on involvement and consensus achievement by at least two stakeholder/multiple researchers from different organisations.

Table 8. Description of systematic reviews and stakeholder documentation included within this umbrella review

First author, year of publication	Type of paper ^a	Number of original studies	Design of original studies ^b	Population	Health outcome(s)	Location(s)**	Synthesis method	Quality of the evidence ^c
Aidala, 2016	1	111	RCT, UC-C, Case-C	Studies including participants living with HIV or AIDS	Any health outcomes	USA, Canada, France, Spain, Italy, Finland, South Korea	Narrative	Moderate/High
Bambra, 2010	1	9*	SR	Adults	Impact on inequalities in health or wellbeing, overall health effect	USA	Narrative	Moderate
Bassuk, 2014	1	6	UR-CS, T-S	Studies including homeless families	Parental mental health, trauma, substance abuse	USA	Narrative	Low
Clark, 2007	1	99	L, C-S	Children, adolescents, adults	Any mental health and wellbeing outcome	32/99 in UK	Narrative	Low/Moderate
DiGuseppi, 2011	1	N/R	RCTs	General population / children	Safety and injury outcomes	N/R	Narrative	Low/Moderate
Fitzpatrick-Lewis, 2011	1	10	RCT, Q, UC-C, C-S	Studies including people who were homeless, marginally housed, or at risk of homelessness	Any health outcome	N/R	Narrative	Moderate

Garin, 2014	1	48	L, CS	Older adults	Any health outcome	HMIC	Narrative	Low/Moderate
Gibson, 2011	1	5*	SR	Interventions targeted at disadvantaged groups	Any health outcome	US, UK, New Zealand, Europe	Narrative	Moderate
Krieger, 2014	1	N/R	RCTs	Individuals with asthma	Asthma outcomes	N/R	Narrative	N/R
Kyle, 2008	1	29	RCT, Q UC-C, C-S	Adults with severe and persistent mental illness	Healthcare utilisation, health status, quality of life	USA, Canada, Denmark, Australia, New Zealand, England	Narrative	Moderate
Leaver, 2007	1	17	CR-CS, L, C-S	Studies including participants living with HIV or AIDS	Any health-related outcome	USA, EU, Canada, Australia, Ivory Coast	Narrative	Moderate
Lindberg, 2010	1	N/R	RCTs	N/R	Any health effects	N/R	Narrative	N/R
Lorenc, 2013	1	47	Cba, uBA	General population	Perception of fear and crime	UK-36, USA-10, Netherlands-1	Narrative	Low
Mansell, 2009	1	19	C-S, CR-CS	Studies including participants with an intellectual disability	QoL	UK, Ireland, Netherlands, Australia	Narrative	N/R
McClure, 2008	1	6	CBA	Older people (>65 years)	Changes in medically treated fall-related injuries	Australia, Denmark, Sweden, Norway, Taiwan	Narrative	Moderate
Nelson, 2007	1	16	E, Q	Studies including participants with mental illness who history of	Hospitalisation, healthcare utilisation	US	Narrative	N/R

				homelessness				
Reif, 2014	1	5	RCT, Q	Studies including participants with substance abuse or co-occurring mental and substance use disorders	Drug and alcohol use, psychiatric symptoms	US	Narrative	Moderate
Sandel, 2010	1	N/R	N/R	N/R	Health outcomes associated with exposure to chemical agents	N/R	Narrative	N/R
Thomson, 2009	1	40	RCT, C-C	N/R	Any health and illness-related outcome	N/R	Narrative	Moderate/High
Thomson, 2013	1	39	RCT, CR-CS, UR-CS, UBA, CBA Qual	Any	Any health-related outcome	Any region	Narrative and meta-analysis	Moderate
WHO, 2005	2	N/R	C-S, E	Any	Any health-related outcome	Developed countries	Narrative	Low/Moderate

Note. (a) 1 = systematic reviews, 2 = stakeholder documentation; (b) RCT = Randomised controlled trial, UBA = Uncontrolled before-and-after, CBA = Controlled before-and-after, CR-CS = Controlled repeat cross-sectional, Q = Quasi-experimental, C-C = Controlled-cohort, C-S = Cross-sectional, UR-CS = Uncontrolled repeat cross-sectional, N = Natural experiment; L = Longitudinal, UC-C Uncontrolled-cohort, Case-C = Case control, T-S, Time series, D = Descriptive, E = Experimental, SR = Systematic reviews, N/R = not reported; (c) = High, Moderate, Low, or Mixed based on original review authors' assessment of study quality. QoL = Quality of life. * = review of systematic reviews **HMIC = high and middle-income countries.

Table 9. Main findings from systematic reviews and stakeholder documentation included within this umbrella review

First author, year of publication	Main findings	Quality of the review ^a
Aidala, 2016	Moderate-to-high quality evidence to suggest that poor housing status (i.e., adequacy, stability, security of tenure) is associated with poorer health outcomes among people living with HIV/AIDS (including HIV medical care, access and adherence to ART medication, sustained viral suppression, risk of forward transmission), controlling for numerous individual patient and care characteristics. Studies also indicate an independent effect of housing assistance on improved health outcomes for inadequately housed/formerly homeless individuals living with HIV.	7
Bambra, 2010	This umbrella review on the wider social determinants of health and health inequalities included an assessment of the impact of housing interventions on health-related outcomes. Nine reviews were identified, including two that explored rental assistance programmes and five that involved environmental changes to housing (e.g., lighting, infrastructure to reduce falls). Results suggest that interventions to promote mixed, affordable housing may result in improvements in perceived neighbourhood safety among low income groups. There was some evidence to suggest that general housing improvements may result in improved social outcomes and a reduction in injury among older adults. However, these results were mixed. Two reviews explored the effects of these interventions on inequalities, the findings were unclear.	7
Bassuk, 2014	This review explored the effectiveness of housing interventions on reducing family homelessness in the USA. Generally speaking, the interventions were poorly defined and demonstrate poor methodological rigour. Health-related outcomes were difficult to consistently define across studies, and the review authors suggest that mental health was underreported. Evidence for the effectiveness of housing interventions for homeless families on health outcomes remains unclear.	7
Clark, 2007	The impacts of housing regeneration, housing quality and housing tenure on mental health and wellbeing were assessed. There was moderate quality evidence for a beneficial association between housing regeneration (i.e., damp proofing, re-roofing, installing new windows, relocation to better areas) and mental health. The evidence for an effect of housing quality (e.g., condensation problems, dissatisfaction with housing, desire to be re-housed) and housing tenure on mental health was weak.	4
DiGiuseppi, 2011	17 housing interventions designed to affect safety and injury outcomes were reviewed. Three (of 17) interventions (working smoke alarms among general population, 4-sided isolation pool fencing for children, pre-set safe hot water temperature for children) provided sufficient evidence of effectiveness for improving safety and injury outcomes. The remaining interventions either require further exploration to determine effectiveness (12) or were found to be ineffective (three-sided pool fencing for children) (1).	4
Fitzpatrick-Lewis, 2011	10 studies of moderate quality were reviewed. Provision of housing was associated with decreased substance abuse and increased housing tenure among homeless people with substance abuse issues. Provision of abstinence-contingent housing was found to be effective in supporting housing status, substance abuse relapse, engagement with health services, and improved psychiatric outcomes than non-abstinence-contingent housing or no housing. Housing provision also resulted in reduced health problems among the homeless with HIV/AIDS. Health promotion programmes have potential to decrease engagement in risky health behaviours.	7

Garin, 2014	48 studies were reviewed. 34 studies assessed physical health in relation to the built environment; 8 assessed mental health and 10 assessed life satisfaction. To some extent the evidence suggests that aspects of the built environment (e.g., poor insulation) are associated with physical health (e.g., mortality). Depressions prevalence was linked to number of rooms in a house, housing quality, satisfaction with housing. Little/no evidence was found for other mental health outcomes. Numerous limitations with available evidence and quality of review. 39 studies were cross-sectional, making causal links difficult to understand. Synthesis of evidence unclear and could be improved.	5
Gibson, 2011	This systematic review of reviews identified five systematic reviews of housing interventions for promoting health. Interventions that aim to address neighbourhood characteristics, moving disadvantaged people from high to low poverty neighbourhoods can improve mental health and reduce obesity, and they may have the potential to reduce health inequalities. Interventions aiming to improve warmth and energy efficiency (fuel poverty interventions) have been shown to have positive impacts on the health of low income groups, particularly when targeted at elderly people with existing health conditions. Evidence on the impact of housing refurbishment and relocation remains unclear. No reviews were identified assessing the impact of housing tenure alteration.	6
Krieger, 2014	10 neighbourhood level interventions designed to improve asthma outcomes were reviewed. Three (of 11) interventions (in-home tailored interventions, pest management and damp management) provided sufficient evidence of effectiveness for improving asthma outcomes. Five interventions (improved insulation, regular cleaning, use of air cleaning devices, use of dehumidifier and one-off professional cleaning) showed promise but require further empirical research. Finally, three interventions (air cleaners, bedding encasement or cleaning alone, and acaricides (treating carpets with chemicals) demonstrated no evidence of effectiveness. The review includes no details on how many studies were assessed and there is no indication of study quality.	4
Kyle, 2008	This review identified 29 studies which explored the relationship between adults with severe and persistent mental illness and housing circumstances. Findings suggest that there is moderate-level evidence for the effectiveness of housing interventions on mental health-related outcomes, healthcare utilisation and quality of life outcomes for the homeless. However, evidence of the effectiveness of housing interventions on those who are housed, but living in precarious/inappropriate housing situations remains unclear.	6
Leaver, 2007	17 studies of moderate were included in this review of the effects of housing status on health-related outcomes in people living with HIV/AIDS. In all studies, a significant positive association was identified between increased housing stability and better health-related outcomes, including medication adherence, utilisation of health and social services and HIV risk behaviours. Caution is required when interpreting these findings as 14 studies were cross-sectional in design.	7
Lindberg, 2010	10 neighbourhood level interventions designed to improve health outcomes were reviewed. Only one intervention, provision of rental vouchers to assist low-income families, older people, and the disabled in accessing adequate housing, was deemed to demonstrate evidence of effectiveness. The remaining interventions, while demonstrating promise, require further research to establish effectiveness. The review includes no details on how many studies were assessed and there is no indication of study quality.	4
Lorenc, 2013	47 studies were reviewed to examine the effectiveness of a variety of environmental interventions to reduce the fear of crime. Home security improvement and none-crime related environmental improvements (cleaning and repainting of bus station, installation of gym equipment's in parks) were effective in reducing indications of fear and crime. The effectiveness of light improvement and CCTV interventions on perception of crime was minimal.	7

Mansell, 2009	This review identified 19 articles exploring the quality of life outcomes associated with dispersed community based housing compared with clustered housing. Overall, dispersed housing for people with intellectual disability was associated with more positive quality of life outcomes than clustered housing. However, there were numerous studies reporting no difference between the two categories. Studies of clustered housing did not report on social inclusion and material-wellbeing outcomes. There was no difference in safety outcomes between clustered and dispersed housing, although those living in clustered village communities were less likely to have been affected by crime. Over-reliance on cross-sectional study designs. No quality appraisal conducted.	5
McClure, 2008	This review assessed changes in medically treated fall-related injuries among older adults following implementation of a community based intervention. Built environmental aspects of these interventions included home hazard reduction, improved lighting and home visits. All six prospective community-level studies reported a significant decrease or downward trend in fall-related injuries among older adults. It is unknown which aspects of the interventions were effective. Included studies were controlled before-and-after studies – not RCTs – raising questions about the methodological rigour.	7
Nelson, 2007	This article reviewed 16 controlled outcome evaluations of housing interventions for people living with mental illness who have been homeless. Findings suggest that such interventions can result in significant reductions in hospitalisation and well-being and quality of life. Study quality is not assessed in the review. Studies are deemed to be of moderate quality given their experimental / quasi-experimental nature.	5
Reif, 2014	A review of six intervention studies identified moderate level evidence of effectiveness of recovery housing interventions for individuals with substance abuse or co-occurring mental and substance use disorders, with positive health-related outcomes reported for drug and alcohol use and presence of psychiatric symptoms. However, study quality was moderate – with problems including limited study designs and small samples, among others.	6
Sandel, 2010	14 housing interventions designed to improve health outcomes related to exposure to chemical agents were reviewed. Four interventions (radon air mitigation using active soil depressurisation systems, integrated pest management to reduce exposure to pesticides, smoke-free home policies making indoor areas smoke-free and residential lead hazard control) were deemed to demonstrate evidence of effectiveness. The remaining interventions either require further exploration to determine effectiveness (7) or were found to have no evidence of effectiveness or be ineffective (3).	4
Thomson, 2009	A review of forty studies reviewing the direct health effects attributable to housing improvement revealed moderate to high quality evidence for the positive impact of warmth improvement on general, respiratory and mental health. Evidence on the effectiveness of neighbourhood renewal was mixed. Notably, there were few reports of adverse health impacts following housing improvement.	7
Thomson, 2013	39 quantitative and qualitative studies assessing the health impacts of housing improvement were reviewed, and judged to be of moderate level quality overall. Warmth improvements were shown to result in improved respiratory health outcomes among adults and children, particularly among those living in poor housing and with existing poor health. However, there was some inconsistency in reported findings, meaning that overall impact remains unclear. Warmth improvements were also shown to result in improvements in general health. Good quality evidence, all from the UK, suggested that the impact of rehousing or retrofitting remains unclear.	7
WHO, 2005	This review collates the best available evidence for the impact of housing improvements on health outcomes. Increases in indoor air pollutants are associated with poorer general health outcomes for the elderly and asthmatics. However, the impact	5

	<p>of improved indoor air quality and reduced dampness has yet to be fully assessed. Improvements in energy efficiency have led to small improvements in general health and respiratory outcomes among asthmatic children. Prevention of lead exposure is identified as the most effective way to avoid lead poisoning. Appropriate installation and maintenance of smoke alarms required to prevent fire-related injury and death. The health impact of noise reduction has not been fully assessed. No studies identified to explore the link between housing tenure and health. Increased housing satisfaction following housing improvements strongly associated with improvements in mental health. Increased housing costs can lead to poorer diets and reduced employment opportunities.</p>	
--	-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	--

Note. (a) = total scores for MQC (systematic reviews): 1-3 = low quality, 4-5 = moderate quality, 6-7 = high quality or MQC-SP (for stakeholder documentation): 1-3 = low quality, 4-5 = moderate quality, 6 = high quality. ART = Anti-retroviral therapy.

Appendix E. Detailed evidence: Healthier food environment

Table 10. Quality assessment of systematic reviews

First author	Research question ^a	Search strategy ^b	Inclusion/exclusion criteria ^c	Study details ^d	Quality assessment ^e	Synthesis ^f	Independent review ^g	Score
Bambra	Y	Y	Y	Y	Y	Y	Y	7
Calancie	Y	Y	Y	Y	N	Y	Y	6
Caspi	Y	Y	Y	Y	N	N	N	4
Cobb	Y	Y	Y	Y	Y	Y	Y	7
Delgado-Noguera	Y	Y	Y	Y	Y	Y	Y	7
De Vet	Y	Y	Y	Y	Y	Y	N	6
Dreissen	Y	Y	Y	Y	Y	Y	Y	7
Feng	Y	Y	Y	N	N	Y	N	4
Gamba	Y	Y	Y	Y	N	Y	N	5
Ganann	Y	Y	Y	N	Y	Y	Y	7
Giskes	Y	Y	Y	Y	N	Y	Y	6
Gittlesohn	Y	Y	Y	N	N	Y	Y	5
Jaime	Y	Y	Y	Y	N	Y	N	5
Kent	Y	Y	Y	N	N	Y	N	4
McCormack	Y	Y	Y	Y	N	Y	N	5
Osei-Assibey	Y	Y	Y	Y	Y	Y	Y	7
Roy	Y	Y	Y	Y	Y	Y	Y	7
Sonntag	Y	Y	Y	Y	Y	Y	N	6
Wall	Y	Y	Y	Y	Y	Y	Unclear	6
Williams	Y	Y	Y	Y	Y	Y	Y	7

Note. (a) = Is there a well-defined question? – The question should define at least the participants, the intervention, the outcomes and the study designs; (b) = Is there a defined search strategy? – The search strategy should include at least one named database combined with reference checking, hand searching, citation, follow-up or expert contact; (c) = Are inclusion / exclusion criteria stated? – The review should make the grounds for study inclusion and exclusion transparent in terms of participants, intervention, outcomes and study design; (d) = Are the primary study designs and number of studies clearly stated? – The review should outline the designs of included studies and make it clear which and how many studies are in the final synthesis; (e) = Have the primary studies been quality assessed? – The review should clearly describe the quality assessment process, which quality appraisal tool is used, and the relative quality of each included study; (f) = Have the studies been appropriately synthesised? – The review should use meta-analysis or narrative synthesis, whichever is most suitable given the heterogeneity of studies and their methodological quality. If studies are very heterogeneous, narrative synthesis is appropriate; (g) = Has more than one author

been involved at each stage of the review process? – To minimise bias, the review should have at least two reviewers involved in each stage (study selection, data extraction, quality appraisal, synthesis) of the review.

Table 11. Description of systematic reviews and stakeholder documentation included within this umbrella review

First author, year of publication	Type of paper ^a	Number of original studies	Design of original studies ^b	Population	Health outcome(s)	Location(s)	Synthesis method	Quality of the evidence ^c
Bambra, 2010	1	1*	SR	Adults	Impact on inequalities in health or wellbeing, overall health effect	USA	Narrative	Moderate
Calancie, 2015	1	29	UBA, Q, C-S	Participants living in rural communities	Any health outcome	USA, Canada	Narrative	N/R
Caspi, 2012	1	38	C-S, N, CR-CS	Adults, children	Any dietary outcome	USA, Scotland, Australia, UK, Japan, Canada, NZ	Narrative	Moderate
Cobb, 2015	1	71	L, C-S	Adults, children	BMI, obesity, BMI change, weight change	USA, Canada	Narrative	Low
Delgado-Noguera, 2011	1	3	RCT, Q	Children	Fruit and vegetable consumption	Norway, UK	Narrative and meta-analysis	Moderate
De Vet, 2010	1	7	SR	Children and adolescents	Any dietary outcome	N/R	Narrative	Moderate/High
Dreissen, 2014	1	18	RCT, UC-C, C-S	Children	Eating behaviours, body weight	USA, UK	Narrative	Low/Moderate
Feng, 2010	1	22	N/R	Adults, children, elderly	Any weight-related outcome	USA, Australia	Narrative	N/R
Gamba, 2015	1	51	C-S, L	Adults, children	Obesity-related health outcome	USA	Narrative	N/R
Gannan, 2014	1	13	RCT, Q, CR-CS, UC-C	Children, teachers, parents	Fruit and vegetable consumption	USA, South Africa, Netherlands, UK, France	Narrative	Low
Giskes, 2010	1	28	C-S, N	Adults (≥ 17 years)	Any measure of weight status	USA, Australia, New Zealand, Japan, UK, Netherlands	Narrative	N/R
Gittelsohn, 2012	1	16	RCT, C-S, UR-CS, D	Low income adults	Healthy food consumption, BMI	USA, Scotland, Australia	Narrative	N/R
Jaime, 2009	1	12	RCT, Q, CR-CS, UR-CS	Children	Fat intake, fruit and vegetable consumption, BMI	USA, Denmark, UK, Norway, Belgium,	Narrative	N/R

						Netherlands, Spain		
Kent, 2014	1	138	N/R	Adults, children	Physical activity, Social isolation, Obesity	Worldwide	Narrative	N/R
McCormack, 2010	1	16	Any	Adults, children	Nutrition-related outcomes	USA	Narrative	N/R
Osei-Assibey, 2012	1	8	RCT, Q, UR-CS	Children <9 years	BMI/weight, skin-fold thickness, % body fat, % overweight/obesity or dietary behaviours linked to obesity	USA, Netherlands, Sweden, UK, Germany	Narrative	Moderate
Roy, 2015	1	15	RCT, UR- CS, Q, CS	Young adults in tertiary education	Changes to healthier food choices, reductions in unhealthy food choices, nutrition knowledge, and/or food/drink sales, food preferences, food-related psychology, motivations, barriers, beliefs, and attitudes toward food and lower BMI, reduced weight.	USA, UK, Belgium, Italy	Narrative	Moderate/High
Sonntag, 2015	1	8	C-S, D, N/R	Children (3-11 years)	Dietary behaviour, weight	USA, Netherlands, UK, Germany, Sweden, Canada, Australia	Narrative	Moderate
Wall, 2006	1	4	RCT	Adults	Food purchases, food consumption, or weight loss	Worldwide	Narrative	Moderate
Williams, 2014	1	30	L, C-S	Children (5-18 years)	Food purchases, dietary intake, body weight	USA, Canada, Europe, Australia, Asia	Narrative	Low

Note. (a) 1 = systematic reviews, 2 = stakeholder documentation; (b) RCT = Randomised controlled trial, UBA = Uncontrolled before-and-after, CBA = Controlled before-and-after, CR-CS = Controlled repeat cross-sectional, Q = Quasi-experimental, C-C = Controlled-cohort, C-S = Cross-sectional, UR-CS = Uncontrolled repeat cross-sectional, N = Natural experiment; L = Longitudinal, UC-C Uncontrolled-cohort, Case-C = Case control, T-S, Time series, D = Descriptive, E = Experimental, SR = Systematic reviews, N/R = not reported; (c) = High, Moderate, Low, or Mixed based on original review authors' assessment of study quality. QoL = Quality of life. * = review of systematic reviews.

Table 12. Main findings from systematic reviews and stakeholder documentation included within this umbrella review

First author, year of publication	Main findings	Quality of the review^a
Bambra, 2010	This umbrella review of review level evidence on the wider social determinants of health and health inequalities included an	7

	assessment of the impact of healthy food interventions on health-related outcomes. Only one review was identified, including evidence from four RCTs. The review found a positive effect for food provision incentives (e.g., provision of vending machines in schools and workplaces containing low-price, low-fat snacks) on weight loss, fruit and vegetable consumption, and attitudes towards fruit and vegetable consumption. There was no evidence of an effect according to socioeconomic position and none of the studies explored disadvantaged groups specifically.	
Calancie, 2015	This review synthesised available evidence for the impact of adaption, implementation, effectiveness of policy and environmental obesity prevention strategies in rural settings. 29 studies were reviewed, with the majority assessing the impact of interventions designed to increase availability of healthy food and beverage choices. Results were mixed, although interventions did have a positive impact on participants' knowledge and self-efficacy related to healthy food consumption and acquisition. There were also positive increases in fruit and vegetable purchasing (1), reduced intake of sugary beverages and reduced dietary fat intake. Evidence for changes in weight status was mixed. Authors did not consider study quality.	6
Caspi, 2012	Moderate quality evidence for associations between neighbourhood food environment and dietary health. Positive associations between healthy food availability and healthy diet. Mixed evidence for relationship between healthy food accessibility and dietary outcomes. Lower regional prices were associated with better dietary health. Food quality and store opening hours associated with fruit and vegetable consumption. Measurement of food access inconsistent across studies. Over reliance on cross sectional studies.	4
Cobb, 2015	Predominantly null association between food availability and obesity. Direct positive associations between fast food availability and obesity in low income children. Among adults, the number of unhealthy food outlets was consistently associated with obesity. Over reliance on cross sectional studies. Limiting review to higher quality studies did not affect overall findings. Caution required as overall quality of studies was low.	7
Delgado-Noguera, 2011	Three of 19 studies included in this review explored the effect of free/subsidised fruit and vegetables on fruit and vegetable consumption among school children. Meta-analysis revealed that such interventions were not effective.	7
De Vet, 2010	This review of environmental correlates of dietary behaviours identified no built environmental characteristics associated with positive dietary behaviours among young people. However, exposure to TV food advertising was negatively related to healthy diets. When comparing children with adolescents, there were no clear differences in environmental influences between the two.	6
Dreissen, 2014	Review of evidence for the effect on isolated school-based food environments on eating behaviours and body in children. There was consistent evidence to demonstrating an improvement in healthy eating behaviours and a reduction in body mass index of children. Overall, findings suggest that changes to school food environment can have a positive impact on eating behaviours; however, as overall study quality was low/moderate, caution is required.	7
Feng, 2010	This review explored the association between the general food environment and weight-related outcomes. The overall evidence was mixed, with the majority reporting a positive significant association, but evidence of a negative/null effect also reported. For fast food density, two studies reported a significant positive association with obesity outcomes, with four studies not observing an association. Overall, 61 of the 63 papers in this review are cross-sectional in design, meaning that caution is required. Study design and study details for food-specific articles are unclear in the reporting of findings, limiting the ability to draw conclusions about the overall utility and quality of the original research.	4
Gamba, 2015	Evidence suggests that food environments are associated with obesity. Most studies found at least one statistically significant relationship between the food environment and obesity. However, there was large variation in measures used, food store	5

	types and frequency, proximity and presence of food stores. When taking these factors into account, the association becomes much less clear. The review is reliant on findings from cross sectional studies – only 7 of 51 are longitudinal – making it difficult to establish causality.	
Gannan, 2014	This review assessed the impact of the access to fruit and vegetables on food sales, fruit and vegetable consumption, attitudes towards consumption and general health measures among children and young people in the school or home setting. The overall evidence was mixed, with some studies reporting positive effects, several finding no impacts and some reporting adverse effects. Overall, study quality was poor.	6
Giskes, 2010	5/6 studies reported that greater accessibility to supermarkets was not associated with fruit and vegetable consumption. 3 of 4 studies found no association between access to takeaway outlets and fruit and vegetable consumption. There were no consistent associations between shelf space and fruit and vegetable consumption. Four of 5 studies reported an inverse association between BMI and supermarket access. Five of 8 studies revealed evidence for a positive association between access to takeaway food outlets and BMI. However, associations between access to grocery/convenience stores and BMI were mixed. Overall, weight status more consistently associated with food environment than dietary intake (i.e., fruit and vegetable consumption). 27 of 28 studies cross-sectional, meaning that overall study quality is low and interpretation requires caution.	6
Gittelsohn, 2012	9/10 studies reported significant increases in purchasing frequency of at least one promoted healthy food (including fruit and vegetables, low-fat milk, high-fibre cereals and water) following food promotion intervention in 'small' local convenience stores. No significant changes in BMI were reported in the four studies assessing this outcome; however, it is unclear from the review which studies these are. Numerous articles (8/16) are drawn from the grey literature. Results from the quality appraisal are not reported and there is no statistical evidence to support claims.	5
Jaime, 2009	Some evidence for the effectiveness of school food policies on improving food environment and dietary intake. However, evidence suggests that policies may be less effective at reducing BMI. Implementing nutritional guidelines was found to be the most effective strategy, with 8 of nine studies demonstrating positive changes in saturated fat intake and dietary intake. Mixed evidence for food and beverage regulation – can result in adverse effects.	5
Kent, 2014	Evidence from the review suggests that the proximity of fruit and vegetable outlets is important in encouraging healthy eating. The review reports on limited evidence for an association between access to fast-food takeaway outlets and weight status in the general population, and obesity and unhealthy eating among children residing in low-income areas. The review also suggests that urban agriculture may increase opportunities for physical activity, social connections, and increased fruit and vegetable consumption. Attitudes towards buying, preparation and eating healthy food are also positively influenced by farmers' markets and community gardens.	4
McCormack, 2010	16 studies were included in this review. Seven studies focused on the impact of farmers' market nutrition programmes for children, five focused on the influence of farmers' market programmes for seniors, and four focused on community gardens. Findings from this review reveal that few well designed research studies utilizing valid and reliable dietary assessment methods to evaluate the influence of farmers' markets and community gardens on nutrition-related outcomes have been completed.	5
Osei-Assibey, 2012	There is some evidence that improving access/availability of food offered in schools/nurseries can lead to an improved diet, although there no evidence for a reduction in the intake of saturated fat. Three (of 5) studies reported a significant reduction in BMI; however, these effects were not sustained. There was limited evidence on other possible influences of food availability and access.	7

Roy, 2015	13 of 15 studies included in this review reported significant positive improvements in health-related outcome measures among young adults in tertiary education settings following food environment intervention. Improvements to nutrition labelling were accepted by young adults and could help to improve diet. Increasing availability of foods and decreasing portion sizes improved dietary intake. Price incentives had a positive effect on nutrition-related outcomes. Overall study quality was moderate to high.	7
Sonntag, 2015	Narrative synthesis identified six 'obesogenic environments' which may be influenced by the food industry. Relevant to the built environment was evidence from schools, home and retailers. One study on schools revealed an inverse association between pouring rights contracts and sugar-sweetened beverage and energy-dense food intake. There was also an adverse association between parental-targeted advertising and children's weight. There was also an indication that retailers can influence children's preferences, which may in turn, influence parents' decisions to buy unhealthy food.	6
Wall, 2006	Four RCTs met the inclusion criteria. All four trials demonstrated a positive effect of monetary incentives on food purchases, food consumption, or weight loss. However, the trials had some methodological limitations including small sample sizes and short durations. In addition, no studies to date have assessed effects according to socioeconomic or ethnic group or measured the cost-effectiveness of such schemes.	6
Williams, 2014	Associations between the food environment around schools and children's food purchases, dietary intake and body weight were inconsistent. There was some effect of the school environment on body weight, however, these findings should be treated with caution due to their reliance observational data. Only two studies in the review used longitudinal data.	7

Note. (a) = total scores for MQC (systematic reviews): 1-3 = low quality, 4-5 = moderate quality, 6-7 = high quality or MQC-SP (for stakeholder documentation): 1-3 = low quality, 4-5 = moderate quality, 6 = high quality.

Appendix F. Detailed evidence: Natural and sustainable environment

Table 13. Quality assessment of systematic reviews

First author	Research question ^a	Search strategy ^b	Inclusion/exclusion criteria ^c	Study details ^d	Quality assessment ^e	Synthesis ^f	Independent review ^g	Score
Ahern	Y	Y	Y	Y	Y	Y	N	6
Alderman	Y	Y	Y	Y	N	Y	N	5
Annear	Y	Y	Y	Y	Y	Y	Y	7

Atkinson	Y	Y	Y	Y	N	Y	N	5
Balti	Y	Y	Y	Y	N	Y	N	5
Bambra	Y	Y	Y	Y	Y	Y	Y	7
Beard	Y	Y	Y	N	Y	Y	N	5
Boninzi	Y	N	Y	Y	N	Y	Y	5
Boothe	Y	N	Y	Y	Y	Y	Y	6
Bowler	Y	Y	Y	Y	Y	Y	N	6
Calogiuri	Y	Y	Y	N	N	Y	N	4
Chen	Y	Y	Y	Y	N	Y	N	5
Clark	Y	Y	N	N	Y	Y	N	4
Davison	Y	Y	Y	N	Unclear	Y	Y	5
Deng	Y	Y	Y	Y	N	Y	Y	6
DiGuisseppi	Y	Y	Y	N	N	Y	N	4
Dunton	Y	N	Y	Y	N	Y	Unclear	4
Eze	Y	Y	Y	Y	N	Y	Y	6
Faulkner	Y	Y	Y	Y	N	Y	Unclear	5
Favarato	Y	Y	Y	N	N	Y	N	4
Frutos	Y	Y	Y	Y	N	Y	N	5
Gascon (a)	Y	Y	Y	Y	Y	Y	Y	7
Gascon (b)	Y	Y	Y	Y	Y	Y	Y	7
Hajna	Y	N	Y	Y	N	Y	N	4
Hamra (a)	Y	Y	Y	Y	N	Y	N	5
Hamra (b)	Y	Y	Y	Y	N	Y	N	5
Hu	Y	Y	Y	Y	N	Y	Y	6
Hunter	Y	Y	Y	Y	Y	Unclear	Y	6
Jafta	Y	Y	Y	Y	Y	Y	Y	7
Jaghorbani	Y	Y	Y	Y	Unclear	N	Y	5
Kabisch	Y	Y	Y	N	N	Y	N	4
Koranteng	Y	N	Y	Y	N	N	Unclear	3
Lacasana,	Y	Y	Y	Y	N	N	N	4
Lee	Y	Y	Y	Y	Y	Y	N	6
Lui	Y	N	Y	Y	N	Y	Y	5
Luo	Unclear	Y	Y	Y	Y	Y	Unclear	5
Mackenbach	Y	N	Y	Y	Y	Y	Y	7
McClure	Y	Y	Y	Y	Y	Y	Y	7
McCormack	Y	Y	Y	Y	N	Y	N	5

Mehta	Y	N	Y	Y	N	Y	Unclear	4
Menichini	Y	Y	Y	Y	N	Y	N	5
Najafi	Y	Y	Y	N	N	Y	Unclear	4
Oja	Y	Y	Y	Y	Y	Y	Y	7
Pedersen	Y	Y	Y	Y	N	Unclear	Unclear	4
Peters	Y	Y	Y	Y	Unclear	Y	Y	6
Rodriguez-Villamizar	Y	Y	Y	Y	Y	Y	Y	7
Sandel	Y	Y	Y	N	N	Y	N	4
Scheers	Y	Y	Y	Y	N	Y	Y	6
Shah	Y	Y	Y	Y	Unclear	N	Y	5
Song	Y	Y	Y	Y	N	N	N	4
Stanke	Y	Y	Y	Unclear	Unclear	Y	Unclear	4
Stieb	Y	Y	Y	Y	Unclear	Y	Y	6
Teng	Y	Y	Y	Y	Y	Y	Y	7
Thompson Coon	Y	Y	Y	Y	Y	Y	Y	7
Turner	Y	Y	Y	Y	Y	Y	Y	7
Van Holle	Y	Y	Y	Y	N	Y	N	5
Van Cauwenberg	Y	Y	y	Y	N	Y	N	5
Vienneau	Y	Y	Y	Y	N	Y	Unclear	5
Vrijheid,	Y	Y	Y	Y	N	Y	Unclear	5
Waite	Y	Y	Y	Unclear	Unclear	Y	Unclear	4
Xu	Y	Y	Y	Y	Y	Y	Y	7

Note. (a) = Is there a well-defined question? – The question should define at least the participants, the intervention, the outcomes and the study designs; (b) = Is there a defined search strategy? – The search strategy should include at least one named database combined with reference checking, hand searching, citation, follow-up or expert contact; (c) = Are inclusion / exclusion criteria stated? – The review should make the grounds for study inclusion and exclusion transparent in terms of participants, intervention, outcomes and study design; (d) = Are the primary study designs and number of studies clearly stated? – The review should outline the designs of included studies and make it clear which and how many studies are in the final synthesis; (e) = Have the primary studies been quality assessed? – The review should clearly describe the quality assessment process, which quality appraisal tool is used, and the relative quality of each included study; (f) = Have the studies been appropriately synthesised? – The review should use meta-analysis or narrative synthesis, whichever is most suitable given the heterogeneity of studies and their methodological quality. If studies are very heterogeneous, narrative synthesis is appropriate; (g) = Has more than one author been involved at each stage of the review process? – To minimise bias, the review should have at least two reviewers involved in each stage (study selection, data extraction, quality appraisal, synthesis) of the review.

Table 14. Quality assessment of stakeholder documentation

First author	Stakeholder involvement ^a	Well-defined aim ^b	Robust methodology ^c	Quality assessment ^d	Synthesis ^e	Independent review ^f	Score
CABE, 2009	Y	Y	Y	N	N	Y	4
WHO, 2005	Y	Y	Y	Y	Y	N	5

Note. (a) = Is there a major stakeholder involved? – The document is developed/endorsed by (1) a nationwide or international organisation which is issuing recommendations or guidelines which are used in clinical practice; or (2) an interdisciplinary or cross-country consortium aiming at providing progress in the discipline or practice for a respective health outcome; (b) = Is there a well-defined aim? – The document specifies the aim of the paper, target population(s), type of

actions and their breadth and the respective health outcome; (c) = Is there a robust methodology? – The methods should list the sources used to obtain comprehensive and heterogeneous data, such as literature review and analysis of several examples of published and unpublished documents; (d) = Quality assessment of analysed materials applied? – The document refers to the quality assessment of the included material and/or refers to quality assessment measures or methods; (e) = Has the included material been appropriately synthesised? – The synthesis of analysed material addresses the heterogeneity of the analysed data; provides specific conclusions; conclusions are supported by analysed material; the key constructs are clearly operationalised; (f) = Has more than one organisation/stakeholder been involved in the process? – To minimise bias, conclusions were based on involvement and consensus achievement by at least two stakeholder/multiple researchers from different organisations.

Table 15. Description of systematic reviews and stakeholder documentation included within this umbrella review

First author, year of publication	Type of paper^a	Number of original studies	Design of original studies^b	Population	Health outcome(s)	Location(s)	Synthesis method	Quality of the evidence^c
Ahern, 2005	1	212	Epidemiological	Any	Any health outcome	Worldwide	Narrative	N/R
Alderman, 2012	1	35	Epidemiological	Any	Any health outcome	Worldwide	Narrative	N/R

Annear, 2014	1	83	RCT, C-S, C	Older adults	Any health outcome	Canada, USA, Western Europe	Narrative	N/R
Atkinson, 2014	1	110	T-S	Any	Any health outcome	Global	Narrative with meta-analysis	Moderate
Balti, 2014	1	10	C	Any	Diabetes-related outcome	USA, Canada, Denmark, Netherlands, Switzerland, Germany	Narrative with meta-analysis	N/R
Bambra, 2010	1	1*	SR	Adults	Impact on inequalities in health or wellbeing, overall health effect	USA	Narrative	Moderate
Beard, 2010	1	51	C-S, L	Older adults	Large range of physical and mental health outcomes	unclear	Narrative	Poor/moderate
Bonzini, 2010	1	18	C-C, T-S	Pregnant women	Preterm delivery, low birth weight, small or gestational age	Brazil, Canada, USA, Australia	Meta-analysis and narrative	N/R
Boothe, 2014	1	9	Case-C, and unclear	Children	Childhood cancer, leukaemia	HICs	Narrative and meta-analysis	Moderate
Bowler, 2010	1	25	C-O, Q	Any	Any health- or wellbeing related outcome	UK	Narrative with meta-analysis	Moderate
CABE, 2009	2	N/R	N/R	Unspecified	Any health-related outcome	N/R	Narrative	N/R
Calogiuri, 2014	1	90	SR, Q, C, E	Adults	Physical activity outcomes	N/R	Narrative	N/R
Chen, 2014	1	17	C, Case-C	Any	Congenital anomalies	USA, UK, Italy, Australia, Israel, South Korea, Spain, Taiwan	Narrative with meta-analysis	Low/Moderate
Clark, 2007	1	99	L, C-S	Children, adolescents, adults	Any mental health and wellbeing outcome	32/94 in UK	Narrative	Low/Moderate
Davison, 2006	1	33	C-S, L	Children age 3-18 years	Physical activity	USA, UK, Portugal, Canada, Australia,	Narrative	N/R

Deng, 2016	1	10	L, C-S, Eco	Adult males	Sperm quality	USA, Czech Republic, Italy, China, Poland, Turkey	Narrative with meta-analysis	Low/Moderate
DiGuseppi, 2011	1	N/R	RCTs	General population / children	Safety and injury outcomes	N/R	Narrative	Low/Moderate
Dunton, 2009	1	15	C-S	Children and Adolescents	Obesity	USA, Canada	Semi-quantitative procedure	N/R
Eze, 2015	1	7	L, C-S	Children and adults	Diagnosis of type II diabetes mellitus	USA, Canada, Germany, Denmark, Netherlands, Sweden	Narrative with meta-analysis	N/R
Faulkner, 2009	1	13	C-S	Children	Physical activity, body weight	USA, Philippines, Australia, UK-4, Denmark-2, New Zealand-1	Narrative	N/R
Favarato, 2014	1	20	N/R	Children	Asthma symptoms or diagnosis	USA, Spain, Netherlands, Sweden, S Korea, Germany, China, France, Czech Republic	Narrative with meta-analysis	N/R
Frutos, 2015	1	7	C	Women	Any fertility outcome	N/R	Narrative	Moderate
Gascon, 2015	1	28	L, Eco, CS	Adults and children	Mental health outcomes	UK, Netherlands, US, Oceania	Narrative	Moderate
Gascon, 2016	1	12	Eco, C, CS	Adults and children	Mortality-related outcomes	UK, US, Oceania, Canada, Lithuania	Narrative	Moderate/High
Hajna, 2015	1	6	unclear	adults	Walking	Europe, Asia	Narrative and meta-analysis	Unclear
Hamra, 2014	1	18	C, Case-C	N/R	Lung cancer incidence and mortality	USA, Canada, UK, Italy, Germany, China, Japan, New Zealand	Narrative with meta-analysis	N/R
Hamra, 2015	1	20	C, Case-C	N/R	Lung cancer incidence and mortality	USA, Canada, Sweden, Norway,	Narrative with meta-	N/R

						France, Netherlands, UK, Italy, Germany, Denmark, China, Japan	analysis	
Hu, 2014	1	10	C, Case-C	Pregnant women	Hypertensive disorders of pregnancy	USA, Spain, Sweden, Australia, Netherlands	Narrative with meta-analysis	N/R
Hunter, 2014	1	12	Q-11, RCT-1	General	Physical activity	USA-9, Australia-3	Narrative	Low
Jafta, 2015	1	8	Case-C, C-S	Children ≤ 15 years	Tuberculosis	India-4, South Africa-2, Spain-1	Meta-analysis and narrative	Moderate
Jaghorbani, 2014	1	17	C-C (6), C-S (2), C-CR (6)	Adults, diabetic adults	Diabetes	USA-7, Europe-7, Asia-1, Canada-2	Meta-analysis	N/R
Kabisch, 2015	1	30	N/R	Any	Any health and wellbeing	UK, USA, Sweden, Canada, Germany, Netherlands	Narrative	N/R
Koranteng, 2007	1	13	T-S	Children	Any health outcome	Canada	Narrative	N/R
Lacasana, 2005	1	31	T-S, C-C	Early childhood, pregnant women	Post neonatal mortality, foetal health	UK-2, Czech Republic, USA, Sweden, Taiwan, Brazil, Mexico, South Korea	Meta-analysis	N/R
Lee, 2010	1	37	CS, Eco, Qual, SR	Any	Any health-related outcome	Australia, USA, UK, Netherlands, Canada, New Zealand, Denmark, Japan	Narrative	Low
Lui, 2015	1	11	C-S (9), L-1	Adults age 18 and above	carotid intima-media thickness	USA-6, UK-1, Netherlands-1, Europe-1, Taiwan-1, Canada-1	Meta-analysis	N/R
Luo, 2015	1	31	T-S, C-CR	General	Myocardial infarction	North America-9, Asia-5, Australiasia-1 South America-2, Europe 14	Meta-analysis	Moderate-high

Mackenbach, 2014	1	92	C-S, L	adults	obesity	UK-6, USA-66, Canada-8, Europe-6	Narrative	Moderate-high
McClure, 2008	1	6	CBA	Older people (>65 years)	Changes in medically treated fall-related injuries	Australia, Denmark, Sweden, Norway, Taiwan	Narrative	Moderate
McCormack 2011	1	33	C-S, Q	Mainly adults	Physical activity	HICs (mostly US, 1 UK)	Narrative	Moderate
Mehta, 2011	1	74	T-S (31), C-C (4), Case-C (3), C-CR (6), C-S (9)	Children	Acute lower respiratory infections	Europe and North America-42, Latin America-24, Asia-4	Meta-analysis	N/R
Menichini, 2010	1	21	P-S, E-S	General	Drug use	Netherlands, USA, France, UK, Chile,	Pooled relative risk and odds ratio	N/R
Najafi, 2015	1	11	C-S, C-C	Male adults	Sperm quality, sperm concentration, sperm motility, sperm morphology and sperm count	China, USA, UK	Meta-analysis	N/R
Oja, 2011	1	16	C-S, Case-C, C-C, RCT	General population	Cardiorespiratory fitness, cardiovascular risk factors, all-cause mortality	Germany, Australia, Denmark, UK, China, USA	Narrative	Low-4 Moderate-5 Strong-7
Pedersen, 2014	1	17	C-C, Case-C	Pregnant women	Pregnancy induced hypertensive disorder, preeclampsia,	USA-9, Europe-5, Iran-1, Japan-1, Australia-1	Meta-analysis	N/R
Peters, 2015	1	8	C-C	Adults in late mid/late life	Dementia, Cognitive function	USA	Descriptive	N/R
Rodriguez-Villamizar, 2015	1	27	T-S, C-CR, L, C-C-C	children	Health service use (HSU), lung function measurement, self-reported respiratory symptoms	Canada	Narrative	Moderate-high
Sandel, 2010	1	N/R	N/R	N/R	Health outcomes associated with exposure to chemical agents	N/R	Narrative	N/R

Scheers, 2015	1	20	C-C, E-S	General population	Stroke incidence and mortality	Europe-8, North America-7, Eastern Asia-5	Meta-analysis	N/R
Shah, 2015	1	94	T-S-(69), C-CR (33)	Adults	Admission to hospital and mortality from stroke	Brazil, Chile Mexico, South Africa, China, Thailand, LMIC	Meta-analysis	N/R
Song, 2014	1	44	T-S, C-C, C-S	General	Chronic obstructive Pulmonary Disease (COPD)	Europe, China, USAQ	Meta-analysis	N/R
Stanke, 2012	1	48	Not reported	Mostly adults	Mental health	USA, China, Vietnam, Poland, Sri Lanka, Germany, Korea, UK	Narrative	N/R
Stieb, 2012	1	62	C-C, Case-C, E-S	Pregnant women, new born	Birth weight and preterm birth	North America-27, Europe-18 (UK-1), Asia-10, Australia-4, South America-3	Meta-analysis	N/R
Teng, 2013	1	8	C-CR	General population	Out-of-hospital cardiac arrest	USA-6, Denmark-1, Finland-1, Australia-1	Meta-analysis and narrative	Moderate-high
Thompson Coon, 2011	1	11	RCT, L	General population, mean age 25.22	Mental health	USA, Australia, Switzerland	Narrative	Moderate
Turner, 2010	1	17	C-C	Meta-analysis	Childhood leukaemia	United States, Canada, France, Brazil, Japan, Germany	Meta-analysis	Low-moderate
Van Cauwenberg, 2011	1	31	C-S, L	Older adults	Walking, cycling, active transport, physical activity	North America-21, Europe-7, Australia-2, Asia-1	Narrative	N/R
Van Holle, 2012	1	70	C-C	18-65 years	Walking, cycling, physical activity	UK-19, Belgium-16, Netherlands-13, Spain-8, Portugal-7, rest of Europe	Meta-analysis	N/R
Vienneau,	1	10	Case-C, Cohort,	Male and	Ischemic heart disease	Europe	Meta-analysis	N/R

2015				female				
Vrijheid, 2011	1	10	Case-c, T-S	Pregnant women	Coarctation of aorta, atrial septal defects, oral lefts	USA—4, UK-3	Meta-analysis	N/R
Waite, 2014	1	23	Not reported	Any	Carbon monoxide poisoning	USA	Narrative	NR
WHO, 2005	2	N/R	C-S, E	Any	Any health-related outcome	Developed countries	Narrative	Low/Moderate
Xu, 2013	1	19	C-S, S-R, C-S	Children and adults	Body weight, cardiovascular health, cancer, mental health and injury	Unclear	Narrative	Mixed (low, moderate and high)

Note. (a) 1 = systematic reviews, 2 = stakeholder documentation; (b) RCT = Randomised controlled trial, UBA = Uncontrolled before-and-after, CBA = Controlled before-and-after, CS = Cross-sectional, Q = Quasi-experimental, N = Natural experiment; L = Longitudinal, C = Cohort, Case-C = Case control, T-S, Time series, D = Descriptive, E = Experimental, Eco = Ecological, Qual = Qualitative, SR = Systematic reviews, C-O = Cross-over study, N/R = not reported; (c) = High, Moderate, Low, or Mixed based on original review authors' assessment of study quality. QoL = Quality of life. * = review of systematic reviews.

Table 16. Main findings from systematic reviews and stakeholder documentation included within this umbrella review

First author, year of publication	Main findings	Quality of the review ^a
Ahern, 2005	The review found limited evidence on the health effects of floods, particularly with regard to morbidity outcomes. The review identified no studies on the effectiveness of public health measures. The immediate risks of trauma and death are generally clear, but it seems that longer-term impacts, specifically on mental well-being, are often underestimated and probably receive too little attention from public health authorities.	6
Alderman, 2012	The review reported that the long-term health effects are currently not well understood. Mortality rates were found to increase by up to 50% in the first year post-flood. After floods, it was found there is an increased risk of disease outbreaks such as hepatitis E, gastrointestinal disease and leptospirosis, particularly in areas with poor hygiene and displaced populations. Psychological distress in survivors (prevalence 8.6% to 53% two years post-flood) can also exacerbate physical	5

	illness.	
Annear, 2014	83 studies of environmental influences on healthy and active ageing were reviewed. Of these, 46 studies of low/moderate quality reported significant relationships between environmental conditions and older adults' health and activity participation. With relation to natural environment, exposure to excessive noise, heavy traffic, temporary hazards, poor air quality, presence of rubbish, and extreme temperatures are associated with poorer <u>physical health outcomes</u> , such as CVD mortality, incidence of falls and reduced longevity. Natural environment features shown to improve physical health outcomes include proximity to open spaces, living in a hillside area, living in an area with high rainfall and living in a rural environment. Improved <u>mental health outcomes</u> are associated architectural features that promote visibility (e.g., housing overlooking public areas). Excessive noise and litter were associated with negative mental health outcomes. Improved <u>physical activity</u> was associated with clean air and a favourable climate. Reductions in physical activity were associated with bad weather and <u>unattractive environmental conditions</u> .	7
Atkinson, 2014	This review of time series studies of PM _{2.5} and health outcomes revealed that a 10 µg/m ³ increment in PM _{2.5} was associated with a 1.04% (95% CI 0.52, 1.56) increase in the risk of death. Associations for respiratory causes of death were larger than for cardiovascular causes, 1.51% (95% CI 1.01, 2.01) versus 0.84% (95% CI 0.41, 1.28). Positive associations with mortality for most other causes of death and for CVD and respiratory hospital admissions were also observed. Overall, the review provides moderate level evidence for adverse health effects of short-term exposure to PM _{2.5} across a range of health outcomes and diseases.	5
Balti, 2014	This review explored the association between exposure to air pollutants and type II diabetes. 10 studies (5 cohort, 5 cross-sectional) were reviewed. All cohort studies revealed a significant overall effect for NO ₂ and PM _{2.5} on diabetes occurrence (13% and 11% increased risk, respectively). Two cross-sectional studies revealed similar associations. Generally, studies were adjusted for age, gender, body mass, and cigarette smoking.	5
Bambra, 2010	This umbrella review of review level evidence on the wider social determinants of health and health inequalities included an assessment of the impact of water and sanitation interventions on health-related outcomes. Only one review was identified, focusing on the impact of improving water quality through water fluoridation. The review found that fluoridation levels of up to 1ppm had no adverse effects on bone fracture incidence, bone mineral density or bone strength. It did not report any effects on health inequalities.	7
Beard, 2010	While evidence is building to support environmental determinants of older people's health, few of these studies can yet point to specific pathways that may be amenable to intervention. Strategies to foster social engagement of older people through improving access to buildings and public transport, improving walkability, creating destinations that encourage older people to leave their homes, and developing innovative technology such as web-based networking and videoconferencing appear justified.	5
Bonzini, 2010	18 studies were reviewed to assess the association between exposure to ambient air pollution among pregnant women and birth related outcomes Exposure to particulate matter may have potential to adversely affect birth weight. There was also evidence of maternal exposure to air pollution and increased risk of preterm delivery	5
Boothe, 2014	A positive and significant association between childhood leukaemia and high residential traffic exposure during the postnatal period was observed; no association was found for traffic exposure during the prenatal period.	6
Bowler, 2010	This review explored the evidence for a relationship between natural compared to synthetic environments and health and	6

	wellbeing outcomes. 25 studies with post-data were reviewed, with some evidence to suggest that walking or running in a natural environment has more beneficial emotional outcomes (i.e., reduced anger, fatigue and sadness, and increased energy) than walking or running in a synthetic environment. Findings for the effect of natural environments on anxiety and tranquillity were less consistent. There was also some limited support for increased attention after exposure to natural environments, but not following statistical adjustments. There was no evidence for an effect on blood pressure or cortisol concentration.	
CABE, 2009	Stakeholder review identifying strong evidence for a correlation between asthma and levels of nitrogen oxide (NO ₂) in air pollution caused by traffic near the home, resulting in repeated hospital encounters. The review also highlights that proximity to green space may influence people physical activity levels. Extremes of heat and cold are reportedly associated with potentially fatal illness, such as heat stress or hypothermia, as well as increasing death from heart and respiratory diseases. Stagnant weather can also cause warm and cold air to become trapped, leading to smog which can lead to negative health consequences. The quality and extent of evidence is not reported in this document, meaning that caution is required when interpreting these findings.	N/R
Calogiuri, 2014	This review explored the impact of access to open green spaces on physical activity. 90 studies were reviewed. Physical activity in open green spaces was positively associated with benefits to positive emotions and psychological states, compared with physical activity in an indoor or urban setting. Numerous cross-sectional studies reported that the availability of open green spaces within the living environment is generally associated with higher levels of physical activity. However, some studies reported null associations and one reported a negative association. Increased availability to open green spaces was associated increased motivation to engage in physical activity. Overall, caution is needed when interpreting these findings as causal relationships can only be drawn from a few studies included within the review.	4
Chen, 2014	This review assessed the relationship between air pollutants and a range of congenital anomalies and revealed a significant association between coarctation of aorta and exposure to NO ₂ . The review did not identify any further significant associations. The authors acknowledge several limitations associated with the quality of the evidence – ranging from small sample size, to application of differing methodologies, to limited consideration of confounding factors.	5
Clark, 2007	The impact of green space and noise on mental health and wellbeing was assessed. There was mixed moderate-quality evidence for a relationship between chronic aircraft noise and mental health outcomes among <u>children</u> . For <u>adults</u> , exposure to road traffic noise was associated with higher anxiety, but not depression scores over five years. These studies were of moderate quality. There was some evidence from four studies with <u>adults and children</u> that access to green or open spaces is associated with better mental health. However, caution is required as these studies were all cross-sectional and deemed to be of low quality.	6
Davison, 2006	Presence of recreational infrastructure was associated with physical activity among children. However, findings were less consistent.	5
Deng, 2016	This review explored the relationship between ambient air pollution and sperm quality. Nine (of 10) studies reported that both PM _{2.5} and PM ₁₀ were negatively associated with sperm quality, affecting sperm concentration, count, morphology, and motility. Meta-analysis of six studies revealed that although there were no statistically significant differences in sperm quality among highly exposed compared with low exposure, the authors suggest that the overall trend is of importance.	6
DiGuseppi, 2011	17 housing interventions designed to affect safety and injury outcomes were reviewed. Three (of 17) interventions (working smoke alarms among general population, 4-sided isolation pool fencing for children, pre-set safe hot water temperature for	4

	children) provided sufficient evidence of effectiveness for improving safety and injury outcomes. The remaining interventions either require further exploration to determine effectiveness (12) or were found to be ineffective (three-sided pool fencing for children) (1).	
Dunton, 2009	15 studies were reviewed to examine the association between the built environment and obesity in children. Access to equipment and facilities, neighbourhood pattern and urban sprawl were associated with obesity in adolescents. Association between the environment and obesity in children differed by demographic characteristics of children. Children from low-socioeconomic status families were reported to have lower BMI than children from high income families	4
Eze, 2015	A meta-analysis of seven studies revealed the risk of type II diabetes mellitus (T2DM) per 10 $\mu\text{g}/\text{m}^3$ in $\text{PM}_{2.5}$ and NO_2 were 1.10 (95% CI 1.02, 1.18) and 1.08 (95% CI = 1.00, 1.17) respectively. The effect was found to be more pronounced among females (NO_2 - 1.15 (95% CI = 1.05, 1.27; $\text{PM}_{2.5}$ - 1.14 (95% CI = 1.03, 1.26)) per 10 $\mu\text{g}/\text{m}^3$ increase in exposure. Authors acknowledge the possibility of bias but also stress the positive association between traffic-related air pollution and T2DM.	6
Faulkner, 2009	This article reviewed 13 studies to assess the association between active school transport and weight related outcomes among children and youth. 11 out of 13 studies found that active school commuters were more physically active than passive commuters. However, evidence of association between active transport to school and body weight in children was inconclusive as only 1 study out of 10 showed a positive association between active school transport and reduction in body weight. Over-reliance on cross-sectional studies	5
Favarato, 2014	This review of the association between exposure to nitrogen dioxide (via traffic pollution) and 12 month prevalence period of asthma symptoms or diagnosis in children. Fourteen of 20 articles demonstrated a positive association but only two were found to be statistically significant. The contribution to incidence, prognosis and severity remain unclear.	4
Frutos, 2015	This review assessed the relationship between air pollution and fertility. Seven studies of human health were reviewed and demonstrated moderate-level evidence for the negative impact of exposure to air pollution on miscarriages and clinical pregnancy rates among the general population. Notably, exposure to high air pollution did not influence clinical pregnancy or implantation rates in IVF patients. However, exposure to high air pollution was associated with a significant increase in miscarriage among IVF patients. The authors of the review identify that the lack of prospective studies in this area exploring the association between air pollution and live births is an important limitation.	5
Gascon, 2015	This review explored the relationship between exposure to green and blue spaces and mental health outcomes. 28 studies were eligible and subsequently reviewed. 22 studies evaluated the mental health benefits of surrounding greenness. Among studies of children, 1 (in 4) was associated with reduced emotional and behavioural problems. Overall, however, due to the limited available evidence, the causal relationship was deemed inadequate. For adults, most studies observed a reduced risk of poor mental health with increasing surrounding greenness. Overall, the evidence was classed as limited. Evidence for access to green spaces for studies of adults and children was considered inadequate, as was evidence on the influences of the quality of green and blue spaces.	7
Gascon, 2016	This review assessed the relation between residential green spaces and mortality-related outcomes. Twelve studies were reviewed, revealing that the risk of mortality from cardiovascular disease (CVD) was statistically reduced in five of eight studies evaluating CVD and residential greenness. However, the reduction was small. Changes in all-cause mortality were less consistent, with some studies reporting positive associations, some null and some negative results. There was no indication that residential greenness is associated with a reduction in lung cancer mortality. Overall study quality was moderate to high.	7
Hajna, 2015	Adults living in high compared to low walkable neighbourhoods accumulated 766 more steps per day (95 % credible interval	4

	250, 1271). This accounts for approximately 8 % of recommended daily steps.	
Hamra, 2014	This review and meta-analysis of 18 studies explored the associations between outdoor particulate matter exposure and lung cancer incidence and mortality. The meta-relative risk for lung cancer associated with PM _{2.5} was 1.09 (95% CI = 1.04, 1.14), and for PM ₁₀ 1.08 (95% CI = 1.00, 1.17). This review was based on the results from cohort and case-control studies, but there was no quality appraisal of the individual studies included in the review.	5
Hamra, 2015	This review and meta-analysis of 20 studies explored the associations between nitrogen dioxide and traffic and lung cancer incidence and mortality. The meta-relative risk for lung cancer associated with a 10 µg/m ³ increase in NO ₂ exposure was 4% (95% CI = 1%, 8%), and for NO _x was 3% (95% CI = 1%, 5%). This review was based on the results from cohort and case-control studies, but there was no quality appraisal of the individual studies included in the review.	5
Hu, 2014	This review and meta-analysis explored the relationship between exposure to ambient air pollution and hypertensive disorders of pregnancy (HDP). Ten studies were reviewed and included in meta-analysis. The risk of HDP and preeclampsia were found to be positively associated with exposure to NO ₂ (OR per 10 ppb = 1.16, 95% CI = 1.03, 1.30 and 1.10, 95% CI = 1.03, 1.17, respectively) during the entire pregnancy. Significant associations between HDP and exposure to CO and O ₃ during the first semester were also observed (OR per 1 ppm = 1.79, 95% CI = 1.31, 2.45 and 1.09, 95% CI = 1.05, 1.13, respectively). This review was based on the results from cohort and case-control studies, but there was no reporting of the results of the quality appraisal of individual studies included in the review.	6
Hunter, 2014	12 studies were included in review of intervention to promote physical activity in urban green space. Built environment only interventions were effective (4/9 studies) in encouraging use and increasing physical activity in urban green space. However, the evidence was stronger (3/3) for interventions that combined physical activity initiatives with improvement in built environment. Improving the quality of urban green space significantly increased visitation and level of physical activity	6
Jafta, 2015	Five case-control and three cross-sectional studies were reviewed. Meta-analysis showed that exposure to environmental tobacco smoke was associated with tuberculosis infection (OR=1.9. 95% CI=1.4-2.9)	7
Janghorbani, 2014	Exposure to air pollution was associated with an increase in the risk of diabetes and susceptibility of diabetic people to air pollution. The evidence was stronger for gaseous pollutants than for particulate matter.	5
Kabisch, 2015	This review explored human-environment interactions in urban green spaces. The reporting of the impact of green spaces on health and wellbeing is limited in this review, with no information provided on study designs and specific populations under investigation. Thirty papers were assessed the impact, with authors summarising that results from studies are often contradictory and based on self-reported outcomes. Generally urban green spaces were found to have a positive impact on health outcomes, but there were findings that did not identify a link between green space availability and general health.	4
Koranteng, 2007	13 Canadian studies were identified. Air pollution may be associated with adverse respiratory health effects in children, adverse pregnancy outcomes and contribute to infant mortality in Canada	3
Lacasana, 2005	31 studies reviewed. An increase of 10µg/m ³ of PM 10 is associated with 5% increase in post-neonatal mortality for all causes and about 22% for post-neonatal mortality associated with respiratory disease. Exposure to air pollution during pregnancy was also associated with damage to foetal health, although findings were inconsistent in some cases	4
Lee, 2010	This review of the health effects of urban green space revealed low/moderate level evidence for the links between physical and mental health and urban green space. Modification of the built environment to provide green space offers an opportunity for engagement in physical activity. Evidence for the links between physical activity and green space availability is weaker.	6

	Much of the literature on the mental health benefits of green space were drawn from qualitative and grey literature sources, and it is of varying quality. The impact of age and other socio-demographic factors was inconsistent and was suggestive of a complex relationship. Overall study quality was described as weak.	
Liu, 2015	An increase in PM _{2.5} and PM ₁₀ by 10µg/m ³ was associated with a corresponding increase in carotid intima-media thickness (CIMT) of 16.79µm (95% CI=4.85-28.63µm) and 4.15µm (95% CI=-5.70-14.04) respectively	5
Luo, 2015	31 observational studies reviewed. Risk of myocardial infarction was significantly associated with exposure to 10ug/m ³ increment of PM ₁₀ (OR=1.005; 95% CI= 1.001-1.008) and PM _{2.5} (OR=1.22; 95% CI-1.015-1.030).	5
Mackenbach, 2014	Urban sprawl and land mix use were associated with weight status, albeit, this finding was only consistent for North American studies	7
McClure, 2008	This review assessed changes in medically treated fall-related injuries among older adults following implementation of a community based intervention. Built environmental aspects of these interventions included home hazard reduction, improved lighting and home visits. All six prospective community-levels studies reported a significant decrease or downward trend in fall-related injuries among older adults. It is unknown which aspects of the interventions were effective. Included studies were controlled before-and-after studies – not RCTs – raising questions about the methodological rigour.	7
McCormack 2011	Land use mix, composite walkability and neighbourhood type were consistently associated with higher physical activity levels even after controlling for neighbourhood self-selection. The built environment was found to be more supportive of walking and cycling than of physical activity more generally. Evidence from quasi-experimental studies suggests changes in the built environment can precede changes in physical activity (increased cyclist activity after the instalment of cycling infrastructure, increased walking, cycling, and other physical activity after instalment of a greenway trail, increased pedestrian activity following instalment of street lighting and increased first time park user following park upgrades).	5
Mehta, 2011	74 studies were included in the review. Meta-analysis found 1.12 increase in risk of acute lower respiratory infection following 10ug/m ³ increase in annual average PM _{2.5} concentration	4
Menichini, 2010	The aim was to investigate the association between drug consumption statistics and short-term air pollution measurement. 21 (ecological and panel studies) articles were reviewed. Although there were associations between variation in drug use and air pollution, the findings were not statistically significant	5
Najafi, 2015	11 articles estimating the impact of air pollution on sperm parameters were included in meta-analysis. Air pollution reduces sperm motility by 39.4%±5.52 but has no impact on other sperm gram parameters	4
Oja, 2011	Cross-sectional and longitudinal evidence showed association between cycling and cardiovascular fitness in youth. 6 studies found consistent dose-response gradient between amount of time spent on cycling and health gain. High strength of association for the link between cycling and cardiorespiratory fitness in adults (2 high quality RCTs and 1 high quality CCT), moderate association between cycling and reduction in cardiovascular risk factors, inconclusive for all course mortality, cancer risk, overweight and obesity	7
Pedersen, 2014	Meta-analysis of 17 studies estimated combined odds ratio associated with 5µg/m ³ increase in PM _{2.5} was 1.57 (95% confidence interval, 1.26-19.6) for combined pregnancy-induced hypertensive disorders and 1.31 (95 CI, 1.14-1.50) for preeclampsia	4
Peters, 2015	Eight studies included in review. There was an association between exposure to air pollution and prevalence of poor cognitive function. 1 (out of 2) study found an association between incident of cognitive decline and exposure to air pollution	6

Rodriguez-Villamizar, 2015	27 studies were included in review. All studies though heterogeneous in design, reported adverse health effects of outdoor air pollution at doses below the Canadian and United States standards	7
Sandel, 2010	14 housing interventions designed to improve health outcomes related to exposure to chemical agents were reviewed. Four interventions (radon air mitigation using active soil depressurisation systems, integrated pest management to reduce exposure to pesticides, smoke-free home policies making indoor areas smoke-free and residential lead hazard control) were deemed to demonstrate evidence of effectiveness. The remaining interventions either require further exploration to determine effectiveness (7) or were found to have no evidence of effectiveness or be ineffective (3).	4
Scheers, 2015	The pooled hazard ratio associated with 10 μ g/m ³ increase in PM ₁₀ was 1.061 (95% CI=1.018-1.105) and 1.080 (0.992-1.177) for stroke incidence and stroke mortality respectively. The hazard ratio associated with 5 μ g/m ³ increase in PM _{2.5} in Europe and North America combined were 1.064 (1.021-1.109) and 1.125 (1.007-1.256) for stroke events and mortality respectively. This suggests that PM _{2.5} in particular is a significant risk factor for stroke.	6
Shah, 2015	Stroke hospital admission and mortality was associated with an increase in concentration of carbon monoxide (RR=1.015 per 1ppm), Sulphur dioxide (RR=1.019 per 10ppb) and nitrogen dioxide (1.014 per 10ppb). Increases in PM concentration was also associated to a lesser extent with stroke admissions and mortality 1.011 per 10 μ g/m ³ of PM _{2.5} and 1.003 per 10 μ g/m ³ of PM ₁₀	5
Song, 2014	Outdoor air pollution was associated with higher incidence and prevalence of COPD. Short term exposure to outdoor air pollution was significantly associated with 6%, 1% and 1% increased risk of COPD mortality in European Union, USA and China. Chronic exposure to PM increased risk of COPD mortality by 10%.	4
Stanke, 2012	The aim of this review was to summarise the effect of flooding on mental health. 48 papers were included in this study. The authors found that flooding affects people of all ages and can worsen mental health outcomes. Flooding can lead to either short term or long-term symptoms (distress) that is difficult to distinguish from symptoms of common mental disorders	4
Stieb, 2012	Majority of the 62 studies included in meta-regression confirmed association between reduced birth weight, increased odds of low birth weight and exposure to carbon monoxide, nitrogen dioxide and particulate matter (PM ₁₀ or PM _{2.5}). The effect size was greater for estimates based on entire pregnancy exposure where the pooled estimate on decrease in birth weight ranged from 11.4g per 1ppm CO to 28.1g per 20ppt NO ₂ .	6
Teng, 2013	5 out of 8 studies reported significant associations between PM, particularly PM _{2.5} and out-of-hospital cardiac arrest (OHCA). The increased risk of OHCA ranged from 2.4% to 7% per interquartile increase in average PM exposure	7
Thompson Coon, 2011	The review found positive effects on self-reported mental wellbeing following exercise in natural environment compared to indoor exercise	7
Turner, 2010	15 studies were included in meta-analysis. Exposure during pregnancy to insecticide and herbicides were positively associated with childhood leukaemia (OR=2.05 for insecticide exposure, OR=1.61 for herbicide exposure). Exposure during childhood to unspecified residential pesticide (OR= 1.38) and herbicides (OR=1.61) were also associated with childhood leukaemia	7
Van Cauwenberg, 2011	The evidence for the relationship between environmental characteristics (such as perceived walkability, access to services and cycling infrastructure) and physical activity among older adults was highly inconsistent. Land use mix and crime-related safety was associated with increased walking in some studies	5
Van Holle, 2012	70 Europe-specific studies were included in review. Elements of the physical environment such as walkability, access to	5

	services/shops and composite factor environmental quality showed strong positive association with physical activity. Other factors such as access to re-recreational facilities, traffic, and crime-related safety were reported to be unrelated to physical activity in Europe. The that some aspect of the physical environment is associated with physical activity is consistent with results from North American/ Australian reviews	
Vienneau, 2015	10 studies were examined to evaluate the association between transportation noise exposure and risk of ischaemic heart disease. Meta-analysis revealed a 6% increase in ischemic heart disease per 10dB Lden increase in noise exposure	5
Vrijheid, 2011	All included studies reported increased risk of congenital anomalies following exposure to a combination of pollutants. Meta-analysis showed that 10ppb nitrogen dioxide and 1ppb sulphur dioxide exposures were related to increases in risk of coarctation of the aorta (OR=1.17 95%CI=1.00-1.36 and OR=1.07, 95%CI=1.01-1.13)	5
Waite, 2014	A review study to describe ways people may be poisoned by carbon monoxide following a flood. 23 studies were included in the review. The authors identified a key issue of under-reporting of flood related poisoning. The evidence identified 3 situations whereby flooding can result in carbon monoxide poisoning; pre-disaster, emergency/recovery phase and post-recovery/delayed phase. Indoor use of portable generators, cooking and heating appliances designed for outdoor use during periods of loss of mains power or gas was identified as a crucial concern. Equipment for pumping, dehumidifying and drying out of properties was also identified as a risk factor.	4
WHO, 2005	This review collates the best available evidence for the impact of housing improvements on health outcomes. Increases in indoor air pollutants are associated with poorer general health outcomes for the elderly and asthmatics. However, the impact of improved indoor air quality and reduced dampness has yet to be fully assessed. Improvements in energy efficiency have led to small improvements in general health and respiratory outcomes among asthmatic children. Prevention of lead exposure is identified as the most effective way to avoid lead poisoning. Appropriate installation and maintenance of smoke alarms required to prevent fire-related injury and death. The health impact of noise reduction has not been fully assessed. No studies identified to explore the link between housing tenure and health. Increased housing satisfaction following housing improvements strongly associated with improvements in mental health. Increased housing costs can lead to poorer diets and reduced employment opportunities.	5
Xu, 2013	Active transport to work/school (walking, cycling or public transportation) showed significant association with improved cardiovascular health, this finding was consistent in 15 out of 16 studies. 3 out of 4 cross-sectional studies found that active travel to and from school was associated with lower BMI. 1 longitudinal study and 1 systematic review found strong evidence of inverse relationship between active transport and BMI. The evidence was mixed in two other systematic reviews and 1 narrative review. No strong evidence on active transport and mental health	7

Note. (a) = total scores for MQC (systematic reviews): 1-3 = low quality, 4-5 = moderate quality, 6-7 = high quality or MQC-SP (for stakeholder documentation): 1-3 = low quality, 4-5 = moderate quality, 6 = high quality.

Appendix G. Detailed evidence: Transport

Table 17. Quality assessment of reviews

First author	Research question ^a	Search strategy ^b	Inclusion/exclusion criteria ^c	Study details ^d	Quality assessment ^e	Synthesis ^f	Independent review ^g	Score (n=7)
Aeron-Thomas	Y	Y	Y	Y	Y	Y	Y	7
Annear	Y	Y	Y	Y	Y	Y	Unclear	6
Beyer	Y	Y	Y	Y	Y	Y	N	6
Cairns	Y	Y	Y	Y	Y	Y	Y	7
Carlin	Y	Y	Y	Y	Y	Y	Y	7
Chilon	Y	Y	Y	Y	Y	Y	Y	7
Clark	Y	Y	N	N	Y	Y	Y	5
D'Haese	Y	Y	Y	Y	Y	Y	Y	7
Davison	Y	Y	Y	N	Unclear	Y	Y	5
Elvik	Y	Y	Y	Unclear	Y	Y	Unclear	5
Faulkner	Y	Y	Y	Y	N	Y	Unclear	5
Fraser	Y	Y	Y	Y	Y	Y	Y	7
Gascon	Y	Y	Y	Y	Y	Y	Y	7

Grasser	Y	Y	Y	Unclear	Y	Y	Y	6
Hanson	Y	Y	Y	Y	Y	Y	N	6
Hosking	Y	Y	Y	Y	Y	Y	Y	7
Høye	Y	Y	N	Y	Y	Y	Unclear	5
Ker	Y	Y	Y	Y	Y	N	Y	6
Larouche	Y	Y	Y	Y	Y	Y	Y	7
McGrath	Y	Y	Y	Y	Y	Y	Unclear	6
Mueller	Y	Y	Y	Y	N	Y	Y	6
Oja	Y	Y	Y	Y	Y	Y	Y	7
Pilkington	Y	Y	Y	Y	Y	Y	Y	7
Porchia	Y	Y	Y	Y	Y	Y	Unclear	6
Rothman	Y	Y	Y	Y	Y	Y	Y	7
Thompson	Unclear	Y	N	N	Y	Y	Unclear	4
Vienneau	Y	Y	Y	Y	N	Y	Unclear	5
Wanner	Y	Y	Y	Y	Y	Y	N	6
Wilson	Y	Y	Y	Y	Y	Y	Y	7
Xu	Y	Y	Y	Y	Y	Y	Y	7

Note. (a) = Is there a well-defined question? – The question should define at least the participants, the intervention, the outcomes and the study designs; (b) = Is there a defined search strategy? – The search strategy should include at least one named database combined with reference checking, hand searching, citation, follow-up or expert contact; (c) = Are inclusion / exclusion criteria stated? – The review should make the grounds for study inclusion and exclusion transparent in terms of participants, intervention, outcomes and study design; (d) = Are the primary study designs and number of studies clearly stated? – The review should outline the designs of included studies and make it clear which and how many studies are in the final synthesis; (e) = Have the primary studies been quality assessed? – The review should clearly describe the quality assessment process, which quality appraisal tool is used, and the relative quality of each included study; (f) = Have the studies been appropriately synthesised? – The review should use meta-analysis or narrative synthesis, whichever is most suitable given the heterogeneity of studies and their methodological quality. If studies are very heterogeneous, narrative synthesis is appropriate; (g) = Has more than one author been involved at each stage of the review process? – To minimise bias, the review should have at least two reviewers involved in each stage (study selection, data extraction, quality appraisal, synthesis) of the review.

Table 18. Description of systematic reviews and stakeholder documentation included within this umbrella review

First author, year of publication	Type of paper^a	Number of original studies	Design of original studies^b	Population	Health outcome(s)	Location(s)	Synthesis method	Quality of evidence^c
Aeron-Thomas, 2005	1	10	cBA	All road users	Road traffic casualties and crashes	Australia, Singapore, USA	Meta-analysis	Moderate
Annear, 2014	1	83	C-S, L, RCT	General population	Mortality, longevity, mental health, functional ability, morbidity	America, Europe, Australia, Asia	Narrative	N/R
Beyer, 2009	1	17	cBA	General	RTCs, Injuries, road traffic speed	USA-10, UK-4, Australia-2, Germany-1	Meta-analysis	Low
Cairns, 2014	1	5	S-R	All ages	Health and socio-economic status outcomes	UK-4	Narrative	Moderate-high
Carlin, 2015	1	12	RCT-7, Q-5	Children and adolescent age 5-18	Walking, physical activity	UK-4, USA-5, Australia- 2, Taiwan-1,	Narrative	Mixed (low, moderate and high)

Chilon, 2011	1	14	RCT, Q	6-18 years	Active transportation, physical activity	USA-8, Australia-3, UK-2	Narrative	Low-3 Moderate-8 High-3
Clark, 2007	1	99	C-S, Qual (n=1), reviews	Adults, children, older adults	Mental health	HICs	Narrative	Poor/moderate
D'Haese, 2015	1	68	C-S, C-C	6-12 year	Walkability	North America, Europe.	Narrative	High
Davison, 2006	1	33	C-S	Children age 3-18 years	Physical activity	USA, UK, Portugal, Canada, Australia,	Narrative	N/R
Elvik, 2005	1	13	N/R	General population	Road safety	N/R	Meta-analysis	Moderate
Faulkner, 2009	1	13	C-S	Children	Physical activity, body weight	USA, Philippines, Australia, UK-4, Denmark-2, New Zealand-1	Narrative	N/R
Fraser, 2011	1	21	C-S, Q	General population	Active travel, cycling	USA, Australia, UK, Canada, Netherlands	Narrative	Low to moderate
Gascon, 2015	1	12	Eco, C, CS	Adults and children	Mortality-related outcomes	UK, US, Oceania, Canada, Lithuania	Narrative	Moderate/High
Grasser, 2013	1	34	Unclear	Health white adults >19 years	Walking, cycling, weight-related measures	N/R	Narrative	Moderate-high
Hanson, 2015	1	42	RCT, Q, C-T, C-C	N/R	Weight-related outcomes	USA, UK, Australia	Meta-analysis	Moderate-High
Hosking, 2010	1	17	RCT, cBA	Working age adults, tertiary students or school-aged children	Any health outcome, Physical activity, change in mode of transport, health inequality	UK-11, USA-3, Japan-1, Ireland-1, Australia-1	Narrative	Low-moderate
Høyve, 2014	1	19	cBA	General population	Crash reduction	UK-6, Australia-3, USA-3, Belgium-1, Spain-1, Netherlands-1, New Zealand-1, Italy-1	Meta-analysis	N/R
Ker, 2005	1	21	RCT-21	Drivers with licence	Traffic offenses, traffic crashes, injury crashes	USA	Meta-analysis	Low- moderate
Larouche,	1	73	C-S, RCT, C-C	N/R	Physical activity,	UK, USA, Sweden,	Narrative	Moderate

2014					cardiovascular fitness	Denmark, Portugal, Philippines		
Mayne, 2015	1	37	CS, L	unspecified	Physical activity, diet/nutrition	US-30, UK-2, Australia- 2, Canada-2, New Zealand-2, Chile-1	Narrative	Moderate
McGrath, 2015	1	23	CS	5-17 years	Physical activity	U.S-12, England-5, Australia-3, Belgium-1, Canada-1, New Zealand-1	Meta-analysis	Moderate
Mueller, 2015	1	30	HIA, CBA	N/R	Known health impact	USA, Netherlands, Spain, UK, Australia, Norway	Narrative	N/R
Oja, 2011	1	16	C-S, Case-C, C-C, RCT	General population	Cardiorespiratory fitness, cardiovascular risk factors, all-cause mortality	Germany, Australia, Denmark, UK, China, USA	Narrative	Low-4 Moderate-5 Strong-7
Pilkington, 2005	1	14	uBA, cBA		Collison, injuries and death	Canada, Norway, UK, New Zealand, Australia	Narrative	Low-moderate
Porchia, 2014	1	8	S-R Qualitative reviews-4	General population	Traffic accidents	USA, UK, Australia, Holland, Canada, Sweden,	Qualitative synthesis	Moderate to high
Rothman, 2015	1	85		Children age 0-12	Safe walking, child pedestrian injury	Western Europe, Australia, Japan, North America, New Zealand	Narrative	Low to moderate
Thompson, 2008	1		S, C-S		Injuries, death, mental health, physical fitness, air pollution, noise pollution, social exclusion, safety	N/R	Narrative	N/R
Vienneau, 2015	1	10	Case-C, Cohort,	Male and female	Ischemic heart disease	Europe	Meta-analysis	N/R
Wanner, 2012	1	46	C-S,	Adults≥18 years	Physical activity, body weight	Europe, North America	Meta-analysis/ Narrative	Low
Wilson, 2010	1	35	cBA	All road users	Speeding, road traffic casualties and crashes	USA-5, UK-6, Australia-10,	Narrative	Low-moderate

						Germany-1, Denmark-1, Finland- 1, Hongkong-1, Spain-1		
Xu, 2013	1	19	C-S, S-R, C-S	Children and adults	Body weight, cardiovascular health, cancer, mental health and injury	Unclear	Narrative	Mixed (low, moderate and high)

Note. (a) 1 = systematic reviews, 2 = stakeholder documentation; (b) RCT = Randomised controlled trial, CR-CS = Controlled repeat cross-sectional, Q = Quasi-experimental, C-C = Controlled-cohort, C-T= Controlled trial; C-S=Cross-sectional, Case-C=case control, uBA= uncontrolled before and after Study, cBA= uncontrolled before and after Study, S-R=Systematic review, HIA= Health Impact Assessment, CBA= Cost Benefit Analysis (c) high, moderate, low based on authors assessment of study quality.

Table 19. Main findings from systematic reviews and stakeholder documentation included within this umbrella review

First author, year of publication	Main findings	Quality ^a
Aeron-Thomas, 2005	10 controlled before and after studies were reviewed to access the effectiveness of red light cameras for the prevention of road traffic collisions. Red light cameras were reported to be effective in reducing total casualty crashes. All studies included in this review were from Singapore, Australia and US	7
Annear, 2014	83 studies exploring the evidence for environmental influences on older adult health and activity participation were reviewed. Street lightning, level of pollution, traffic conditions, accessibility and appropriateness of services, exposure to natural settings and pedestrian infrastructure were significantly associated with activity participation in older adults	6
Beyer, 2009	A review of 17 controlled before-after studies on the effectiveness of street lighting in preventing crashes found positive evidence (low quality) for the effectiveness of street lighting in preventing road traffic crashes, injuries and fatalities	6
Cairns, 2014	Authors performed an umbrella review of 5 systematic reviews to access the link between 20 mph zones and health/ health inequalities. 4 of the 5 systematic reviews included were of good quality while the fifth was of moderate quality. Evidence strongly supports that 20 mph zones are effective in reducing accidents and injuries. However, no direct evidence of impact of 20 mph limits on health inequalities	7
Carlin, 2015	A review of 12 studies to access the effectiveness of interventions to promote walking in children and adolescents. Walking interventions in school increased physical activity levels in children and adolescents. 9 out of 12 studies found significant increase in walking in intervention group compared to control group. 7 RCT's and 5 Quasi-experimental studies	7
Chilon, 2011	14 studies were investigated to determine effectiveness of interventions to promote active transport to schools (mostly primary school children). Interventions designed primarily to promote active transport to school were found to be more effective than those with a broader focus. However, most of the interventions reported a small effect size on active transportation (6/14).	7
Clark, 2007	Consistent association found between urban birth and schizophrenia, as well as an association between rural residence in adulthood and suicide rates for males, but not females. Some evidence for an effect of chronic noise exposure on mental health in adults. The evidence for an effect of poor housing on mental health was weak.	5

D'Hease, 2015	A review of 65 studies to determine the environmental characteristics and different contexts of active transports in 6 -12 year olds across different countries. Active transport (walking or cycling) to school was positively associated with walkability (land use mix, residential density and street connectivity). Walking to school was positively associated with walkability, density and accessibility. Association between traffic safety and all forms of active transportation to school was positive. No convincing evidence was found for associations between the physical environment and active transportation during leisure.	7
Davison, 2006	Active transport among children was associated with presence of recreational infrastructure (access to recreational facilities and schools) and transport infrastructure (presence of sidewalks and controlled intersections, access to destinations and public transportation)	5
Elvik, 2005	This article is a meta-analysis of six studies to examine the effects of porous asphalt on road safety. There was no clear association between the use of porous asphalt and road safety. All findings reported were neither statistically significant nor showed great effect size	5
Erke, 2009	Installation of red light cameras led to a 15% increase in the number of crashes, 49% increase in rear end collision and 10% decrease in right angle collisions (right angle collisions are the primary reason for installing red light cameras). However, the results were not statistically significant.	3
Faulkner, 2009	This article reviewed 13 studies to assess the association between active school transport and weight related outcomes among children and youth. 11 out of 13 studies found that active school commuters were more physically active than passive commuters. However, evidence of association between active transport to school and body weight in children was inconclusive as only 1 study out of 10 showed a positive association between active school transport and reduction in body weight. Over-reliance on cross-sectional studies	5
Fraser, 2011	A review of 21 studies to investigate environmental correlates of physical activity associated with cycling showed that dedicated cycle paths, proximity of cycle path, short trip distance, high population density, separation of cycling from other traffic, promoting 'safe route to school' among children were positively associated with cycling. Other factors such as perceived or objective danger, long trip distance, distance from cycle paths, steep inclines had negative impact on cycling. Evidence on the impact of air pollution on active transport was complex. Walkers and cyclists were reported to experience lower direct TRAP exposure than vehicle occupants, however, increased ventilation rate resulting from physical strain can increase the uptake of pollutants by at least twofold. All studies included in this review were observational	7
Gascon, 2015	This review explored the relationship between exposure to green and blue spaces and mental health outcomes. 28 studies were eligible and subsequently reviewed. 22 studies evaluated the mental health benefits of surrounding greenness. Among studies of children, 1 (in 4) was associated with reduced emotional and behavioural problems. Overall, however, due to the limited available evidence, the causal relationship was deemed inadequate. For adults, most studies observed a reduced risk of poor mental health with increasing surrounding greenness. Overall, the evidence was classed as limited. Evidence for access to green spaces for studies of adults and children was considered inadequate, as was evidence on the influences of the quality of green and blue spaces.	7
Grasser, 2013	34 studies were reviewed to explore the association between GIS based measures of walkability and active transport. Population density, intersection density and walkability indexes were associated with measures of physical activity for transport but the association was inconsistent for weight-related outcomes.	6
Hanson, 2015	Walking groups have wide-ranging health benefits. Meta-analysis showed statistically significant reductions in mean difference for	6

	systolic and diastolic blood pressure, resting heart rate, body fat, BMI, total cholesterol and other weight-related health outcomes. Heterogeneity was minimal for 16 health outcomes except for depression (83%)	
Hosking, 2010	Results were inconsistent in most cases. One RCT study found that organisational travel plans improved health related quality of life and increased walking times. The authors indicated that there is insufficient evidence to assess the effectiveness of organisational travel plans in improving health or increasing active transport	7
Høyve, 2014	19 studies investigating the effect of speed cameras and section control on road crashes were included in meta-analysis. Speed cameras reduced total number of road traffic collisions by 20% and number of fatal crashes by 51%. Section control was reported to have higher crash reducing effect than speed cameras (30% reduction). The effectiveness of speed camera in reducing collision declines as the distance between from the camera location increases	5
Ker, 2005	21 randomised control trials investigating the association between post-driver education and road crashes were reviewed. There was no evidence of the effectiveness of post-driver education on prevention of road traffic injuries and crashes. Heterogeneity= 75% at P<0.000001	6
Larouche, 2014	Moderate quality evidence to show that active school transport interventions leads to increase in physical activity. 54/68 studies were cross-sectional. The evidence for the effectiveness of active school transport for cardiovascular fitness is inconsistent and weak	7
Mayne, 2015	Infrastructural improvements for active transport and policies to restrict unhealthy food increased physical activity levels and improved diet. However, studies with weaker designs were more likely to report positive associations to a health outcome of interests.	5
McGrath, 2015	14 studies to explore the relationship between aspects of the built environment and youth moderate to vigorous physical activity were included in meta-analysis. Built environment features designed to encourage physical activity among adolescents do not have the same level of effect among children. Play facilities, parks, playgrounds and walkability showed negative effect on children's activity but positive effects on adolescents' activity.	6
Mueller, 2015	Studies included in this review applied different HIA methodologies, yet findings suggest that active transport can provide considerable net health benefit regardless of geographical context. Increase in physical activity levels from active transport policies or intervention was shown to exceed any the adverse effect of traffic incidents and air pollution	6
Oja, 2011	Cross-sectional and longitudinal evidence showed association between cycling and cardiovascular fitness in youth. 6 studies found consistent dose-response gradient between amount of time spent on cycling and health gain. High strength of association for the link between cycling and cardiorespiratory fitness in adults (2 high quality RCTs and 1 high quality CCT), moderate association between cycling and reduction in cardiovascular risk factors, inconclusive for all cause mortality, cancer risk, overweight and obesity	7
Pilkington, 2005	Speed cameras are effective in reducing RTCs, however, authors reported that the level of evidence is poor due to most studies having inadequate control/comparison group	7
Porchia, 2014	Introduction of graduated driver licensing and interventions to improve pedestrian and cyclist visibility were effective in preventing road traffic collisions	6
Rothman, 2015	85 studies investigating built environment correlates of walking and pedestrian injury among children were reviewed. Traffic calming and presence of recreational facilities/playgrounds showed consistent association with more walking time and lower risk of pedestrian injuries. Other built environment features such as land mix use were associated with higher amount of time spent	7

	walking but also higher risks of injuries. Evidence in many of these areas were inconsistent. 94% of 'walking' studies were cross-sectional while 60% of pedestrian injury studies were cross-sectional.	
Thompson, 2008	Road transport policies and interventions were reported to be effective for prevention of RTC, and injuries. Asides, these outcomes, there is insufficient evidence on the impact of such policies on other health relates related outcomes	4
Vienneau, 2015	10 studies were examined to evaluate the association between transportation noise exposure and risk of ischaemic heart disease. Meta-analysis revealed a 6% increase in ischemic heart disease per 10dB Lden increase in noise exposure	5
Wanner, 2012	5 out of 15 studies found positive link between active transport and all variables of physical activity levels. 13 out of 30 studies reported positive association between active transport and all variables of body weight. However, over-reliance on cross-sectional studies (35/36) and high heterogeneity across studies. Assessment of active transport was based on self-reported measures, However, study heterogeneity, predominantly cross-sectional designs, and crude measures for active transport and physical activity impede quantitative conclusions	6
Wilson, 2012	Speed cameras are effective in reducing the number of RTCs, injuries and deaths. The relative reduction in vehicle speeding following speed camera intervention ranged from 14% to 65% compared to control.	7
Xu, 2013	Active transport to work/school (walking, cycling or public transportation) showed significant association with improved cardiovascular health, this finding was consistent in 15 out of 16 studies. 3 out of 4 cross-sectional studies found that active travel to and from school was associated with lower BMI. 1 longitudinal study and 1 systematic review found strong evidence of inverse relationship between active transport and BMI. The evidence was mixed in two other systematic reviews and 1 narrative review. No strong evidence on active transport and mental health	7

Note. (a) = total scores for MQC (systematic reviews): 1-3 = low quality, 4-5 = moderate quality, 6-7 = high quality or MQC-SP (for stakeholder documentation): 1-3 = low quality, 4-5 = moderate quality, 6 = high quality.