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CHAPTER 2

Built environmental characteristics and diabetes: a systematic review and meta-analysis

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Abstract

Background: The built environment influences behaviour, like physical activity, diet or sleep, that affects the risk of type 2 diabetes (T2D). This study systematically reviewed and meta-analysed evidence on the association between built environmental characteristics related to lifestyle behaviour and T2D risk/prevalence, worldwide.

Methods: We systematically searched PubMed, EMBASE.com, and Web of Science from their inception to June 6th, 2017. Studies were included with: adult populations (>18y); T2D or glycaemic markers as outcomes; and physical activity and/or food environment and/or residential noise as independent variables. We excluded studies: in specific subsamples of the population; focused on built environmental characteristics that directly affect the cardiovascular system; that performed prediction analyses; and that do not report original research. Data appraisal and extraction was based on published reports (PROSPERO-ID: CRD42016035663).

Results: From 11,279 studies 109 were eligible and 40 were meta-analysed. Urban residence was associated with higher T2D risk/prevalence (n=19, OR: 1.40 (95% CI: 1.2-1.6; I^2=83%)) as compared to rural residence. Higher neighbourhood walkability was associated with lower T2D risk/prevalence (n=6, OR: 0.79 (95% CI: 0.72-0.87; I^2=92%)) and more green space tended to be associated with lower T2D risk/prevalence (n=4, OR: 0.91 (95% CI: 0.88–0.95; I^2=0%)). No convincing evidence was found of an association between food environment with T2D risk/prevalence.

Conclusions: An important study strength was the comprehensive overview of literature, but our study was limited by the conclusion of mainly cross-sectional studies. In addition to other positive consequences of walkability and access to green space, these environmental characteristics may also contribute to T2D prevention. These results may be relevant for infrastructure planning.
Introduction

Key risk factors for type 2 diabetes (T2D) are lack of physical activity (PA), an unhealthy diet, and lack of sleep (1, 2). Real-life T2D prevention programmes aimed at changing people's lifestyle behaviours have often been ineffective on the long term (3). An important reason for this may be the focus on individual-level determinants of these lifestyle behaviours, such as motivation and ability, whereas they are also determined by more ‘upstream’ drivers, such as availability and accessibility of healthy options in an individual’s environment. In terms of changing and sustaining healthy lifestyle behaviours, the built environment is of importance (4-7).

Urbanisation is one example of an upstream driver. Urbanisation is associated with less total PA and increased consumption of processed foods, which are high in fat, added sugars, animal products and refined carbohydrates (4, 8). However, urbanisation has also been linked to higher total walking and cycling for transportation (4). Built environmental characteristics such as higher walkability, access to parks, and access to shops and services are consistently associated with higher PA (4, 5). Food built environmental characteristics such as perceived availability of healthy foods, are also associated with higher diet quality. In addition, greater availability of fast-food outlets has been associated with lower fruit and vegetable consumption (9, 10). Other built environmental characteristics have been associated with higher stress and lack of sleep through residential noise, e.g. noise due to road and air traffic (11, 12).

By influencing PA, diet, and sleep, these built environmental characteristics may also affect the risk/prevalence of T2D. Indeed, the diabetes atlas showed higher T2D prevalence in urban versus rural areas (8), and a recent systematic meta-analysis reported similar results for Southeast Asia (13). Two other systematic reviews addressed the association between specific built environmental characteristics and T2D (14, 15). However, one review only included German studies (14), while the second review included a broad range of cardiovascular disease outcomes, but only one study was included that considered T2D as an outcome (15). Regarding residential noise, a recent meta-analysis showed that higher residential noise was associated with higher T2D risk (16).
A comprehensive systematic review and meta-analysis of the current international evidence is thus lacking. This study aims to systematically review the evidence on the association between built environmental characteristics, related to lifestyle behaviours, and T2D risk or prevalence, worldwide. Since characteristics of the built environment may vary alongside country-specific income level, we stratified our analyses by this factor when possible. Meta-analyses were performed when ≥3 studies investigated the same exposure and outcome.

Methods

Data sources and searches
A literature search was performed based on the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement (www.prisma-statement.org). We systematically searched the bibliographic databases PubMed, EMBASE.com, and Web of Science Core Collection from their inception to June 6th, 2017 (NdB and LS). Search terms included indexed terms from MeSH in PubMed, EMtree in EMBASE.com, as well as free text terms. We used free text terms only in Web of Science. Search terms expressing ‘diabetes’ were used in combination with search terms comprising ‘environment’. Bibliographies of the identified articles were hand-searched for relevant publications. Duplicate articles were excluded. The full search strategies for all databases can be found in Supplementary file 1. The protocol and search strategy used was uploaded to PROSPERO prior to the study being carried out (ID: CRD42016035663).

Study selection
Two reviewers independently screened titles, abstracts and full-text articles for eligibility (NdB and JL, or JBe). Studies were included if they: (i) studied a population of adults, 18 years or older; (ii) had T2D incidence or prevalence, or the glycaemic markers glycated haemoglobin (HbA1c), glucose, or insulin sensitivity as outcomes; (iii) included independent variables covering built environmental characteristics that potentially influence the risk of T2D via lifestyle behaviours, PA, diet and sleep; and (iv) were written in English, Dutch, or German. We excluded studies if they: (i) were not conducted in the general population, but in specific subsamples, like pregnant women, or T2D patients; (ii) focused on built environmental characteristics that directly
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(i.e. not via lifestyle behaviours) affect the cardiovascular system, such as exposure to particulates due to roadway proximity; (iii) performed prediction analyses; and (iv) were specific publication types that do not report original scientific research (editorials, letters, legal cases, interviews). As in the general population the vast majority of diabetes cases are T2D (>90%), studies were included if they did not specify type of diabetes (Type 1 Diabetes Mellitus or T2D). Inconsistencies in study selection were resolved through consensus with a third reviewer (JL or JBe).

Data extraction
One reviewer (NdB) performed data extraction, according to a standard protocol, including measures of study design, outcome, outcome assessment and exposure assessment, demographics, and prevalence or effect measure. Data extraction was appraised by a second reviewer (JL) for a random subsample of the included studies.

Quality assessment
Two reviewers (NdB and JBe or JL) independently evaluated the methodological quality of the full-text papers using the Quality Assessment Tool for Quantitative Studies, as described earlier by Mackenbach et al. (17). This tool provides a quality score based on study design, representativeness at baseline (selection bias) and follow-up (withdrawals, drop-outs), confounders, data collection, data analysis, and reporting. Each domain received a weak, moderate, or strong score, resulting in seven scores. A study was rated as strong if it received four strong ratings and no weak ratings. Second, a study was rated as moderate if it received one weak rating and less than four strong ratings. Finally, a study was rated weak if it received two or more weak ratings. Study quality was assessed in terms of the reported association between the relevant built environmental characteristic and T2D, even if this was not the primary analysis presented in the study. Studies with a weak rating (n=23) are presented in Supplementary file 2 and were included in sensitivity analyses, but excluded from the main analyses.

Data synthesis
Study characteristics were described in a systematic manner, according to the built environmental characteristics under investigation. These categories were made as
homogeneous as possible, based on the lifestyle behaviours. Findings were further described according to country-level income, based on the World Bank list of economies, 2016 (18).

Studies were meta-analysed when ≥ 3 studies investigated the same exposure and outcome variables. In addition, the studies had to provide at least age and sex adjusted or standardised risk ratios or prevalence, and have a moderate or strong quality rating. If reported ratios were stratified and could not be pooled with the information provided in the publication, the study’s authors were contacted and asked to provide the pooled-risk ratio (19-23). Reference categories were harmonised by taking the inverse of the risk ratio and 95% confidence interval (95% CI). In case a risk ratio for a continuous variable was reported, we transformed this to a categorical risk ratio based on the methods of Danesh et al (24). Forest plots and random-effects meta-analyses models were fitted to relative risks or odds ratios. Plots and models were stratified for country-income level and study quality, where permitted. In sensitivity analyses, the studies with weak quality ratings were added to the models. Heterogeneity was tested using $I^2$. Analyses were performed in R version 3.2.5 and using the Metafor package.

**Results**

From the 11,279 identified references, 299 full articles were screened, and 109 of these studies were included in our review, of which 23 were not included in our main analyses due to a weak quality rating (Figure 1, Supplementary file 2). Included studies were categorised according to the built environmental characteristic investigated (Tables 1 and 2), and built environment were subdivided by PA environment, food environment and residential noise (Table 2).
Urban versus rural environment

Sixty studies compared T2D risk/prevalence in urban versus rural environments (Table 1, Supplementary file 2). The studies rated weak (n=16) did not differ in terms of country-income levels from the other studies (25-40).

Of the remaining 44 studies, 25 (57%) of them found a higher risk or prevalence of T2D in urban areas as compared to rural areas. Nineteen studies were eligible for meta-analysis, which revealed a significantly higher risk/prevalence of T2D in urban areas versus rural areas (1.40 (95% CI: 1.22 – 1.61)) (Figure 2). This association was stronger in studies with strong quality ratings (1.44 (95% CI: 1.18 – 1.75)), as compared to those with
moderate quality ratings (1.38 (95% CI: 1.11 – 1.70)). After stratifying for country-income level, one study was excluded (41) because the subgroup contained fewer than three studies. Associations were not different for upper-middle income countries (1.49 (95% CI: 1.16 – 1.92)) and lower-middle income countries (1.45 (95% CI: 1.20 – 1.74)), but were non-significant for high-income countries (1.16 (95% CI: 0.70 – 1.89)).

Sensitivity analyses that included studies with weak quality ratings (33, 40) did not significantly change the results (Supplementary file 3).

**Physical activity environment**

Thirty studies investigated PA environment (19-22, 42-64) (Figure 1, Table 2, Supplementary file 2). All studies were performed in high-income level countries, except for one, which was performed in an upper-middle level income country (49).

Ten studies investigated the association between neighbourhood walkability and T2D risk/prevalence. Six studies received a strong quality rating (20, 48, 57, 58, 62, 65). Six studies observed that highly walkable neighbourhoods were associated with a lower T2D risk/prevalence (19-22, 45, 54, 65). In the meta-analyses of six studies, a pooled-risk ratio of 0.79 (95% CI: 0.72 - 0.87) was found, with an I² for heterogeneity of 91.9%.

Six studies investigated the association between facilities for PA and T2D risk/prevalence. Three studies received a strong quality rating (48, 49, 61). Four studies did not observe an association between density of facilities and T2D risk/prevalence (46, 48, 49, 61). In two other studies, higher availability of neighbourhood resources for PA was associated with lower T2D risk (47, 63).

Eight studies investigated the association between green space and T2D risk/prevalence. Two studies received a strong quality rating (44, 59). Five studies observed that a higher availability of green space was associated with lower T2D risk/prevalence (44, 54, 59, 64, 66). Three studies did not observe an association (42, 53, 60). In meta-analyses of four studies, more green space was associated with lower T2D risk/prevalence with a pooled-risk ratio of 0.91 (95% CI: 0.88 – 0.95) with an I² for heterogeneity of 0%.
Four studies investigated infrastructure in relation to T2D risk/prevalence. Two studies received a strong quality rating (49, 67). Four studies did not observe an association between connectivity, infrastructure, and road quality and T2D risk/prevalence (49, 56, 68). One study observed that a better transportation infrastructure, defined as more paved roads, was associated with higher T2D prevalence (67).

Four studies investigated the association between safety and T2D risk/prevalence. One study received a strong rating (49). None of the studies showed an association between either traffic safety, or safety from crime and T2D risk/prevalence (49, 50, 56).

**Food environment**

Twenty studies investigated characteristics of food environment (46-48, 51-55, 60, 61, 63, 69-77) (Figure 1, Table 2, Supplementary file 2). All studies were performed in high-income level countries.

Eight studies investigated the association between supermarkets and grocery stores and T2D risk/prevalence. Two studies received a strong quality rating (61, 69). One study observed that greater availability of grocery stores was associated with lower T2D prevalence and that a higher percentage of households without a car located far from a supermarket was associated with higher T2D prevalence (46). A second study observed an unadjusted correlation between a greater distance to markets and lower fasting-glucose levels (53). Five studies did not observe a significant association between availability of supermarkets/grocery stores and T2D prevalence (60, 61, 63, 69, 71, 75). In meta-analysis of three studies (48, 60, 61), a higher density of grocery stores was not associated with T2D risk/prevalence (1.01 (95% CI: 0.98-1.05) I²=0%).

Seven studies investigated the association between availability of fast-food outlets and convenience stores and T2D risk/prevalence. Three studies received a strong quality rating (61, 69, 72). Four studies did not observe an association between availability of fast-food outlets/convenience stores and T2D prevalence (61, 63, 69, 71, 75). A higher availability of fast-food outlets and convenience stores was associated with higher T2D prevalence in two studies (46, 72). Studies could not be meta-analysed because the studies did not investigate consistent outcomes (T2D risk versus markers).
Figure 2: Forest plots of meta-analysis of the association between built environmental characteristics and T2D risk/prevalence. (A) urban versus rural environments, stratified for study quality; (B) urban versus rural environments, stratified for country income level; (C) walkability; (D) green space; (E) grocery stores; (F) noise
C

| Author(s) and Year                          | Relative Risk [95% CI] |
|--------------------------------------------|------------------------|
| Booth (long-term residents), 2013          | 0.76 [0.73, 0.80]      |
| Booth (recent immigrants), 2013             | 0.63 [0.57, 0.70]      |
| Sundquist, 2015                             | 0.84 [0.73, 0.97]      |
| Paquet, 2015                                | 0.88 [0.80, 0.97]      |
| Muller-Remenschneider, 2013                 | 0.95 [0.72, 1.23]      |
| Lee, 2015                                   | 0.86 [0.75, 0.99]      |
| Glazier, 2014                               | 0.75 [0.74, 0.76]      |
| RE Model (I² = 91.9%)                       | 0.79 [0.72, 0.87]      |

D

| Author(s) and Year            | Relative Risk [95% CI] |
|-------------------------------|------------------------|
| Ngorn, 2016                   | 0.92 [0.88, 0.96]      |
| Dalton, 2016                  | 0.81 [0.66, 1.00]      |
| Bodicoat, 2014                | 0.53 [0.35, 0.81]      |
| Axell-Burt, 2014              | 0.94 [0.85, 1.03]      |
| RE Model (I² = 0.0%)          | 0.91 [0.88, 0.95]      |

E

| Author(s) and Year            | Relative Risk [95% CI] |
|-------------------------------|------------------------|
| Gebreab, 2017                 | 1.03 [0.98, 1.09]      |
| Fujiwara, 2017                | 0.97 [0.88, 1.07]      |
| Christine, 2015               | 1.01 [0.96, 1.07]      |
| RE Model (I² = 0.0%)          | 1.01 [0.98, 1.05]      |

F

| Author(s) and Year            | Relative Risk [95% CI] |
|-------------------------------|------------------------|
| Heideman, 2014                | 1.97 [1.07, 3.63]      |
| Dahambov, 2016                | 4.49 [1.38, 14.60]     |
| Eriksson, 2014                | 0.94 [0.33, 2.69]      |
| RE Model (I² = 44.2%)         | 1.95 [0.96, 3.97]      |

Figure 2: Forest plots of meta-analysis of the association between built environmental characteristics and T2D risk/prevalence. (A) urban versus rural environments, stratified for study quality; (B) urban versus rural environments, stratified for country income level; (C) walkability; (D) green space; (E) grocery stores; (F) noise (continued)
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Four studies investigated healthiness of the food environment subjectively or as an index and the association with T2D risk/prevalence. One study received a strong quality rating (48). Two studies focused on the perceived availability of healthy foods, rather than objectively measured availability. One study observed greater self-reported availability of healthy food resources to be associated with lower T2D risk (47). The second study assessed perceived availability, objective availability, and a combination of the two, of which only perceived availability was associated with a lower T2D risk (48). Another study found no association between the presence of food deserts and T2D prevalence (78).

Three studies used a ratio of unhealthful food stores to more healthful food stores, such as the Relative Food Environment Index (RFEI), with a higher value indicating an unhealthier food environment. One study received a strong quality rating (70). This study observed that a higher ratio, i.e. a relatively unhealthier food environment, was associated with a higher risk of T2D. Two studies did not observe consistent associations between RFEI and T2D risk (54, 74).

Six studies used composite measures of PA and food related built environmental characteristics (Table 2, 3, Supplementary file 4). One study received a strong quality rating (79). A summary score indicating the presence of more healthy food resources and PA resources was associated with lower T2D incidence (47). Furthermore, residing in a neighbourhood with physical and social-environmental disadvantages was associated with higher T2D prevalence (79). Clusters of large metropolitan counties, characterised by low population density, median income, low socioeconomic status index, greater access to food observed less T2D (73). Finally, no association was observed between vibrancy index, density, and obesogenicity clusters and T2D risk/prevalence (68, 80, 81).

Residential noise

Five studies investigated the association between residential noise and T2D risk/prevalence. One study received a strong quality rating (82). Four studies observed that higher exposure to residential noise was associated with increased T2D risk/prevalence (82-84, 86), and two studies did not observe an association (56, 85). In meta-analyses of three studies (83, 85, 86), higher exposure to residential noise was not associated with T2D risk/prevalence (1.95 (95% CI: 0.96 – 3.97), I² = 44.2%).
**Discussion**

This systematic review investigated evidence of the association between built environmental characteristics, related to lifestyle behaviours, and T2D risk/prevalence, worldwide. The association between built environmental characteristics and T2D risk/prevalence has been investigated a fair amount, with 84 studies on the subject - although for our review, 23 of these studies were excluded due to their low quality ratings. Urbanisation was associated with a higher T2D risk/prevalence. The evidence for an association between the PA environment and T2D risk was more consistent than it was for the food environment. Higher neighbourhood walkability was associated with lower T2D risk and more green space tended to be associated with lower T2D risk.

First, we observed that residing in urban areas was associated with higher T2D risk/prevalence, in line with the findings of the IDF diabetes atlas (8) and a recent meta-analysis for Southeast Asia (13). Urbanisation describes a process by which inhabitants of a particular region increasingly move to more densely populated areas. Urbanisation is a broad operationalisation of the built environment and includes a range of characteristics such as higher availability of food, facilities, and infrastructure. In general, previous reviews have observed conflicting results with regard to urbanisation (4, 5, 8). Urbanisation has consistently been associated with less PA and unhealthier dietary habits, but also with higher total walking and cycling for transportation (4, 5, 8). The observed heterogeneity in terms of results might be due to the variety in definitions used to classify an urban area, which is distinct for different countries and studies. To account for this, we stratified our analyses by country-income level (18), and the majority (38 out of 60) was conducted in middle-income countries, which reduces the heterogeneity in the included studies. It must be recognised that great heterogeneity in definitions of urban versus rural exists beyond stratification on country-income level. Across countries with the same country-income level, there is a large variety of what urban or rural areas may look like and the populations that reside in these areas. At present there is no homogeneous and generally accepted definition of urban or rural areas and the majority of studies did not include a definition that was used to make this classification.
Second, the present study provides consistent evidence for an association between built PA environment and T2D risk/prevalence. Higher walkability and availability of green space were most consistently associated with lower T2D risk/prevalence. Our results on urbanisation seem contradictory to the lower T2D risk/prevalence associated with greater neighbourhood walkability, since greater walkability is often observed in more urbanised environments (5). These seemingly contradictory results could be explained by the underrepresentation of high-income countries in the urban to rural comparison studies, and the overrepresentation of these countries in walkability studies. The (perceived) walkability of urban area also varies across different parts of the world. So, whereas walkability may be a feature of cities in high-income regions, this may not be the case in cities in lower-income regions. Furthermore, urbanisation is a much broader construct than walkability, and even within one urban area, walkability may differ between or even within neighbourhoods. In addition, other urbanisation-related issues, besides walkability, may be more important, such as other PA environmental characteristics and the food environment, that counterbalance the effects of walkability in urban areas. These results would suggest that certain aspects of the built food environment were associated with a higher T2D risk, but we could not find consistent evidence of this in our review.

An association between the built food environment and T2D risk/prevalence was not consistently observed. Availability of fast-food and convenience stores and perceived healthiness of the food environment tended to be associated with higher T2D risk/prevalence and lower T2D risk/prevalence, respectively. However, due to heterogeneity in the studies, insufficient studies were available for meta-analysis, thus preventing us from drawing solid conclusions. The only possible meta-analyses were three studies including the density of grocery stores, but this confirmed that no significant associations could be observed. Furthermore by reviewing the evidence, supermarkets and grocery stores and the Relative Food Environment Index were not associated with T2D risk/prevalence. These findings are consistent with an earlier systematic review that reported that perceived availability was associated with healthy dietary behaviours, whereas objective measures of accessibility and availability of food environment yielded mixed results (9). The association between perceived environment and healthier diet can be explained by not limiting the concept of
environment to specific shops or locations, but rather to the participant’s resources for healthy food, e.g. garden, market. On the other hand, perceptions may also reflect an individual’s intentions and motivations rather than a location alone. A difficulty with regard to establishing useful diet measures is that they are very heterogeneous and difficult to define. For instance, access to a supermarket is often seen as contributing to a healthy food environment, despite the fact that it is also a source of unhealthy products (9). Establishing a comprehensive definition is further complicated by the fact that food can be bought in a variety of shops and locations that are not directly associated with food, e.g. at the counter of a pharmacy. The same heterogeneity was observed to a lesser extent in the built PA environment. For instance, infrastructure includes drivers for active transportation (sidewalks, cycling lanes) as well as for passive transportation (public transport, roads) (87). We conclude that the heterogeneity in exposure assessment associated with built environmental variables made the examination of the associations with T2D risk/prevalence more difficult.

Finally, although higher exposure to residential noise was consistently associated with higher T2D risk/prevalence in individual studies, this was not confirmed in our meta-analysis, in contrast with an earlier meta-analysis (16). This difference could be explained by the inclusion of only confounder adjusted risk ratios in our study.

A strength of this study is the comprehensive overview of literature on the association between built environmental characteristics and T2D risk/prevalence provided, in which we included worldwide evidence, assessed study quality and took country-income levels into account. However, certain limitations of this study need to be addressed.

A weakness of any systematic review and meta-analysis is that its quality is dependent on the quality of studies included. For instance, not all studies that were included distinguished between T2D and Type 1 Diabetes Mellitus. However, the majority of all people with diabetes have T2D, therefore the evidence provided in our review was very likely applicable to T2D risk/prevalence (1). Secondly, because most studies in the present review were cross sectional, our review cannot provide the foundation for causal inferences. Third, publication bias could influence our findings, but our search turned out a relatively high number of null findings, suggesting publication
bias is unlikely to have been a major issue here. Finally, residential self-selection is an important issue that should be included in studies investigating the associations between built environment and disease. Self-selection occurs when residents choose their residence based on socioeconomic or other circumstances, or lifestyle preferences. Evidently, such selections may influence our results, as for instance higher SES neighbourhoods may contain more green space, as well as more highly educated and health conscious residents. However, the true effect of residential self-selection on these associations has often not been accounted for in the included studies and is difficult to investigate. One narrative review observed that studies using various approaches to identify self-selection (i.e. questionnaire, statistical methods) explained only a minor part of the associations between built environment and travel behaviours (88). Two studies included in the present review observed that residential relocation, as an indicator of self-selection, resulted in inconsistent effects on associations with health outcomes (57, 58). It is therefore hard to conclude on the effect of self-selection bias on our results, based on the current evidence.

Despite the limitations of our study, our results may be relevant for infrastructure planning. For example, in addition to other positive consequences of walkability and access to green space, these environmental characteristics may also contribute to T2D prevention. Future research should focus on developing a more homogeneous definition of environmental characteristics, particularly in relation to the food environment. Also, more in-depth explorations are necessary of the pathways through which environments affect diabetes risk, while taking the potential confounding variables into account.

**Conclusion**

In conclusion, urbanisation is associated with higher T2D risk/prevalence. The built PA environment - walkability and access to green space, in particular - was consistently associated with reduced T2D risk/prevalence, while no consistent evidence was found for an association between the built food environment and T2D risk/prevalence. These conclusions have implications in terms of urban planning and the inclusion of walkable and green cities.
Table 1: Study characteristics and results of studies investigating the association of urban and rural built environment with T2D

| Author                  | Year  | Country                          | Country income level | Study design   | Sample size | Age            | Outcome* Outcome assessment‡ | Result               | Adjustment for confounding | Quality statement |
|-------------------------|-------|----------------------------------|----------------------|----------------|-------------|----------------|-------------------------------|----------------------|--------------------------|-------------------|
| Aekplakorn et al. (89)  | 2011  | Thailand                         | Upper middle         | Cross-sectional| 18,629      | NFG: 44.3 ± 0.3 DM: 54.1 ± 0.7 | T2D/T1D Blood prevalence sample | X                    | Age and sex              | Moderate          |
| Agyemang et al. (90)    | 2016  | Ghana, Netherlands, Germany, England | Lower middle and high | Cross-sectional | 5,659       | 25-70y (NR) | T2D Blood prevalence sample | X                    | Age, sex, education      | Moderate          |
| Ali et al. (91)         | 1993  | Malaysia                         | Upper middle         | Cross-sectional| 681         | 38.6 ± 13.7 | T2D/T1D Blood prevalence sample | X                    | Age                      | Moderate          |
| Al-Moosa et al. (92)    | 2006  | Oman                             | High                 | Cross-sectional| 5,840       | 24% > 50y 41% < 30y | T2D/T1D Blood prevalence sample | X                    | -                        | Moderate           |
| Anjana et al. (93)      | 2011  | India                            | Lower middle         | Cross-sectional| 13,055      | 40 ± 14      | T2D/T1D Blood prevalence sample | Southern area, Western area, Eastern area | Northern area | Age and sex              | Moderate          |
| Assah et al. (94)       | 2011  | Cameroon                         | Lower middle         | Cross-sectional| 552         | 38.4 ± 8.6  | T2D/T1D Blood prevalence sample | X                    | -                        | Moderate           |
| Attard et al. (67)      | 2012  | China                            | Upper middle         | Cross-sectional| NA          | 51 ± 0.4    | T2D/T1D Blood prevalence sample, self-report | X                    | Age, sex, income, region, BMI | Strong           |
Table 1: Study characteristics and results of studies investigating the association of urban and rural built environment with T2D (continued)

| Author          | Year | Country  | Country income level | Study design | Sample size | Age       | Outcome* | Outcome assessment‡ | Result               | Adjustment for confounding | Quality statement |
|-----------------|------|----------|----------------------|--------------|-------------|-----------|----------|--------------------|------------------------|-------------------------|---------------------|
| Allender et al. (95) | 2011 | Sri Lanka | Lower middle         | Cross-sectional | 4,485       | 46.1 ± 15.1 | T2D/T1D   | Blood prevalence sample | X                     | Age, sex, income                | Moderate            |
| Bahendeka et al. (41) | 2016 | Uganda   | Low                  | Cross-sectional | 3,689       | 35.1 ± 12.6 | T2D/T1D   | Blood prevalence sample | X                     | Age, sex, region of residence, floor finishing of dwelling, BMI, waist circumference, total cholesterol | Moderate            |
| Baldé et al. (96)   | 2007 | Guinea   | Low                  | Cross-sectional | 1,537       | 47.7 ± 12.5 | T2D/T1D   | Blood prevalence sample | X                     | Age, Location excess of waist, raised systolic BP, raised diastolic BP | Moderate            |
| Balogun et al. (97)  | 2012 | Nigeria  | Lower middle         | Longitudinal   | 1,330       | 77.3 ± 0.3  | T2D       | Self-report incidence | X                     | Age, sex, education               | Strong              |
| Baltazar et al. (98) | 2003 | Philippines | Lower middle        | Cross-sectional | 7,044       | 39.0 ± 0.5  | T2D/T1D   | Blood prevalence sample | X                     | Age and sex                    | Moderate            |
Table 1: Study characteristics and results of studies investigating the association of urban and rural built environment with T2D (continued)

| Author               | Year | Country   | Country income level | Study design | Sample size | Age              | Outcome* | Outcome assessment‡ | Result | Adjustment for confounding | Quality statement |
|----------------------|------|-----------|----------------------|--------------|-------------|------------------|----------|---------------------|--------|------------------------|------------------|
| Barnabé-Ortiz (99)   | 2016 | Peru      | Upper middle         | Longitudinal | 3,123       | 24% < 45y, 25% > 65y | T2D incidence | Blood sample        | X      | Sex, age, education level, socioeconomic status, family history of diabetes, daily smoking, hazardous drinking, TV watching for 2+ hours per day, transport-related physical inactivity, fruits and vegetables consumption, body mass index, and metabolic syndrome | Moderate |
| Bocquier et al. (100)| 2010 | France    | High                 | Cross-sectional | 3,038,670   | 48.9 ± 18.6 | T2D/T1D prevalence | Secondary X | Age and sex | Strong |
| Cubbin et al. (23)   | 2006 | Sweden    | High                 | Cross-sectional | 18,081      | 48% > 45y, 25% < 35y | T2D/T1D prevalence | Self-report X |
| Christensen et al. (101) | 2009 | Kenya     | Lower middle         | Cross-sectional | 1,459       | 38.6 ± 12.6 | T2D/T1D prevalence | Blood sample X | Age and sex | Moderate |
| Author          | Year | Country                                                                 | Country income level | Study design | Sample size | Age | Outcome* | Outcome assessment‡ | Result | Adjustment for confounding | Quality statement |
|-----------------|------|-------------------------------------------------------------------------|----------------------|--------------|-------------|-----|----------|--------------------|--------|------------------------|------------------|
| Dagenais et al. (102) | 2016 | Bangladesh, India, Pakistan, Zimbabwe, China, Colombia, Iran, Argentina, Brazil, Chile, Malaysia, Poland, South Africa, Turkey, Canada, Sweden, United Arab Emirates | Lower, lower middle, upper middle and high | Cross-sectional | 119,666 | 52 ± 9.3 | T2D/T1D prevalence sample | Blood sample | X | Age, sex, residency location, BMI, waist-to-hip ratio, PA levels, AHEI score, combined former and current smoking, education level, family history of diabetes, and ethnicity | Strong |
| Dar et al. (25) | 2015 | India                                                                   | Lower middle         | Cross-sectional | 3,972   | 43% > 50y | T2D Blood prevalence sample | Blood sample | X | - | Weak |
| Davila et al. (103) | 2013 | Colombia                                                                | Upper middle         | Cross-sectional | 1,026  | 35% > 55y | T2D/T1D Blood prevalence sample | Blood sample | X | Age, sex, education, SES, marital status, smoking, alcohol, intake of fruit and vegetables, PA | Strong |
| Author                  | Year   | Country         | Country income level | Study design | Sample size | Age   | Outcome* | Outcome assessment‡ | Result | Adjustment for confounding | Quality statement |
|------------------------|--------|-----------------|----------------------|--------------|-------------|-------|----------|---------------------|--------|------------------------|------------------|
| Delisle et al. (104)   | 2012   | Benin           | Low                  | Cross-sectional | 541         | 38.2 ± 0.6 | Glycaemic marker: HOMA index | Blood sample | X | Age, sex, SES, location, diet quality, PA, alcohol, BMI | Moderate          |
| Dong et al. (105)      | 2005   | China           | Upper middle         | Cross-sectional | 12,240      | 46.4 ± 13.9 | T2D prevalence | Blood sample | X (men) | Age and sex | Moderate          |
| Du et al. (106)        | 2016   | China           | Upper middle         | Cross-sectional | 3,797       | 15% > 60y 8% 20-29y | T2D/T1D prevalence | Blood sample | X | Age and sex | Moderate          |
| Esteghamati et al. (107)| 2009  | Iran            | Upper middle         | Cross-sectional | 3,397       | 23% > 55y 25% < 35y | T2D/T1D prevalence | Blood sample | X | Age, sex, residential area | Moderate          |
| Georgous-opoulou et al. (108) | 2017 | Mediterranean islands | High                  | Cross-sectional | 2,749       | 75 ± 7.3 | T2D/T1D prevalence | Blood sample | X | age, sex, BMI, physical inactivity, smoking, siesta habit, education, living alone, adherence to Mediterranean diet, GDS, number of friends and family members, frequency of going out with friends and family, number of holiday excursions per year | Moderate          |
| Author          | Year | Country     | Country income level | Study design   | Sample size | Age          | Outcome* | Outcome assessment‡ | Result | Adjustment for confounding | Quality statement                     |
|-----------------|------|-------------|----------------------|----------------|-------------|--------------|-----------|---------------------|--------|------------------------|---------------------------------------|
| Gong et al.     | 2015 | China       | Upper middle         | Cross-sectional | 5,923       | 38% > 50y, 62% < 50y | T2D/T1D prevalence | Blood sample | X                  | Urban > rural                        | Age, sex, education, PA, smoking, alcohol, BMI, triglycerides, HDL-cholesterol, hypertension. | Strong                                 |
| Hussain et al.  | 2004 | Bangladesh  | Lower middle         | Cross-sectional | 6,312       | 14% > 50y, 46% < 30y | T2D/T1D prevalence | Blood sample | X                  | Rural > urban                       | Age and sex                            | Moderate                               |
| Han et al.      | 2017 | Korea       | High                 | Longitudinal    | 7,542       | 52 ± 8.8     | T2D incidence | Blood sample | X                  | No difference                       | Age, sex, residential area, family history of diabetes, smoking, alcohol, exercise, abdominal obesity, hypertension, high triglycerides, and low HDL cholesterol | Strong                                 |
| Katchunga et al.| 2012 | Congo       | Low                  | Cross-sectional | 699         | 42.5 ± 18.1  | T2D/T1D prevalence | Blood sample | X                  | X                                  | -                                    | Moderate                               |
| Keel et al.     | 2017 | Australia   | High                 | Cross-sectional | 4,836       | Non-indigenous: 66.6 ± 9.7, Indigenous: 54.9 ± 8.7 | T2D/T1D Self-report prevalence | X (indigenous), X (non-indigenous) | Age, sex, ethnicity, education, English-speaking at home, ethnicity | Moderate                               |
### Table 1: Study characteristics and results of studies investigating the association of urban and rural built environment with T2D (continued)

| Author            | Year | Country                        | Country income level | Study design | Sample size | Age                  | Outcome* | Outcome assessment‡ | Result | Adjustment for confounding | Quality statement |
|-------------------|------|--------------------------------|----------------------|--------------|-------------|----------------------|----------|---------------------|--------|------------------------|-----------------|
| Mayega et al.     | 2013 | Uganda                         | Low                  | Cross-sectional | 1,497       | 45.8% > 45y, 54.2% < 45y | T2D      | Blood prevalence sample | X      |                        |                 |
| Mohan et al.      | 2016 | India                          | Lower middle         | Cross-sectional | 6,853       | 35-70y (NR)             | T2D/T1D  | Blood prevalence sample | X      |                        |                 |
| Msyamboza et al.  | 2014 | Malawi                         | Low                  | Cross-sectional | 3,056       | 12.5% > 55y, 45% < 35y | T2D/T1D  | Blood prevalence sample |       |                        |                 |
| Ntandou et al.    | 2009 | Benin                          | Low                  | Cross-sectional | 541         | 38.2 ± 10              | T2D/T1D  | Blood prevalence sample | X      |                        |                 |
| Oyebode et al.    | 2015 | China, Ghana, India, Mexico, Russia, South Africa | Upper and Lower middle | Cross-sectional | 39,436      | 47.3% > 60y, 12.3% < 40y | T2D/T1D  | Self-prevalence report (pooled) | X      |                        |                 |
| Papoz et al.      | 1996 | New Caledonia                  | High                 | Cross-sectional | 9,390       | 30-59y (NR)             | T2D/T1D  | Blood prevalence sample | X      |                        |                 |
| Pham et al.       | 2016 | Vietnam                        | Lower middle         | Cross-sectional | 16,730      | 54 ± 8                 | T2D/T1D  | Blood prevalence sample | X (men) |                        |                 |
| Author               | Year  | Country | Country income level | Study design | Sample size | Age | Outcome* | Outcome assessment‡ | Result | Adjustment for confounding | Quality statement |
|----------------------|-------|---------|----------------------|--------------|-------------|-----|----------|---------------------|--------|------------------------|------------------|
| Raghupathy *et al.* (121) | 2007  | India  | Lower middle | Longitudinal | 2,218 | 28 ± 1.2 | T2D prevalence | Blood sample | X | Age, sex, number of household possessions, education, PA, smoking, alcohol, parental consanguinity, family history of DM, body fat, BMI, WH ratio, subcapular/triceps ratio | Strong |
| Ramdani *et al.* (122)   | 2012  | Morocco | Lower middle | Cross-sectional | 1,628 | 54.2 ± 10.9 | T2D/T1D prevalence | Blood sample | X | Age, sex, BMI | Moderate |
| Sadikot *et al.* (123) | 2004  | India  | Lower middle | Cross-sectional | 41,270 | 36% > 50y, 34% < 40y | T2D Blood prevalence | sample | X | Age and sex | Moderate |
| Sobngwi *et al.* (124) | 2004  | Cameroon | Lower middle | Longitudinal | 1,726 | 24% > 55y, 28% < 35y | T2D/T1D Blood prevalence | sample (women) | X (men) | Age, sex, residence, socio-professional category, alcohol, smoking, PA. | Moderate |
| Stanifer *et al.* (125) | 2016  | Tanzania | Low | Cross-sectional | 481 | 25% > 60y | T2D/T1D Blood prevalence | sample | X | Age and sex | Moderate |
Table 1: Study characteristics and results of studies investigating the association of urban and rural built environment with T2D (continued)

| Author      | Year | Country | Country income level | Study design | Sample size | Age | Outcome* Outcome assessment‡ | Result | Adjustment for confounding | Quality statement |
|-------------|------|---------|----------------------|--------------|-------------|-----|-------------------------------|--------|---------------------------|------------------|
| Weng et al. (126) | 2007 | China   | Upper middle         | Cross-sectional | 529         | NR  | T2D/T1D Blood prevalence sample |         | X Age and sex              | Moderate         |
| Wu et al. (127)  | 2016 | China   | Upper middle         | Cross-sectional | 23,010      | 40 (30.4 – 56.3) | T2D/T1D Blood prevalence sample |         | X Age                      | Moderate         |
| Zhou et al. (128) | 2015 | China   | Upper middle         | Cross-sectional | 98,658      | 20% > 60y 80% < 60y | T2D/T1D Blood prevalence sample |         | X Age, sex, region         | Moderate         |

Abbreviations: T2D = type 2 diabetes; T1D = type 1 diabetes, NR = Not Reported, PA = Physical Activity, *Prevalence; incidence or glycaemic marker level, ‡Blood sample = study diagnosed diabetes based on glycaemic marker or oral glucose tolerance test; secondary = from data sources such as national health survey; self-report = ever diagnosed with diabetes.
Table 2: Study characteristics of studies investigating the association of physical activity environment, food environment or residential noise with T2D

| Author               | Year | Country       | Income level | Study design | Sample size | Age | Outcome* | Outcome assessment† | Exposure category | Exposure assessment | Level geodata | Quality statement |
|----------------------|------|---------------|--------------|--------------|-------------|-----|----------|---------------------|-------------------|-------------------|--------------|------------------|
| Ahern et al. (46)    | 2011 | US            | High         | Cross-sectional | 3,128       | NR  | T2D/T1D prevalence | Secondary          | PA, food          | Place of residence | Aggregate      | Moderate         |
| AliHasan et al. (69) | 2016 | US            | High         | Cross-sectional | NA          | NR  | T2D/T1D prevalence | Secondary          | Food              | GIS             | Aggregate      | Strong           |
| Astell-Burt et al. (42) | 2014 | Australia    | High         | Cross-sectional | 48,072      | 28% | T2D/T1D prevalence | Self-report         | PA                | GIS             | Individual     | Moderate        |
| Auchincloss et al. (47) | 2009 | US            | High         | Longitudinal  | 2,285       | 62.1 ± 10 | T2D incidence | Blood sample, self-report | PA, food          | Self-report       | Individual     | Moderate        |
| Bodicoat et al. (44) | 2014 | UK            | High         | Cross-sectional | 10,476     | 59 ± 10.4 | T2D prevalence | Secondary (screen detected) | PA               | GIS             | Individual     | Strong          |
| Bodicoat et al. (72) | 2015 | UK            | High         | Cross-sectional | 10,461     | 59 ± 10.4 | T2D prevalence | Secondary (screen detected) | Food             | GIS             | Individual     | Strong          |
| Booth et al. (19)    | 2013 | Canada        | High         | Longitudinal  | 1,024,380   | 30-64y (NR) | T2D/T1D incidence | Secondary          | PA, food          | GIS             | Aggregate      | Moderate        |
| Braun et al. (80)    | 2015 | US            | High         | Cross-sectional | NA          | NR  | T2D/T1D prevalence | Secondary          | PA, food          | Register        | Aggregate      | Moderate        |
| Braun et al. (58)    | 2016 | US            | High         | Longitudinal  | 1,079       | 39.7 ± 3.7 | Glycaemic marker: ln(HOMA index) | Blood sample | PA               | GIS             | Individual     | Strong          |
| Braun et al. (57)    | 2016 | US            | High         | Longitudinal  | 583         | 69.4 ± 9.5 | Glycaemic marker: fasting glucose | Blood sample | PA               | GIS             | Individual     | Strong          |
| Cai et al. (82)      | 2017 | The Netherlands | High       | Cross-sectional | 93,277      | 44.9 ±12.3 | Glycaemic marker: fasting glucose | Blood sample | Noise            | GIS             | Aggregate      | Strong          |
Table 2: Study characteristics of studies investigating the association of physical activity environment, food environment or residential noise with T2D (continued)

| Author                  | Year | Country | Income level | Study design     | Sample size | Age       | Outcome* | Outcome assessment† | Exposure category | Exposure assessment | Level geodata | Quality statement |
|-------------------------|------|---------|--------------|------------------|-------------|-----------|----------|---------------------|-------------------|-------------------|---------------|------------------|
| Carroll et al. (71)     | 2017 | Australia | High         | Longitudinal     | 2,582       | 50 ± 15   | Glycaemic marker: HbA1c | Blood sample   | Food              | GIS           | Aggregate Moderate |
| Christine et al. (48)   | 2015 | US       | High         | Longitudinal     | 2,157       | 60.7 ± 9.9 | T2D incidence          | Blood sample   | PA, food          | GIS, self-report | Individual Strong |
| Creatore et al. (20)    | 2016 | Canada   | High         | Longitudinal     | ±4,505,000  | 61% 30-49y  | T2D/T1D incidence       | Secondary      | PA                | GIS           | Aggregate Strong  |
| Cunningham-Myrie et al. (49) | 2015 | Jamaica | Upper middle | Cross-sectional  | 2,848       | 36.9 ± 2.7 | T2D/T1D prevalence     | Blood sample   | PA                | Environmental audit | Individual Strong |
| Dalton et al. (59)      | 2016 | UK       | High         | Longitudinal     | 23,865      | 59.1 ± 9.3 | T2D/T1D incidence       | Self-report    | PA                | GIS           | Individual Strong  |
| Dzhambov et al. (83)    | 2016 | Bulgaria | Upper middle | Cross-sectional  | 581         | 36.5 ± 15.4 | T2D/T1D prevalence     | Secondary      | Noise             | Secondary | Aggregate Moderate |
| Eichinger et al. (50)   | 2015 | Austria  | High         | Cross-sectional  | 660         | 47.1 ± 14.1 | T2D/T1D prevalence     | Blood sample   | PA                | Self-report     | Individual Moderate |
| Eriksson et al. (85)    | 2014 | Sweden   | High         | Longitudinal     | 5,156       | 47 ± 5     | T2D incidence           | Blood sample   | Noise             | GIS           | Individual Moderate |
| Flynt et al. (73)       | 2015 | US       | High         | Cross-sectional  | NA          | NR         | T2D/T1D prevalence     | Secondary      | Food              | Secondary | Aggregate Moderate |
| Frankenfeld et al. (74) | 2015 | US       | High         | Cross-sectional  | 3,227       | 11% > 65y  | T2D/T1D prevalence     | Blood sample   | Food              | GIS           | Aggregate Moderate |
| Freedman et al. (68)    | 2011 | US       | High         | Cross-sectional  | NA          | 100% > 50y | T2D/T1D prevalence     | Self-report    | PA, food          | Secondary | Aggregate Moderate |
| Fujiware et al. (60)    | 2017 | Japan    | High         | Cross-sectional  | 8,904       | 72.5 ± 5.2 | T2D/T1D prevalence     | Blood sample   | PA, food          | GIS           | Individual Moderate |
Table 2: Study characteristics of studies investigating the association of physical activity environment, food environment or residential noise with T2D (continued)

| Author            | Year | Country | Income level | Study design | Sample size | Age       | Outcome* | Outcome assessment† | Exposure category | Exposure assessment | Level geodata | Quality statement |
|-------------------|------|---------|--------------|--------------|-------------|-----------|----------|---------------------|-------------------|--------------------|---------------|-------------------|
| Gebreab et al. (61) | 2017 | US      | High         | Longitudinal | 3,661       | 54 ± 12   | T2D incidence | Blood sample       | PA, Food          | GIS                | Individual | Strong            |
| Glazier et al. (21) | 2014 | Canada  | High         | Cross-sectional | 2,446,029  |  T2D/T1D prevalence | Secondary | PA | GIS            | Aggregate | Moderate          |
| Hipp et al. (78)   | 2015 | US      | High         | Cross-sectional | 3,109 counties | 44.8 ± 13.7 | T2D prevalence | Secondary | Noise | Self-report | Individual | Strong            |
| Heideman et al. (86) | 2014 | Germany | High         | Longitudinal | 3,604       | 44.8 ± 13.7 | T2D incidence | Secondary | Noise | Self-report | Individual | Strong            |
| Lee et al. (45)    | 2015 | Korea   | High         | Cross-sectional | 13,478     | 47.6 ± 12.2 | T2D/T1D prevalence | Secondary | PA | GIS            | Aggregate | Moderate          |
| Liu et al. (79)    | 2014 | US      | High         | Cross-sectional | 17,254     | 46.5 ± 18.5 | T2D/T1D prevalence | Blood sample | PA, food | Self-report | Individual | Strong            |
| Loo et al. (62)    | 2017 | Canada  | High         | Cross-sectional | 78,023     | 35% 18-40y 23% > 65y | Glycaemic marker: HbA1c and fasting glucose | Blood sample | PA | GIS            | Individual | Strong            |
| Maas et al. (66)   | 2009 | Netherlands | High         | Cross-sectional | 345,103    | 38% > 45y 63% < 45y | T2D/T1D prevalence | Secondary | PA | Register | Individual | Moderate          |
| Mena et al. (53)   | 2015 | Chile   | High         | Cross-sectional | 832        | 45 ± 14   | Glycaemic marker: Fasting glucose level | Blood sample | PA, food | GIS            | Individual | Moderate          |
| Meyer et al. (81)  | 2015 | US      | High         | Longitudinal | 14,379 (observations) | 45.2 ± 3.6 | Glycaemic marker: HOMA index | Blood sample | PA, food | GIS            | Individual | Moderate          |
| Mezuk et al. (70)  | 2016 | Sweden  | High         | Longitudinal | 2,948,851  | NR        | T2D incidence | Secondary | Food | GIS            | Individual | Strong            |
Table 2: Study characteristics of studies investigating the association of physical activity environment, food environment or residential noise with T2D (continued)

| Author                  | Year   | Country | Income level | Study design | Sample size | Age | Outcome* | Outcome assessment† | Exposure category | Exposure assessment | Exposure level geodata | Quality statement |
|-------------------------|--------|---------|--------------|--------------|-------------|-----|----------|---------------------|-------------------|---------------------|-----------------------|-------------------|
| Morland et al. (75)     | 2006 US| High    |              | Cross-sectional | 10,763      | 100% > 50y | T2D/T1D prevalence | Blood sample     | Food                | GIS                   | Aggregate          | Moderate             |
| Müller-Riemenschneider et al. (65) | 2013 Australia High| Cross-sectional | 5,970 | 29% > 65y, 30% < 45y | T2D prevalence | Self-report | PA | GIS | Individual Strong |
| Myers et al. (63)       | 2016 US| High    |              | Cross-sectional | NA          | NR | T2D/T1D prevalence | Secondary | PA, food | Secondary | Aggregate Moderate |
| Ngom et al. (64)        | 2016 Canada | High   |              | Cross-sectional | 3,920,000   | NR | T2D/T1D prevalence | Secondary | PA | GIS | Aggregate Strong |
| Paquet et al. (54)      | 2014 Australia High | Longitudinal | 3,145 | 51.5 ± 15.5 | T2D incidence | Blood sample | PA, food | GIS | Individual Moderate |
| Schootman et al. (56)   | 2007 US | High    |              | Longitudinal | 644         | 56.2 ± 4.3 | T2D/T1D incidence | Self-report | PA, noise | Self-report, environmental audit | Individual Moderate |
| Sørensen et al. (84)    | 2013 Denmark High | Longitudinal | 57,053 | 56.1 (50.7 – 64.2) | T2D/T1D incidence | Secondary | Noise | GIS | Individual Moderate |
| Sundquist et al. (22)   | 2015 Sweden High  | Longitudinal | 512,061 | 55 ± 14.9 | T2D incidence | Secondary | PA | GIS | Aggregate Moderate |

Abbreviations: US = United States; UK = United Kingdom; T2D = type 2 diabetes; T1D = type 1 diabetes; PA = Physical activity; GIS = Geographic Information Systems; NA = not applicable

*Prevalence; incidence or glycaemic marker level, †Blood sample = study diagnosed diabetes based on glycaemic marker or oral glucose tolerance test; secondary = from data sources such as national health survey; self-report = ever diagnosed with diabetes.
| Author                      | Exposure                                      | Study result | 95% Confidence interval or p-value | Adjustment for confounding                                   |
|-----------------------------|-----------------------------------------------|--------------|-----------------------------------|-------------------------------------------------------------|
| Ahern et al., 2011          | Food environment:                             | Beta (SE)    |                                   |                                                             |
|                             | 1. % household with no car living more than 1 mile from a grocery store | 1. 0.07 (0.01) | 1. $P < 0.001$                    | Age and obesity rate                                       |
|                             | 2. fast food restaurants per 1000             | 2. 0.41 (0.07) | 2. $P < 0.001$                    |                                                             |
|                             | 3. Full service restaurants per 1000          | 3. -0.15 (0.04) | 3. $P < 0.01$                     |                                                             |
|                             | 4. grocery stores per 1000                    | 4. -0.37 (0.09) | 4. $P < 0.001$                    |                                                             |
|                             | 5. convenience stores per 1000                | 5. 0.30 (0.06) | 5. $P < 0.001$                    |                                                             |
|                             | 6. direct money made from farm sales per capita| 6. -0.01 (0.02) | 6. $P < 0.01$                     |                                                             |
|                             | PA environment:                               | Beta (SE)    |                                   |                                                             |
|                             | 7. recreational facilities per 1000            | 7. -0.12 (0.21) | 7. NS                             |                                                             |
| Al Hasan et al., 2016       | Food outlet density:                           | Beta (SE)    |                                   |                                                             |
|                             | 1. Fast food restaurant density (per 1000 residents) | 1. -0.55 (0.90) | 1. NS                             | Age, obesity, PA, recreation facility density, unemployed, education, household with no cars and limited access to store and race. |
|                             | 2. Convenience store density                  | 2. 0.89 (0.86) | 2. NS                             |                                                             |
|                             | 3. Super store density                        | 3. -0.4 (1.66) | 3. NS                             |                                                             |
|                             | 4. Grocery store density                      | 4. -3.7 (2.13) | 4. NS                             |                                                             |
| Astell-Burt et al., 2014    | Green space (percent):                         | OR:          | 95% CI:                           |                                                             |
|                             | 1. >81                                        | 1. 0.94      | 1. 0.85 - 1.03                    |                                                             |
|                             | 2. 0-20                                       | 2. 1         | 2. NA                             |                                                             |
| Auchincloss et al., 2009    | Neighbourhood resources:                      | HR:          | 95% CI:                           |                                                             |
|                             | 1. Healthy food resources                     | 1. 0.63      | 1. 0.42 - 0.93                    | Age, sex, family history, income, assets, education, ethnicity, alcohol, smoking, PA, diet, BMI |
|                             | 2. PA resources                               | 2. 0.71      | 2. 0.48 - 1.05                    |                                                             |
|                             | 3. Summary score                              | 3. 0.64      | 3. 0.44 - 0.95                    |                                                             |
Table 3: study results of studies investigating physical activity environment, food environment, residential noise and DM. (continued)

| Author          | Exposure                                                                 | Study result | 95% Confidence interval or p-value | Adjustment for confounding                                                                 |
|-----------------|---------------------------------------------------------------------------|--------------|-----------------------------------|------------------------------------------------------------------------------------------|
| Bodicoat et al., 2014 | Green space (percent)                                                     | OR:          | 95%CI:                            | Age, sex, area social deprivation score, urban/rural status, BMI, PA, fasting glucose, 2 h glucose, total cholesterol |
|                  | 1. Least green space (Q1)                                                | 1. 1         | 1. NA                             |                                                                                          |
|                  | 2. Most green space (Q4)                                                 | 2. 0.53      | 2. 0.35 - 0.82                    |                                                                                          |
| Bodicoat et al., 2015 | Number of fast-food outlets (per 2)                                      | OR:          | 95%CI:                            | Age, sex, area social deprivation score, urban/rural status, ethnicity, PA                |
|                  | 1.                                                                   | 1. 1.02      | 1. 1.00 – 1.04                    |                                                                                          |
|                  | 2. Density of fast-food outlet (per 200 residents)                       | 2. 13.84     | 2. 1.60 – 119.6                   |                                                                                          |
| Booth et al., 2013 | Walkability:                                                            | HR:          | 95%CI:                            | Age, sex, income                                                                         |
| Men Recent immigrants | Least walkable quintile                                                  | 1. 1.58      | 1. 1.42 – 1.75                    |                                                                                          |
|                  | 2. Most walkable quintile                                               | 2. 1         | 2. NA                             |                                                                                          |
| Long-term residents | Least walkable quintile                                                | 1. 1.32      | 1. 1.26 – 1.38                    |                                                                                          |
|                  | 2. Most walkable quintile                                               | 2. 1         | 2. NA                             |                                                                                          |
| Women Recent immigrants | Least walkable quintile                                               | 1. 1.67      | 1. 1.48 – 1.88                    |                                                                                          |
|                  | 2. Most walkable quintile                                               | 2. 1         | 2. NA                             |                                                                                          |
| Long-term residents | Least walkable quintile                                                | 1. 1.24      | 1. 1.18 – 1.31                    |                                                                                          |
|                  | 2. Most walkable quintile                                               | 2. 1         | 2. NA                             |                                                                                          |
Table 3: study results of studies investigating physical activity environment, food environment, residential noise and DM. (continued)

| Author       | Exposure                                                                 | Study result | 95% Confidence interval or p-value | Adjustment for confounding                                      |
|--------------|--------------------------------------------------------------------------|--------------|-----------------------------------|----------------------------------------------------------------|
| Braun et al., 2016 | Walkability index, after residential relocation 1. Fixed effects model | Beta (SE) 1. -0.011 (0.015) | 1. P > 0.05 | 1. income, household size, marital status, employment status, smoking status, health problems that interfere with PA 2. Additionally adjusted for age, gender, ethnicity, education |
|              |                                                                          | 2. -0.016 (0.010) | 2. P > 0.05 | |
| Braun et al., 2016 | Walkability: within person change in Street Smart Walk Score | Beta (SE): 0.999 (0.002) | P > 0.05 | Age, sex, ethnicity, education, household income, employment status, marital status, neighbourhood SES |
| Cai et al., 2017 | Daytime noise (dB)                                                      | % change in fasting glucose per IQR | P < 0.05 | age, sex, season of blood draw, smoking status and pack-years, education, employment and alcohol consumption, air pollution |
| Carroll et al., 2017 | Count of fast-food outlets: 1. Interaction with overweight/obesity 2. Interaction with time 3. Interaction with time and overweight/obesity | Beta per SD change: | 95% CI: | Age, sex, marital status, education, employment status, and smoking status |
|              |                                                                          | −0.0094 | −0.030 − 0.011 |
|              |                                                                          | 1. −0.002 | 1. −0.023 − 0.019 |
|              |                                                                          | 2. 0.0003 | 2. −0.003 − 0.004 |
|              |                                                                          | 3. −0.002 | 3. −0.006 − 0.001 |
|              | Count of healthful food resources: 4. Interaction with overweight/obesity 5. Interaction with time 6. Interaction with time and overweight/obesity | 0.012 | −0.008 − 0.032 |
|              |                                                                          | 4. 0.021 | 4. −0.000 − 0.042 |
|              |                                                                          | 5. −0.003 | 5. −0.006 − 0.001 |
|              |                                                                          | 6. −0.006 | 6. −0.009 − 0.002 |
Table 3: study results of studies investigating physical activity environment, food environment, residential noise and DM. (continued)

| Author                  | Exposure                                                                 | Study result | 95% Confidence interval or p-value | Adjustment for confounding                                                                 |
|-------------------------|---------------------------------------------------------------------------|--------------|-----------------------------------|-------------------------------------------------------------------------------------------|
| Christine et al., 2015  | Neighbourhood physical environment, diet related:                         | HR:          | 95%CI:                            | Age, sex, family history, household per capita income, educational level, smoking, alcohol, neighbourhood SES |
|                         | 1. Density of supermarkets and fruit and vegetable markets (GIS)           | 1. 1.01      | 1. 0.96 – 1.07                   |                                                                                           |
|                         | 2. Healthy food availability (self-report)                                | 2. 0.88      | 2. 0.78 – 0.98                   |                                                                                           |
|                         | 3. GIS and self-report combined measure                                   | 3. 0.93      | 3. 0.82 – 1.06                   |                                                                                           |
|                         | Neighbourhood physical environment, PA related:                          | HR:          | 95%CI:                            | Age, sex, family history, household per capita income, educational level, smoking, alcohol, neighbourhood SES |
|                         | 1. Density of commercial recreational facilities (GIS)                    | 1. 0.98      | 1. 0.94 – 1.03                   |                                                                                           |
|                         | 2. Walking environment (self-report)                                       | 2. 0.80      | 2. 0.70 – 0.92                   |                                                                                           |
|                         | 3. GIS and self-report combined measure                                   | 3. 0.81      | 3. 0.68 – 0.96                   |                                                                                           |
| Creatore et al., 2016   | Walkability:                                                              | Absolute incidence rate difference over 12 year FU:   | 95%CI:                            | Age, sex, area income and ethnicity                                                       |
|                         | 1. Low walkable neighbourhoods (Q1)                                       | -0.65        | 1. -1.65 – 0.39                  |                                                                                           |
|                         | 2. High walkable neighbourhoods over (Q5)                                 | -1.5         | 2. -2.6 – -0.4                   |                                                                                           |
| Cunningham-Myrie et al, 2015 | Neighbourhood characteristics:                                            | OR:          | 95%CI:                            | Age, sex, district, fruit and vegetable intake                                             |
|                         | 1. Neighbourhood infrastructure                                          | 1. 1.02      | 1. 0.95 – 1.1                    |                                                                                           |
|                         | 2. Neighbourhood disorder score                                          | 2. 0.99      | 2. 0.95 – 1.03                   |                                                                                           |
|                         | 3. Home disorder score                                                    | 3. 1         | 3. 0.96 – 1.03                   |                                                                                           |
|                         | 4. Recreational space in walking distance                                | 4. 1.12      | 4. 0.86 – 1.45                   |                                                                                           |
|                         | 5. Recreational space availability                                        | 5. 1.01      | 5. 0.77 – 1.32                   |                                                                                           |
|                         | 6. Perception of safety                                                  | 6. 0.99      | 6. 0.88 – 1.11                   |                                                                                           |
Table 3: study results of studies investigating physical activity environment, food environment, residential noise and DM. (continued)

| Author            | Exposure                                                                 | Study result | 95% Confidence interval or p-value | Adjustment for confounding                                                                 |
|-------------------|---------------------------------------------------------------------------|--------------|-----------------------------------|-------------------------------------------------------------------------------------------|
| Dalton et al.,    | Green space:                                                              | HR:          | 95%CI:                            | Age, sex, BMI, parental diabetes, and SES. Effect modification by urban-rural status and SES was investigated, but association was not moderated by either |
| 2016              | 1. Least green space (Q1)                                                 | 1. 1         | 1. NA                             |                                                                                           |
|                   | 2. Most green space (Q4)                                                  | 2. 0.81      | 2. 0.65 – 0.99                    |                                                                                           |
|                   | 3. Mediation by PA                                                        | 3. 0.96      | 3. 0.88 -1.06                     |                                                                                           |
| Dzhambov et al.,  | Day-evening-night equivalent sound level:                                 | OR:          | 95%:                              | Age, sex, fine particulate matter, benzo alpha pyrene, body mass index, family history of T2D, subjective sleep disturbance, and bedroom location |
| 2016              | 1. 51-70 decibels                                                        | 1. 1         | 1. NA                             |                                                                                           |
|                   | 2. 71-80 decibels                                                        | 2. 4.49      | 2. 1.39 – 14.7                    |                                                                                           |
| Eichinger et al., | Characteristics of built residential environment:                        | Beta:        |                                   | Age, sex, individual-level SES                                                             |
| 2015              | 1. Perceived distance to local facilities                                | 1. 0.006     | 1. P < 0.01                       |                                                                                           |
|                   | 2. Perceived availability / maintenance of cycling/walking infrastructure | 2. NS        |                                   |                                                                                           |
|                   | 3. Perceived connectivity                                                | 3. NS        |                                   |                                                                                           |
|                   | 4. Perceived safety with regards to traffic                              | 4. NS        |                                   |                                                                                           |
|                   | 5. perceived safety from crime                                           | 5. NS        |                                   |                                                                                           |
|                   | 6. Neighbourhood as pleasant environment for walking / cycling           | 6. NS        |                                   |                                                                                           |
|                   | 7. Presence of trees along the streets                                   | 7. NS        |                                   |                                                                                           |
| Eriksson et al.,  | Aircraft noise level:                                                     | OR:          | 95%CI:                            | Age, sex, family history, SES based on education, PA, smoking, alcohol, annoyance due to noise. |
| 2014              | 1. <50 dB                                                                 | 1. 1         | 1. NA                             |                                                                                           |
|                   | 2. ≥55 dB                                                                | 2. 0.94      | 2. 0.33 – 2.70                    |                                                                                           |
Table 3: study results of studies investigating physical activity environment, food environment, residential noise and DM. (continued)

| Author          | Exposure                                                                 | Study result | 95% Confidence interval or p-value | Adjustment for confounding |
|-----------------|---------------------------------------------------------------------------|--------------|-----------------------------------|----------------------------|
| Flynt et al., 2015 | Clusters (combination of number of counties, urban-rural classification, population density, income, SES, access to food stores, obesity rate, diabetes rate): | Median standardized DM rate: | IQR: | - |
|                 |                                                                          | 1. 0         | 1. -0.05 - 0.7                    |                            |
|                 |                                                                          | 2. 0         | 2. -0.04 – 0.7                    |                            |
|                 |                                                                          | 3. 0         | 3. -0.08 – 0.01                   |                            |
|                 |                                                                          | 4. -0.04     | 4. -1.01 – 0.6                    |                            |
|                 |                                                                          | 5. -0.08     | 5. -1.5 – -0.04                   |                            |
| Frankenfeld et al., 2015 | RFEI† ≤ 1 Clusters: 1. Grocery stores 2. Restaurants 3. Specialty foods | Predicted prevalence: | 95% CI: | Demographic and SES variables |
|                 |                                                                          | 1. 7.1       | 1. 6.3 – 7.9                      |                            |
|                 |                                                                          | 2. 5.9       | 2. 5.0 – 6.8, p < 0.01             |                            |
|                 |                                                                          | 3. 6.1       | 3. 5.0 – 7.2, p < 0.01             |                            |
|                 |                                                                          | 4. 6.0       | 4. 4.9 – 7.1, p < 0.01             |                            |
|                 |                                                                          | 5. 6.1       | 5. 4.9 – 7.3, p < 0.01             |                            |
| Freedman et al., 2011 | Built environment: Men: 1. Connectivity (2000 Topologically Integrated Geographic Encoding and Referencing system). 2. Density (number of food stores, restaurants, housing units per square mile) | OR: | 95% CI: | Age, ethnicity, marital status, region of residence, smoking, education, income, childhood health, childhood SES, region of birth, neighbourhood scales |
|                 |                                                                          | 1. 1.06      | 1. 0.86 – 1.29                    |                            |
|                 |                                                                          | 2. 1.05      | 2. 0.89 – 1.24                    |                            |
|                 |                                                                          | 3. 1.01      | 3. 0.84 – 1.20                    |                            |
|                 |                                                                          | 4. 0.99      | 4. 0.99 – 1.17                    |                            |
Table 3: study results of studies investigating physical activity environment, food environment, residential noise and DM. (continued)

| Author                  | Exposure                                                                 | Study result                  | 95% Confidence interval or p-value | Adjustment for confounding                                                                 |
|-------------------------|---------------------------------------------------------------------------|-------------------------------|-----------------------------------|------------------------------------------------------------------------------------------|
| Fujiware et al., 2017   | Count within neighbourhood unit (mean 6.31 ± 3.9 km²)                     | OR per IQR increase:          | 95%CI:                            | age, sex, marital status, household number, income, working status, drinking, smoking, vegetable consumption, walking, going-out behaviour, frequency of meeting, BMI, depression |
|                         | 1. Grocery stores                                                        | 1. 0.97                       | 1. 0.88 – 1.08                    |                                                                                           |
|                         | 2. Parks                                                                  | 2. 1.16                       | 2. 1 – 1.34                       |                                                                                           |
| Gebreab et al., 2017    | Density within 1 mile buffer:                                            | HR:                           | 95%CI:                            | age, sex, family history of diabetes, SES, smoking, alcohol consumption, PA and diet     |
|                         | 1. Favourable food stores                                                | 1. 1.03                       | 1. 0.98 – 1.09                    |                                                                                           |
|                         | 2. Unfavourable food stores                                              | 2. 1.07                       | 2. 0.99 – 1.16                    |                                                                                           |
|                         | 3. PA resources                                                           | 3. 1.03                       | 3. 0.98 – 1.09                    |                                                                                           |
| Glazier et al., 2014    | Walkability index                                                        | Rate ratio:                   | 95%CI:                            | Age and sex                                                                               |
|                         | 1. Q1                                                                     | 1. 1                          | 1. NA                             |                                                                                           |
|                         | 2. Q5                                                                     | 2. 1.33                       | 2. 1.33 – 1.33                    |                                                                                           |
|                         | Index components:                                                        |                               |                                   |                                                                                           |
|                         | 1. Population density (Q1:Q5)                                            | 1. 1.16                       | 1. 1.16 – 1.16                    |                                                                                           |
|                         | 2. Residential density (Q1:Q5)                                           | 2. 1.33                       | 2. 1.33 – 1.33                    |                                                                                           |
|                         | 3. Street connectivity (Q1:Q5)                                           | 3. 1.38                       | 3. 1.38 – 1.38                    |                                                                                           |
|                         | 4. Availability of walkable destinations (Q1:Q5)                          | 4. 1.26                       | 4. 1.26 – 1.26                    |                                                                                           |
| Heideann et al., 2014   | Residential traffic intensity:                                           | OR:                           | 95%CI:                            | Age, sex, smoking, passive smoking, heating of house, education, BMI, waist circumference, PA, family history |
|                         | 1. No traffic                                                            | 1. 1                          | 1. NA                             |                                                                                           |
|                         | 2. Extreme traffic                                                       | 2. 1.97                       | 2. 1.07 – 3.64                    |                                                                                           |
| Hipp et al., 2015       | Food deserts                                                             | Correlation: NR               | NS                                | -                                                                                         |
| Lee et al., 2015        | Walkability:                                                              | OR:                           | 95%CI:                            | Age, sex, smoking, alcohol, income level                                                 |
|                         | 1. Community 1                                                            | 1. 1                          | 1. NA                             |                                                                                           |
|                         | 2. Community 2                                                            | 2. 0.86                       | 2. 0.75 – 0.99                    |                                                                                           |
Table 3: study results of studies investigating physical activity environment, food environment, residential noise and DM. (continued)

| Author               | Exposure                                                                 | Study result                        | 95% Confidence interval or p-value | Adjustment for confounding                                                                 |
|----------------------|--------------------------------------------------------------------------|-------------------------------------|-----------------------------------|-------------------------------------------------------------------------------------------|
| Loo et al., 2017     | Walkability (Walk score) Difference between Q1 and Q4                    | Beta for HbA1C:                     |                                   | Age, sex, current smoking status, BMI, relevant medications and medical diagnoses, neighbourhood violent crime rates and neighbourhood indices of material deprivation, ethnic concentration, dependency and residential instability |
|                      |                                                                          | 1. -0.06                            | 1. -0.11 – 0.02                   |                                                                                           |
|                      |                                                                          | 2. 0.03                             | 2. -0.04 – 0.1                    |                                                                                           |
| Maas et al., 2009    | Green space:                                                             | OR:                                 | 95%CI:                            | Demographic and socioeconomic characteristics, urbanity                                    |
|                      |                                                                          | 1. Q1                               | 1. NA                             |                                                                                           |
|                      |                                                                          | 2. Q4                               | 2. 0.83 – 0.85                    |                                                                                           |
| Mena et al., 2015    | Distance to parks:                                                      | Correlation:                        |                                   | -                                                                                         |
|                      |                                                                          | 1. NR                               | 1. NA                             |                                                                                           |
|                      |                                                                          | 2. -0.094                           | 2. P < 0.05                       |                                                                                           |
| Mezuk et al., 2016   | Ratio of the number of health-harming food outlets to the total number of food outlets within a 1,000-m buffer of each person | OR per km²: 2.11                     | 95%CI:                            | Age, sex, education, and household income                                                  |
| Morland et al., 2006 | Presence of:                                                             | Prevalence ratio:                   | 95%CI:                            | Age, sex, income, education, ethnicity, food stores and service places, PA                 |
|                      | Supermarkets                                                            | 1. 0.96                             | 1. 0.84 – 1.1                     |                                                                                           |
|                      | Grocery stores                                                          | 2. 1.11                             | 2. 0.99 – 1.24                    |                                                                                           |
|                      | Convenience stores                                                      | 3. 0.98                             | 3. 0.86 – 1.12                    |                                                                                           |
| Müller-Riemenschneider et al., 2013 | Walkability (1,600 m buffer):                                              | OR:                                 | 95%CI:                            | Age, sex, education, household income, marital status.                                    |
|                      | High walkability                                                        | 1. 0.95                             | 1. 0.72 – 1.25                    |                                                                                           |
|                      | Low walkability                                                         | 2. 1                                | 2. NA                             |                                                                                           |
|                      | Walkability (800 m buffer):                                              | 3. 0.69                             | 3. 0.62 – 0.90                    |                                                                                           |
|                      | High walkability                                                        | 4. 1                                | 4. NA                             |                                                                                           |
|                      | Low walkability                                                         | 4. 1                                | 4. NA                             |                                                                                           |
### Table 3: study results of studies investigating physical activity environment, food environment, residential noise and DM. (continued)

| Author | Exposure | Study result | 95% Confidence interval or p-value | Adjustment for confounding |
|--------|----------|--------------|----------------------------------|----------------------------|
| Myers et al., 2016 | Physical activity: | Beta: | 95%CI: | Age |
| 1. Recreation facilities per 1000 | 1. | -0.457 | 1. -0.809 – -0.104 |
| 2. Natural amenities (1–7) | 2. | 0.084 | 2. 0.042 – 0.127 |
| Food: | | | | |
| 3. Grocery stores & supercentres per 1000 | 3. | 0.059 | 3. -0.09 – 0.208 |
| 4. Fast food restaurants per 1000 | 4. | -0.032 | 4. -0.125 – 0.062 |
| Ngom et al., 2016 | Distance to green space: | PR: | 95%CI: | Age, sex, social and environmental predictors |
| 1. Q1 (0 – 264 m) | 1. | 1 | 1. NA |
| 2. Q4 (774 – 27781 m) | 2. | 1.09 | 2. 1.03 – 1.13 |
| Paquet et al., 2014 | Built environmental attributes: | RR: | 95%CI: | Age, sex household income, education, duration of FU, area-level SES. |
| 1. RFEIV | 1. | 0.99 | 1. 0.9 – 1.09 |
| 2. Walkability | 2. | 0.88 | 2. 0.8 – 0.97 |
| 3. POS | 3. | | |
| a. POS count | a. | 1 | a. 0.92 – 1.08 |
| b. POS size | b. | 0.75 | b. 0.69 – 0.83 |
| c. POS greenness | c. | 1.01 | c. 0.9 – 1.13 |
| d. POS type | d. | 1.09 | d. 0.97 – 1.22 |
Table 3: study results of studies investigating physical activity environment, food environment, residential noise and DM. (continued)

| Author               | Exposure                                                                 | Study result | 95% Confidence interval or p-value | Adjustment for confounding                                                                 |
|----------------------|---------------------------------------------------------------------------|--------------|-----------------------------------|-------------------------------------------------------------------------------------------|
| Schootman et al.,    | Neighbourhood conditions (objective):                                     | OR:          | 95%CI:                            | Age, sex, income, perceived income adequacy, education, marital status, employment, length of time at present address, own the home, area |
| 2007                 | 1. Housing conditions                                                     | 1. 1.11      | 1. 0.63 – 1.95                   |                                                                                           |
|                      | 2. Noise level from traffic, industry, etc.                               | 2. 0.9       | 2. 0.48 – 1.67                   |                                                                                           |
|                      | 3. Air quality                                                            | 3. 1.2       | 3. 0.66 – 2.18                   |                                                                                           |
|                      | 4. Street and road quality                                                | 4. 1.03      | 4. 0.56 – 1.91                   |                                                                                           |
|                      | 5. Yard and sidewalk quality                                              | 5. 1.05      | 5. 0.59 – 1.88                   |                                                                                           |
|                      | Neighbourhood conditions (subjective):                                    |              |                                   |                                                                                           |
|                      | 6. Fair - poor rating of the neighbourhood                                | 6. 1.04      | 6. 0.58 – 1.84                   |                                                                                           |
|                      | 7. Mixed or terrible feeling about the neighbourhood                      | 7. 1.1       | 7. 0.6 – 2.02                    |                                                                                           |
|                      | 8. Undecided or not at all attached to the neighbourhood                  | 8. 0.68      | 8. 0.4 – 1.18                    |                                                                                           |
|                      | 9. Slightly unsafe - not at all safe in the neighbourhood                 | 9. 0.61      | 9. 0.35 – 1.06                   |                                                                                           |
| Sørensen et al.,     | Exposure to road traffic noise per 10 dB:                                 | Incidence rate ratio: | 95%CI: |                                                                                           |
| 2013                 | 1. At diagnosis                                                           | 1. 1.08      | 1. 1.02 – 1.14                   | Age, sex, education, municipality SES, smoking status, smoking intensity, smoking duration, environmental tobacco smoke, fruit intake, vegetable intake, saturated fat intake, alcohol, BMI, waist circumference, sports, walking, pollution. |
|                      | 2. 5 years preceding diagnosis                                            | 2. 1.11      | 2. 1.05 – 1.18                   |                                                                                           |
| Sundquist et al.,    | Walkability:                                                              | OR:          | 95%CI:                            | Age, sex, income, education, neighbourhood deprivation.                                    |
| 2015                 | 1. D1 (low)                                                               | 1. 1.16      | 1. 1.00 – 1.34                   |                                                                                           |
|                      | 2. D10 (high)                                                             | 2. 1         | 2. NA                             |                                                                                           |

Abbreviations: NA = not applicable; NS = not significant; NR = not reported; 95%CI = 95% Confidence interval; RFEI = Retail Food Environment Index; PSE = Neighbourhood physical and social environment; POS = Public open space; SE = standard error; RR = relative risk; OR = odds ratio; HR = hazard ratios. *Prevalence: Beta (SE); RR; OR; HR. Quality of accessible groceries, likelihood that neighbours help each other, examples of neighbours working together, sense of belonging, degree of trust in neighbours, poverty level, † RFEI = ratio of fast-food restaurants and unhealthful food stores to healthful food stores.
Chapter 2

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Chapter 2

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Supplementary files

Supplementary file 1: Search strategy

Search strategy in PubMed February 29, 2016 (read from bottom-up).

| Set | Search terms                                                                                           | Result   |
|-----|--------------------------------------------------------------------------------------------------------|----------|
| #3  | #1 AND #2                                                                                              | 3726     |
| #2  | “Environment Design”[Mesh] OR “City Planning”[Mesh] OR “Spatial Analysis”[Mesh] OR “Geographic Information Systems”[Mesh] OR “Noise”[Mesh] OR “Parks, Recreational”[Mesh] OR “Crowding”[Mesh] OR green space*[tiab] OR greenspace*[tiab] OR green environment*[tiab] OR green infrastructure*[tiab] OR natural space*[tiab] OR natural environment*[tiab] OR environmental influence*[tiab] OR environmental determinant*[tiab] OR environmental support*[tiab] OR environmental approach*[tiab] OR environmental variable*[tiab] OR environmental attribute*[tiab] OR environmental barrier*[tiab] OR environmental characteristic*[tiab] OR environmental correlat*[tiab] OR environment design*[tiab] OR city planning*[tiab] OR urban design*[tiab] OR urban planning*[tiab] OR urban form*[tiab] OR town planning*[tiab] OR neighbourhood*[tiab] OR neighborhood*[tiab] OR geospatial*[tiab] OR local environment*[tiab] OR rural environment*[tiab] OR urban environment*[tiab] OR objective environment*[tiab] OR perceived environment*[tiab] OR measured environment*[tiab] OR obesogenic environment*[tiab] OR built environment*[tiab] OR physical environment*[tiab] OR geoepidemiology*[tiab] OR spatial analysis*[tiab] OR land use*[tiab] OR spatial access*[tiab] OR residential environment*[tiab] OR urban-rural epidemiology*[tiab] OR geographic cluster*[tiab] OR residential factor*[tiab] OR residence characteristic*[tiab] OR geographic information system*[tiab] OR geographical information system*[tiab] OR sprawl*[tiab] OR zoning*[tiab] OR residential location*[tiab] OR residential proximit*[tiab] OR population densit*[tiab] OR food outlet*[tiab] OR grocery store*[tiab] OR fast food density*[tiab] OR fast food restaurant*[tiab] OR retail densit*[tiab] OR walkability*[tiab] OR cyclability*[tiab] OR sidewalk*[tiab] OR pedestrian*[tiab] OR cycle path*[tiab] OR cyclepath*[tiab] OR recreational facilit*[tiab] OR recreation facility*[tiab] OR worksite*[tiab] OR sports facilit*[tiab] OR food environment*[tiab] OR food suppl*[tiab] OR public open space*[tiab] OR crowding*[tiab] OR park access*[tiab] OR urban park*[tiab] OR noise pollution*[tiab] OR contextual research*[tiab] OR ecological stud*[tiab] OR ecological analysis*[tiab] OR remoteness*[tiab] OR aesthetic*[tiab] OR active travel*[tiab] OR passive travel*[tiab] OR travel to work*[tiab] | 157779   |
| #1  | “Diabetes Mellitus”[Mesh:NoExp] OR “Diabetes Mellitus, Type 2”[Mesh] OR “Blood Glucose”[Mesh] OR “Hyperglycemia”[Mesh] OR “Insulin Resistance”[Mesh] OR diabetes*[tiab] OR diabetic*[tiab] OR dm2*[tiab] OR niddm*[tiab] OR dm 2*[tiab] OR T2D*[tiab] OR dm type 2*[tiab] OR insulin*[tiab] OR glucose*[tiab] OR prediabetes*[tiab] OR pre-diabetes*[tiab] OR prediabetic*[tiab] OR glycemic*[tiab] OR glycaemic*[tiab] OR glycemia*[tiab] OR glycaemia*[tiab] OR HbA1*[tiab] OR HbA1c*[tiab] OR hemoglobin*[tiab] OR haemoglobin*[tiab] OR hyperglycemia*[tiab] | 1024441  |
Search strategy in Embase.com February 29, 2016 (read from bottom-up).

| Set | Search terms | Result |
|-----|--------------|--------|
| #4  | #3 NOT ('conference abstract'/it OR 'editorial'/it OR 'erratum'/it OR 'letter'/it OR 'note'/it) | 6934 |
| #3  | #1 AND #2 | 8753 |
| #2  | ‘environmental planning'/exp OR ‘city planning'/exp OR ‘spatial analysis'/exp OR ‘geographic information system'/exp OR ‘noise pollution'/exp OR ‘land use'/exp OR ‘neighbourhood'/exp OR ‘recreational park'/exp OR ‘crowding (area)'/exp OR ‘green space':ab,ti OR ‘green infrastructure':ab,ti OR ‘natural space':ab,ti OR ‘natural environment':ab,ti OR ‘natural infrastructure':ab,ti OR ‘environment’ design*:ab,ti OR ‘environment’ influence*:ab,ti OR ‘environment’ determinant*:ab,ti OR ‘environment’ support*:ab,ti OR ‘environment’ approach*:ab,ti OR ‘environment’ variable*:ab,ti OR ‘environment’ attribute*:ab,ti OR ‘environment’ barrier*:ab,ti OR ‘environment’ characteristic*:ab,ti OR ‘environment’ correlat*:ab,ti OR ‘city planning’:ab,ti OR ‘urban design’:ab,ti OR ‘urban form’:ab,ti OR ‘urban planning’:ab,ti OR ‘town planning’:ab,ti OR ‘neighbourhood’:ab,ti OR ‘geospatial’:ab,ti OR ‘local environment’:ab,ti OR ‘rural environment’:ab,ti OR ‘urban environment’:ab,ti OR ‘objective environment’:ab,ti OR ‘perceived environment’:ab,ti OR ‘measured environment’:ab,ti OR ‘obesogenic environment’:ab,ti OR ‘built environment’:ab,ti OR ‘physical environment’:ab,ti OR ‘geoepidemiology’:ab,ti OR ‘spatial analysis’:ab,ti OR ‘land use’:ab,ti OR ‘spatial access’:ab,ti OR ‘residential environment’:ab,ti OR ‘urban rural epidemiology’:ab,ti OR ‘geographic cluster’:ab,ti OR ‘residential factor’:ab,ti OR ‘residence characteristic’:ab,ti OR ‘geographic information system’:ab,ti OR ‘sprawl’:ab,ti OR ‘zoning’:ab,ti OR ‘residential location’:ab,ti OR ‘residential’ proximit*:ab,ti OR ‘population densit*:ab,ti OR ‘food outlet’:ab,ti OR ‘grocery store’:ab,ti OR ‘fast food densit*:ab,ti OR ‘fast food restaurant’:ab,ti OR ‘retail densit*:ab,ti OR ‘walkability’:ab,ti OR ‘cycability’:ab,ti OR ‘sidewalk’:ab,ti OR ‘pedestrian’:ab,ti OR ‘cycle path’:ab,ti OR ‘cyclepath’:ab,ti OR ‘recreation’ facilit*:ab,ti OR ‘worksite’:ab,ti OR ‘sport’ facilit*:ab,ti OR ‘food environment’:ab,ti OR ‘park access’:ab,ti OR ‘urban park’:ab,ti OR ‘noise pollution’:ab,ti OR ‘contextual research’:ab,ti OR ‘ecological stud*:ab,ti OR ‘ecological analys*:ab,ti OR ‘remoteness’:ab,ti OR ‘aesthetic’:ab,ti OR ‘active travel’:ab,ti OR ‘passive travel’:ab,ti OR ‘travel to work’:ab,ti |
| #1  | ‘diabetes mellitus'/de OR ‘non insulin dependent diabetes mellitus'/exp OR ‘glucose blood level'/exp OR ‘hyperglycemia'/exp OR ‘insulin resistance'/exp OR ‘insulin sensitivity'/exp OR ‘diabetes':ab,ti OR ‘diabetic’:ab,ti OR ‘dm2’:ab,ti OR ‘niddm’:ab,ti OR ‘dm 2’:ab,ti OR ‘t2d’:ab,ti OR ‘dm type 2’:ab,ti OR ‘insulin':ab,ti OR ‘glucose':ab,ti OR ‘pre-diabetes':ab,ti OR ‘pre-diabetic’:ab,ti OR ‘glycemic':ab,ti OR ‘glycaemic':ab,ti OR ‘glycemia':ab,ti OR ‘glycaemia':ab,ti OR ‘HbA1c':ab,ti OR ‘HB A1c':ab,ti OR ‘HbA1c':ab,ti OR ‘haemoglobin':ab,ti OR ‘haemoglobiwn':ab,ti OR ‘hyperglycemia':ab,ti |

1416599
Search strategy in Web of Science Core Collection, February 29, 2016 (read from bottom-up).

| Set | Search terms                                                                                                                                  | Result |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------|--------|
| #4  | #2 AND #1 <br>**Refined by:** WEB OF SCIENCE CATEGORIES: (ENDOCRINOLOGY METABOLISM OR PUBLIC ENVIRONMENTAL OCCUPATIONAL HEALTH OR GERIATRICS GERONTOLOGY OR SPORT SCIENCES OR NUTRITION DIETETICS OR ECOLOGY OR HEALTH POLICY SERVICES OR MEDICINE GENERAL INTERNAL OR BEHAVIOURAL SCIENCES OR ENVIRONMENTAL SCIENCES OR MULTIDISCIPLINARY SCIENCES OR PATHOLOGY OR FOOD SCIENCE TECHNOLOGY OR PHYSIOLOGY OR GEO SCIENCES MULTIDISCIPLINARY OR CARDIAC CARDIOVASCULAR SYSTEMS OR HEALTH CARE SCIENCES SERVICES OR PSYCHOLOGY OR ANTHROPOLOGY )<br>Indexes=SCI-EXPANDED, SSCI, A&HCI, ESCI Timespan=All years | 4067   |
| #3  | #1 AND #2                                                                                                                                       | 11217  |
| #2  | TS=(“environment design*” OR “city planning*” OR “spatial analysis” OR “geographic information system*” OR noise OR crowding OR “green space*” OR greenspace* OR “green environment*” OR “green infrastructure*” OR “natural space*” OR “natural environment*” OR “natural infrastructure*” OR “environmental influence*” OR “environmental determinant*” OR “environmental support*” OR “environmental approach*” OR “environmental variable*” OR “environmental attribute*” OR “environmental barrier*” OR “environmental characteristic*” OR “environmental correlat*” OR “urban design*” OR “urban planning*” OR “urban form” OR “town planning*” OR “neighbourhood*” OR neighborhood* OR “local environment*” OR “rural environment*” OR “urban environment*” OR “objective environment*” OR “perceived environment*” OR “measured environment*” OR “obesogenic environment*” OR “built environment*” OR “physical environment*” OR geoepidemiology OR “spatial analysis” OR “land use” OR “spatial access” OR “residential environment*” OR “urban-rural epidemiology” OR “geographic cluster*” OR “residential factor*” OR “residence characteristic*” OR “geographic information system*” OR “geographical information system*” OR sprawl OR zoning OR “residential location*” OR “residential proximit*” OR “population densit*” OR “food outlet*” OR “grocery store*” OR “fast food density” OR “fast food restaurant*” OR “retail densit*” OR “walkability” OR “cyclicity” OR sidewalk* OR pedestrian OR “cycle path*” OR cyclepath* OR “recreational facilit*” OR “recreational park*” OR “recreation facility*” OR worksite* OR “sports facilit*” OR “food environment*” OR “food suppl*” OR “public open space*” OR crowding OR “park access” OR “urban park*” OR “noise pollution” OR “contextual research” OR “ecological stud*” OR “ecological analy*” OR “ remoteness OR aesthetic*” OR “active travel*” OR “passive travel*” OR “travel to work”)<br>Indexes=SCI-EXPANDED, SSCI, A&HCI, ESCI Timespan=All years | 116726  |
| #1  | TS=(diabetes OR diabetic* OR “blood glucose” OR “hyperglycemia” OR insulin* OR dm2 OR niddm OR dm 2 OR T2D* OR dm type 2 OR glucose OR prediabetes OR “pre-diabetes” OR prediabetic OR glycemic OR glycaemic OR glycaemia* OR glycemia* OR HbA1 OR “HB A1” OR HbA1c OR hemoglobin* OR haemoglobin* OR hyperglycemia*)<br>Indexes=SCI-EXPANDED, SSCI, A&HCI, ESCI Timespan=All years | 1173823 |
## Supplementary file 2: Study characteristics and results of studies with a weak quality rating

Supplementary table 2.1: Study characteristics and results of studies with a weak quality rating investigating the association of urban and rural environment with T2D

| Author          | Year | Country | Country income level | Study design | Sample size | Age       | Outcome† | Outcome assessment‡ | Result: At least adjusted for age and sex | Quality statement |
|-----------------|------|---------|----------------------|--------------|-------------|-----------|-----------|---------------------|------------------------------------------|-----------------|
| Asadollahi et al. | 2015 | Iran    | Upper middle         | Cross-sectional | 2,158       | 45.5 ± 14.0 | T2D/T1D prevalence | Blood sample                       | Yes                         | Weak            |
| Azizi et al.     | 2003 | Iran    | Upper middle         | Cross-sectional | 595,717     | 62% < 50 y | 38% ≥ 50 y | T2D/T1D prevalence | Blood sample                       | No              | Weak            |
| Bharati et al.   | 2011 | India   | Lower middle         | Cross-sectional | 214         | 100% > 60 y | T2D/T1D prevalence | Self-report                        | No              | Weak            |
| Ceesay et al.    | 1997 | Sierra Leone | Low                  | Cross-sectional | 501         | 35.7 ± 15.7 | Glycaemic marker: random blood glucose | Blood sample                      | No              | Weak            |
| Colleran et al.  | 2007 | Mexico  | Upper middle         | Cross-sectional | 200         | 100% > 50 y | T2D/T1D prevalence | Secondary                          | X               | No              | Weak            |
| Dar et al.       | 2015 | India   | Lower middle         | Cross-sectional | 3,972       | 100% > 40 y | T2D prevalence   | Blood sample                       | X               | No              | Weak            |
| Gangqiang et al. | 2004 | China   | Upper middle         | Longitudinal    | 3,650,000   | NA         | T2D/T1D incidence | Secondary                          | X               | No              | Weak            |
| Khan et al.      | 2014 | Bangladesh | Lower middle         | Cross-sectional | 7,543       | 100% > 35 y | T2D/T1D prevalence | Secondary                          | Yes             | Weak            |
### Supplementary table 2.1: Study characteristics and results of studies with a weak quality rating investigating the association of urban and rural environment with T2D (continued)

| Author         | Year | Country       | Country income level | Study design | Sample size | Age          | Outcome†          | Outcome assessment‡ | Result: Urban > Rural | Rural > Urban | No difference | At least adjusted for age and sex | Quality statement |
|----------------|------|---------------|----------------------|--------------|-------------|--------------|-------------------|----------------------|----------------------|----------------|---------------|----------------------------------|-------------------|
| Kodaman et al. | 2016 | Ghana         | Lower middle         | Cross-sectional | 3,316       | 43.5 ± 13.4 | T2D/T1D prevalence | Blood sample         | X                    | Sex             | No             | Weak                              |                   |
| Mi et al.      | 2016 | China         | Upper middle         | Cross-sectional | 231,289     | 56.4 ± 11.4 | T2D/T1D prevalence | Blood sample         | X                    | Yes             | Weak            | Weak                              |                   |
| Mierzecki et al.| 2014 | Poland        | High                 | Cross-sectional | 271         | 25-45 years | Glycaemic marker: fasting blood glucose | Blood sample         | X                    | No              | Weak            | Weak                              |                   |
| Mohamud et al. | 2010 | Malaysia      | Cross-sectional      | Cross-sectional | 4,341       | 47.8 ± 14.5 | Insulin resistance: HOMA-IR ≥ 2.6 | Blood sample         | X                    | No              | Weak            | Weak                              |                   |
| Nakibuuka et al.| 2015 | Uganda        | Low                  | Cross-sectional | 5,420       | Urban: 32.7 ± 12.4 Rural: 40.1 ± 16.3 | T2D/T1D prevalence | Blood sample         | X                    | No              | Weak            | Weak                              |                   |
| Njelekeka et al.| 2003 | Tanzania      | Low                  | Cross-sectional | 445         | 51.8 ± 3.4 | Glycaemic marker: HbA1c | Blood sample         | X                    | (women)         | (men)           | Weak                              |                   |
| Shera et al.   | 2007 | Pakistan      | Lower middle         | Cross-sectional | 5,433       | 74% < 55y 26% ≥ 55y | T2D/T1D prevalence | Secondary            | X                    | No              | Weak            | Weak                              |                   |
| Valverde et al.| 2006 | Spain         | High                 | Cross-sectional | 1,556       | 58% < 50y 42% ≥ 50y | T2D/T1D prevalence | Blood sample         | X                    | No              | Weak            | Weak                              |                   |
Supplementary table 2.2: Study characteristics of studies with a weak quality rating investigating physical activity environment, food environment and T2D

| Author          | Year | Country | Income level | Study design | Sample size | Age | Outcome† | Outcome assessment‡ | Exposure category | Exposure assessment | Level geodata | Quality statement |
|-----------------|------|---------|--------------|--------------|-------------|-----|----------|----------------------|-------------------|-------------------|---------------|-------------------|
| Babey et al. (76) | 2008 | US      | High         | Cross-sectional | 43,000      | > 18y | T2D/T1D prevalence rate | Self-report | Food GIS | Individual | Weak |
| Ewing et al. (129) | 2014 | US      | High         | Cross-sectional | 709,234    | > 18y | T2D/T1D prevalence | Blood sample | PA Secondary | Aggregate | Weak |
| Herrick et al. (51) | 2015 | US      | High         | Cross-sectional | 15,522     | 41.0 ± 12.6 | T2D/T1D prevalence | Blood sample | PA food Place of residence | Individual | Weak |
| Jiao et al. (77) | 2015 | US      | High         | Cross-sectional | 2,001      | 54.0 ± 15.0 | T2D/T1D prevalence | Blood sample | Food GIS | Individual | Weak |
| Marshall et al. (52) | 2014 | US      | High         | Cross-sectional | 1,044      | 35.5 ± 8.3 | T2D/T1D prevalence | Self-report | PA food | Aggregate | Weak |
| Salois et al. (55) | 2012 | US      | High         | Cross-sectional | NA NA | NA | T2D/T1D prevalence | Secondary PA food | Secondary Aggregate | Weak |
| Shaffer et al. | 2017 | US      | High         | Cross-sectional | 444        | 21.3 ± 1.43 | Glycaemic marker: fasting glucose | Blood sample | PA | Self-report | Individual | Weak |
| Author          | Exposure                                                                 | Study result* | 95% Confidence interval or p-value | At least age and sex adjusted |
|-----------------|--------------------------------------------------------------------------|---------------|-----------------------------------|------------------------------|
| Babey et al., 2008 | Food environment: RFEI<sup>a</sup>                                      | Prevalence:   | P < 0.05 (high vs. low RFEI)       | No                           |
|                 | 1. RFEI > 5                                                             |               |                                   |                              |
|                 | 2. RFEI 3 - 4,9                                                          |               |                                   |                              |
|                 | 3. RFEI < 3                                                             |               |                                   |                              |
| Ewing et al., 2014 | 1. Original sprawl index (density)                                       | T-ratio       | P < 0.05                          | Yes                          |
|                 | 2. Refined sprawl index<sup>‡</sup>                                       |               |                                   |                              |
| Herrick et al., 2015 | 1. Walkability (per SD change)                                          | OR:           | 95% CI:                           | Yes                          |
|                 | 2. Supermarket density (per square mile)                                |               | 1.04 – 1.37                       |                              |
| Jiao et al., 2015 | Distance to closest fast food restaurant                               | OR:           | 0.83 – 1.99                       | Yes                          |
| Marshall et al., 2014 | Block group level variables                                           | Beta (SE):    |                                   | No                           |
|                 | 1. Intersection variables                                               |               | 1. NS                              |                              |
|                 | 2. Intersection density (per square mile)                               |               | 2. NS                              |                              |
|                 | 3. Number of fast food restaurants                                      |               | 3. NS                              |                              |
|                 | 4. Number of big box stores                                              |               | 4. P < 0.10                        |                              |
|                 | 5. Number of grocery stores                                             |               | 5. NS                              |                              |
|                 | City level:                                                             |               |                                   |                              |
|                 | 6. Intersection density (per square mile)                               | -0.0004       | 6. P < 0.05                        |                              |
|                 | 7. Average tot number of lanes on major streets                          | 0.029         | 7. P < 0.05                        |                              |
|                 | 8. Percent of major streets with bike lanes                              | -0.07         | 8. P < 0.05                        |                              |
|                 | 9. Number of fast food restaurants                                      | -0.001        | 9. P < 0.05                        |                              |
|                 | 10. Number of fitness centres                                           | NR            | 10. NS                             |                              |
|                 | 11. Number of convenience stores                                        | 0.008         | 11. P < 0.05                       |                              |
| Salois et al., 2012 | Local food economy:                                                     | Intercept = 9.5, |                                   | No                           |
|                 | 1. Farmers’ market density                                              | -0.925        | 1. p < 0.05                        |                              |
|                 | 2. Direct farm sales per capita (dollars)                               | -0.013        | 2. p < 0.01                        |                              |
|                 | 3. Percent of farms with direct sales                                   | -0.007        | 3. NS                              |                              |
|                 | 4. Fast food restaurants density                                         | 0.321         | 4. p < 0.01                        |                              |
|                 | 5. Full-service restaurants density                                     | -0.606        | 5. p < 0.01                        |                              |
|                 | 6. Supermarkets-grocery store density                                   | -0.002        | 6. NS                              |                              |
|                 | 7. Convenience stores no gas density                                    | 1.993         | 7. p < 0.01                        |                              |
|                 | 8. Convenience stores with gas density                                  | 0.199         | 8. NS                              |                              |
|                 | 9. Supercentres and club density                                        | 1.69          | 9. NS                              |                              |
|                 | 10. Recreational and fitness facilities density                         | -0.644        | 10. NS                             |                              |
|                 | 11. ERS natural amenity index                                           | -0.051        | 11. NS                             |                              |
Chapter 2

Supplementary table 2.3: Study results of studies a weak quality rating investigating the association of physical activity environment, food environment or residential noise with T2D (continued)

| Author       | Exposure | Study result* | 95% Confidence interval or p-value | At least age and sex adjusted |
|--------------|----------|---------------|-----------------------------------|------------------------------|
| **Shaffer et al., 2017** | Walkability: | Correlation: |                                  |                              |
|              | Males:   |              |                                   |                              |
|              | 1. sidewalks | 1. 0.17     | 1. P > 0.05                      |                              |
|              | 2. traffic    | 2. -0.08   | 2. P > 0.05                      |                              |
|              | 3. crime during day | 3. -0.09 | 3. P > 0.05                      |                              |
|              | 4. crime at night | 4. -0.02 | 4. P > 0.05                      |                              |
|              | Females |              |                                   |                              |
|              | 5. sidewalks | 5. 0.09     | 5. P > 0.05                      |                              |
|              | 6. traffic    | 6. 0.28    | 6. P < 0.05                      |                              |
|              | 7. crime during day | 7. 0.21 | 7. P < 0.05                      |                              |
|              | 8. crime at night | 8. -0.16 | 8. P > 0.05                      |                              |
**Supplementary file 3: Sensitivity analyses**

Forest plots of meta-analysis of the association between built environmental characteristics and T2D risk/prevalence, including studies with a weak quality rating.

### Strong quality rating

| Author(s) and Year | Relative Risk [95% CI] |
|--------------------|-----------------------|
| Balogun, 2012      | 4.25 [1.81, 9.90]     |
| Raghupathy, 2007   | 1.06 [0.84, 1.33]     |
| Du, 2016           | 1.14 [0.88, 1.48]     |
| Attard, 2012       | 1.94 [1.35, 2.79]     |
| Davila, 2013       | 0.71 [0.31, 1.63]     |
| Gong, 2015         | 1.90 [1.27, 2.84]     |
| Oyebode, 2015      | 1.88 [1.28, 2.76]     |
| Han, 2017          | 1.38 [1.23, 1.55]     |
| Dagenais, 2016     | 1.24 [1.11, 1.39]     |
| Pharm, 2016        | 1.20 [1.06, 1.36]     |
| Bahendeka, 2016    | 1.80 [0.75, 4.33]     |
| Allender, 2011     | 2.05 [1.35, 3.11]     |

### Moderate quality rating

| Author(s) and Year | Relative Risk [95% CI] |
|--------------------|-----------------------|
| Anjana, 2011       | 1.30 [1.11, 1.52]     |
| Christensen, 2009  | 2.10 [1.43, 3.07]     |
| Ramdani, 2012      | 1.22 [0.89, 1.68]     |
| Barnabe–ortiz, 2016| 1.94 [1.35, 2.79]     |
| Zhou, 2015         | 1.22 [1.05, 1.42]     |
| Keel (non–indigenous), 2017 | 1.01 [0.65, 1.57] |
| Keel (indigenous), 2017 | 0.62 [0.40, 0.97]    |
| Georgousopoulou, 2017 | 2.57 [1.09, 6.03] |

### Weak quality rating

| Author(s) and Year | Relative Risk [95% CI] |
|--------------------|-----------------------|
| Asadollahi, 2015   | 1.60 [1.37, 1.86]     |

**RE Model for All Studies (I² = 81.9%)**

**High income**

| Author(s) and Year                      | Relative Risk [95% CI] |
|----------------------------------------|-----------------------|
| Han, 2017                              | 1.38 [1.23, 1.55]     |
| Keel (non–indigenous), 2017             | 1.01 [0.65, 1.57]     |
| Keel (indigenous), 2017                 | 0.62 [0.40, 0.97]     |
| Georgousopoulou, 2017                  | 2.57 [1.09, 6.03]     |

**Upper middle income**

| Author(s) and Year | Relative Risk [95% CI] |
|--------------------|-----------------------|
| Dagenais, 2016     | 1.24 [1.11, 1.39]     |
| Du, 2016           | 1.14 [0.88, 1.48]     |
| Attard, 2012       | 1.94 [1.35, 2.79]     |
| Davila, 2013       | 0.71 [0.31, 1.63]     |
| Gong, 2015         | 1.90 [1.27, 2.84]     |
| Oyebode, 2015      | 1.88 [1.28, 2.76]     |
| Barnabe–ortiz, 2016| 1.94 [1.35, 2.79]     |
| Zhou, 2015         | 1.22 [1.05, 1.42]     |

**Lower middle income**

| Author(s) and Year | Relative Risk [95% CI] |
|--------------------|-----------------------|
| Pharm, 2016        | 1.20 [1.06, 1.36]     |
| Asadollahi, 2015   | 1.60 [1.37, 1.86]     |
| Balogun, 2012      | 4.25 [1.81, 9.96]     |
| Raghupathy, 2007   | 1.06 [0.84, 1.33]     |
| Allender, 2011     | 2.05 [1.35, 3.11]     |
| Anjana, 2011       | 1.36 [1.11, 1.52]     |
| Christensen, 2009  | 2.10 [1.43, 3.07]     |
| Ramdani, 2012      | 1.22 [0.89, 1.68]     |

**Low income**

| Author(s) and Year | Relative Risk [95% CI] |
|--------------------|-----------------------|
| Bahendeka, 2016    | 1.80 [0.75, 4.33]     |

**RE Model for All Studies (I² = 81.9%)**
## Supplementary file 4: Studies investigating combined characteristics

### Supplementary table 4: Study characteristics and results of studies investigating combinations of environmental characteristics

| Author            | Exposure                        | Study result* | 95% Confidence interval or p-value | At least age and sex adjusted |
|-------------------|---------------------------------|---------------|-----------------------------------|------------------------------|
| Braun et al., 2015| Vibrancy index†                | Beta (SE):    | NS                                | Yes                          |
|                   |                                 | -0.002 (0.001)|                                   |                              |
| Freedman et al., 2011 | Built environment: | OR:           | 95% CI:                           | Yes                          |
|                   | Men:                            |               |                                   |                              |
|                   | 5. Connectivity (2000 Topologically Integrated Geographic Encoding and Referencing system). | 5. 1.06 | 5. 0.86 – 1.29 |                              |
|                   | 6. Density (number of food stores, restaurants, housing units per square mile) | 6. 1.05 | 6. 0.89 – 1.24 |                              |
|                   | Women:                          |               |                                   |                              |
|                   | 7. Connectivity                 | 7. 1.01       | 7. 0.84 – 1.20                    |                              |
|                   | 8. Density                      | 8. 0.99       | 8. 0.99 – 1.17                    |                              |
| Liu et al., 2014  | PSE ‡:                          | OR:           | 95% CI:                           | Yes                          |
|                   | 1. Q1 ( < 0.62)                 | 1. 1          | 1. NA                             |                              |
|                   | 2. Q4 (0.70 – 0.76)             | 2. 1.53       | 2. 1.25 – 1.88                    |                              |
| Meyer et al., 2015| Obesogenicity clusters (latent class analyses) | Beta:         | 95% CI:                           | Yes                          |
|                   | Lower population density clusters: |               |                                   |                              |
|                   | 1. Low obesogenicity, moderate development: moderate level of neighbourhood features, relatively more Pa resources (than the other two low-population-density classes) and a diverse mix of food resources | 1. 0 | 1. NA |                              |
|                   | 2. Moderate obesogenicity, moderate development: high connectivity, moderate Pa resources, high convenience store, supermarkets, grocery store (relative to other food resources) | 2. -0.038 | 2. -0.083 – 0.006 |                              |
|                   | 3. High obesogenicity, low development: low connectivity, few PA resources, food environment relatively high in convenience store and moderate in fast food | 3. -0.013 | 3. -0.045 – 0.019 |                              |
|                   | Higher population density clusters: |               |                                   |                              |
|                   | 4. Low obesogenicity, high development: high connectivity, many PA resources, food environment characterised by high in coops, specialty markets, and non-fast-food restaurants, low in convenience stores | 4. 0 | 4. NA |                              |
|                   | 5. Moderate obesogenicity, moderate development: moderate levels of all features | 5. 0.034 | 5. 0.002 – 0.067 |                              |
|                   | 6. High obesogenicity, high development: high connectivity, large number of parks and PA resources, convenience stores, grocery stores | 6. -0.007 | 6. -0.045 – 0.032 |                              |

†Vibrancy index = composed of compactness, density, regional connectivity, local connectivity, destination accessibility, mixed use, social diversity. ‡ Refined sprawl index = density, land use mix, population and employment centering, street accessibility, D PSE = access to and usage of recreational facilities, access to fruits and vegetables, quality of accessible groceries, likelihood that neighbours help each other, examples of neighbours working together, sense of belonging, degree of trust in neighbours, poverty level.
Built environmental characteristics and diabetes: a systematic review and meta-analysis