Public Health Ontario | Santé publique Ontario

EVIDENCE BRIEF

Impact of Environmental Features on Diabetes

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Key Messages

- The built environment, which includes neighbourhoods, streets, buildings, and parks, as well as urban design, transportation networks, and land-use planning, may support or discourage people from leading healthy lives. These environmental features have an impact on the development and management of Type 2 diabetes (T2D).
- Highly walkable neighbourhoods are associated with a decrease in diabetes prevalence. The presence and closeness of green space can boost physical activity and protect against T2D.
- The food environment has an impact on diabetes risk. Diabetes incidence was higher in areas with high concentration of fast food outlets compared to low concentration areas.
- Although an association between environmental features and T2D has been established, there is still a knowledge gap, as this association has only been documented by a limited number of quality studies. The larger focus of the literature is on the behavioural and lifestyle risk factors.
- Population-level interventions that are implemented in communities, as well as built environment interventions that try to improve community environmental features, can help to address risk factors, and reduce T2D prevalence.
- The burden of T2D disproportionately affects groups based on race, ethnicity, and socioeconomic position; hence, in order to reduce inequities, attempts to improve built environment characteristics should be rooted in addressing the structural determinants of health and to prioritize the unique needs and perspectives of impacted populations.

Issue and Research Question

Recent projections indicate that by 2050, more than 1.27 billion people across the globe will be affected by Type 2 Diabetes (T2D).[1-3] Diabetes-related complications include nerve and blood vessel damage, blindness, kidney failure, heart attacks, stroke, lower limb amputation and premature death.[4,5] Canada spends $9 billion annually on health care, disability, work loss, and premature death costs related to diabetes.[6] In Canada, the burden of diabetes is predicted to increase demand on the health system with estimates that, between 2011/2012 and 2021/2022, new cases of diabetes are expected to result in $15.36 billion in health care costs.6 As of 2023, 30% of Ontarians live with diabetes or pre-diabetes resulting in the direct cost of 1.7 billion to the health care system.[4,7]

T2D has a complex etiology. Socioeconomic, environmental, genetic, metabolic, and behavioural factors all play a role in either preventing or accelerating the onset of the disease.[8] Living conditions have a significant impact on whether or not individuals are able to engage in healthy behaviours. There is a

growing recognition of the importance of built environment interventions for reducing the prevalence of chronic diseases, such as T2D.[9] The built environment, which includes neighbourhoods, streets, buildings, and parks, as well as urban design, transportation networks, land-use planning, and related legislation, can either encourage or prevent people from living healthy lives. These environmental features and their interactions with modifiable behavioural risk factors (e.g., physical activity, healthy eating) influence the onset and management of T2D.[10]

Availability of active and public transportation are important environmental elements for improving health. Diabetes Canada defines active transportation as "any form of transportation powered by the human body," which includes walking, jogging, cycling, skating, etc.[11] According to the Toronto Charter for Physical Activity, one of the best investments for sustainable physical activity across the population is the implementation of policies that enable access to safe walk-bike infrastructure, such as sidewalks, bike lanes, and footpaths.[11] Since the majority of transit trips begin and end with active movement, taking public transportation also increases physical activity.[12] An association has been observed between increasing physical activity and lowering the incidence of T2D.[21,51] Walking to and from public transportation stops accounts for more than 30 minutes of physical exercise per day for around 29% of commuters who use public transportation.[11] Access to a reasonably priced, dependable, and effective public transit system is an important feature of the built environment that can lead to increased physical activity and beneficial health effects.[11]

One of the major factors of the built environment is walkability. Connectivity of streets, variety of land use, population and residential density, neighbourhood aesthetics, and availability of green space, all contribute to a walkable community.[11] Some evidence suggests the prevalence of T2D is lower in highly walkable neighbourhoods.[13]

The food environment is another component of environmental features that influence T2D. The food environment is defined by the National Collaborating Centre for Environmental Health as "physical, social, economic, cultural, and political factors that impact the accessibility, availability, and adequacy of foods within a community or region".[14] By increasing the availability and accessibility of healthy foods, a healthy food environment can influence dietary habits and may improve health outcomes associated with nutrition.[14] Within a community food environment , different regions may be classified as either "food swamps," "food deserts," or "food mirages".[11] Food swamps describe geographic locations where there are a disproportionate number of food stores offering foods high in fat, sugar, and calories in comparison to the number of retailers selling more healthful options.[11,60] It is the predominant form of community food environment in urban neighbourhoods in Canada.[60] On the other hand, food deserts, are used to describe neighbourhoods with limited access to healthy foods, causing residents additional travel expenses and to travel further distances to obtain nutritious foods.[11,60] Canadians residing in rural areas may encounter food deserts, necessitating lengthy journeys to obtain nutritious food.[60] Food mirages describe individuals or groups who face financial barriers to accessing nutritious foods in their community.[11] As reported by Diabetes Canada, creating a health-promoting food environment for all Canadians would increase the affordability and accessibility of nutritious food options, potentially leading to beneficial health outcomes such as enhanced T2D prevention and control.[11]

Health indicators, such as the prevalence of overweight and obesity, T2D and cardiovascular disease, are strongly correlated with a community's socioeconomic position. Individuals living in low-income neighbourhoods may be disproportionately impacted for many reasons, including less access to recreation opportunities and less disposable income, among other barriers.[11] The aforementioned inequities have a direct influence on the individuals' ability to access urban infrastructure that fosters well-being and enhances their overall quality of life.[62] The experience of being exposed to low quality built environments is not a matter of personal choice and presents several complexities when it comes to initiating change. The ability of people to exert control over the many systemic concerns and

structural variables that impact their health outcomes is inherently restricted.[61,62] The built environment can foster an atmosphere in which people are more able to engage in health-promoting activities.[11] Policies that influence the built environment to improve access to physical activity and access to nutritious foods may provide an opportunity to promote health equity in the prevention and management of T2D among Canadians.[11]

Although an association has been established, there is a knowledge gap in diabetes research regarding the influence of environmental features on T2D. Few studies have explored this association, and in most cases, the study designs used have not been sufficiently robust to demonstrate impact.[15] Furthermore, there is a disparity between diabetes prevention and management knowledge and actual implementation. As a result, there is a need for new approaches to improve the translation of research related to diabetes prevention and management into practice.[15]

In this evidence brief, we aimed to bridge this knowledge gap by addressing the following question: *What are the features of environments (or changes to environments) that help to reduce risk factors for diabetes?*

Methods

A literature search was conducted on April 19, 2023 by Public Health Ontario (PHO) Library Services for articles published between 2012 and 2023. The search involved six databases including MEDLINE, Embase, CINAHL, PsycINFO, Health Policy Reference Center, and Scopus. The full search strategy (including search vocabulary) is available upon request from PHO.

Search strategies were peer-reviewed by members of the Library Services team. All searches were restricted to English-language articles published in 2012 or later and only research involving human subjects conducted in OECD countries. Articles were eligible for inclusion if they targeted the general population. These articles focus on environmental features and their influence on T2D incidence and prevalence. Included were primary studies and review-level evidence, while commentaries, editorials, books, and conference proceedings were excluded.

PHO Library Services combined search results from all databases and removed duplicates, leaving 879 results for screening. Two reviewers independently screened the same 20% of results against relevant criteria at the title and abstract level, reaching consensus on any conflicting reviews. A single reviewer independently screened the remaining set. At this level, studies focusing on gestational diabetes or screening were excluded.

Full text articles were retrieved, and 102 studies that met inclusion criteria were subjected to a full-text review by two reviewers. Single studies that were included in other included reviews were excluded at this level of screening. Consensus on discrepancies was achieved through discussion. In all, 37 articles were considered for inclusion in the process of data extraction and synthesis.

Two reviewers independently conducted quality appraisal. The Health Evidence Tool[16] was used to assess the quality of systematic reviews. The Critical Appraisal Skills Programme Tool[17] was used to assess the quality of qualitative studies and the Newcastle-Ottawa Scale Tool[18] was used to assess the quality of cross-sectional, cohort, and case-control primary studies. Discrepancies in quality appraisal outcomes between the reviewers were resolved by consensus. More information on quality appraisal is available upon request.

Main Findings

A total of 37 articles met the inclusion criteria for this evidence brief on environmental features and their association with the incidence of T2D. Among the included articles, one was a systematic review[19] and another a scoping review.[20] The remaining thirty-five articles were primary studies.[21-55] The majority of the studies were conducted in the United States (n=21), while the remaining were conducted in Australia (n=4), Canada (n=3), Germany (n=2), United Kingdom (n=2), Chile (n=1), Italy (n=1), Netherlands (n=1), New Zealand (n=1) and Saudi Arabia (n=1). The following findings are organized according to the most prominent environmental features that emerged from the examined data that included active transportation, public transportation, built environment, and food environment (food swamps and deserts). Additionally, equity considerations that had an impact on T2D are summarized.

Active Transportation

Active transportation was found to positively impact T2D outcomes in two primary studies.[27, 55] In a five-year longitudinal cohort study, proximity to amenities was associated with active transportation, which reduced the risk of T2D.[27] In a cross sectional study the risk of incident T2D was 31% lower compared to those who did not have local amenities within walking distance, after controlling for individual and area level covariates.[55]

Public Transportation

Among three primary studies on public transportation, access to and use of public transportation had a positive impact on T2D outcomes. A five-year longitudinal cohort study observed an association between more frequent public transit use and decreased T2D incidence.[28] This finding was consistent with another qualitative study, which reported that lack of access to reliable transportation was an impediment to adopting positive lifestyle adjustments that can impact T2D.[45] Additionally, one cross-sectional study observed correlations between patients with unmet healthcare transportation and experiencing increased risk of uncontrolled diabetes (Adjusted Odds-Ratio: 1.54 (95% CI: 1.22, 1.95).[26]

Built Environment

WALKABILITY

Five studies investigated the relationship between walkability and T2D prevalence and incidence, with four finding walkability could reduce T2D risk. Three quantitative studies, including an eight-year long Canadian cohort study[31], found that walkability decreased T2D risk [24,29,31], with a qualitative study indicating lack of sidewalks were a barrier to walking.[51] One cross-sectional study found no correlation between walkability and T2D.[37]

GREEN SPACE

Nine articles, including one systematic review and one scoping review, examined the availability and proximity of green space and its effect on T2D. Findings revealed a protective role of green space in relation to T2D. In two reviews, the presence of green space was associated with a lower prevalence of T2D (OR=0.87, 95% CI=0.85-0.89).[19,20] Similar findings were reported in a case-control study[49], two prospective cohorts[30,54] and four cross-sectional studies.[50,43,33,55]

PUBLIC SPACES

Four studies showed there was an association between public spaces and T2D.[25,28,48,51] A five-year longitudinal cohort and a cross-sectional study revealed that chronic exposure to poor quality built environment (property disorder, territoriality, vacancy, and public nuisances) may deteriorate health

and well-being over time and reduce the capacity of individuals to recover from other stressors.[25,28] Results from these studies further indicate that, apart from the dietary environment and physical activity resources, neighbourhood built environment features are associated with diabetes at the individual level.[25,28] Similar results were found in another two qualitative studies, wherein the poor maintenance of public spaces in an under resourced neighbourhood (i.e., the uneven roads, as well as the closure of the shopping mall, the downsizing of the local market and lack of bike lanes) was a significant factor that could prevent residents from engaging in daily physical activity, thereby increasing the risk of T2D.[48,51]

RESIDENTIAL SETTINGS

In four studies, the effect of residential setting (including safety, aesthetics, and social cohesion in the neighbourhood) on T2D incidence was explored.[27,28,34,42] Findings demonstrated an association, but not a direct impact of the residential settings on T2D. Two longitudinal cohorts and a cross-sectional study revealed that a safe neighbourhood may encourage physical activity and walking, which, in turn, may reduce the risk of T2D.[27,28,34] Findings from a five-year longitudinal study, showed that the proximity to destinations and neighbourhood crime were associated with reduced physical activity.[27,28] Neighbourhood violence, poor aesthetics, and social incoherency raised stress, making glycemic levels more difficult to regulate.[42] Consequently, there were indirect effects between violence and higher HbA1c via stress (Blood test that measures average blood sugar level over the past 2-3 months) ($r=0.05$, $p=0.04$).[42]

HOUSING CONDITIONS

An association between housing conditions and prevalence of T2D was highlighted in five studies. Three cohort studies found that higher household socioeconomic position was associated with more favourable environmental features and that individuals residing in environments with more resources to support physical activity and healthy food had a lower incidence of T2D, while lower household socioeconomic position was associated with higher incidence of T2D.[32,35,52] Similar findings were observed in a cross-sectional study[26] and a qualitative study.[22]

Food Environment

FOOD SWAMPS

Five studies examined the association between the high prevalence of fast food restaurants and the incidence of T2D.[36,39,44,50,55] These studies generally support the prevalence of fast food restaurants as an independent predictor of T2D. In a two-year longitudinal cohort the availability of fast-food restaurants in comparison to other types of restaurants was associated with an increased risk of T2D in every community type.[36] This association was also observed in four other cross sectional studies. [39,44,50,55] Lastly, a qualitative study conducted in the United Kingdom with focus groups of 25 healthcare professionals focused on management of pre-diabetes, and revealed that the abundance of fast food restaurants in the area is a reflection of the demand for quick, inexpensive food and the cultural acceptability of fast food.[22]

FOOD DESERTS

Seven studies investigated food deserts (neighbourhoods with limited access to healthy foods), with five of seven studies supporting an association between access to healthy food and the reduced risk of T2D.[38,40,42,45,47,51,53] Several participants in two cross-sectional studies reported having limited access to healthy foods in their neighbourhood, especially fresh vegetables, and were frequently exposed to advertisements for fast food, making it difficult to resist high energy and low nutrient density foods.[40,53] Moreover in three qualitative studies, adolescents, parents, and professionals viewed a lack of access to

healthy food as a barrier that negatively affects the incidence of T2D.[38,45,51] Two cross-sectional studies found no correlation between access to healthy food and T2D incidence.[42,47]

Equity Considerations

The built environment is a key consideration for contributing to health equity as it influences the social determinants of health, including people's physical activity, access to green space and recreation, access to jobs and services, transportation, etc. The prevalence of T2D has been associated with low income, low levels of education, unemployment, and under resourced neighborhoods.[33,39,43,47,49,50,52,53] A Canadian study, found that the environmental and socioeconomic differences between neighbourhoods may have an influence on T2D prevalence rates.[33] Low levels of education and unemployment were associated with increased T2D incidence.[33] Those who resided in the most economically under resourced neighbourhoods and who also had the most negative impressions of their neighbourhood were shown to have the highest rates of T2D.[26,28,29] The extent to which the built environment affects health may vary from person to person and is informed by the broader social and structural context, where chronic exposure to substandard built environment may deteriorate individuals' health and well-being over time and reduce their resilience to other stressors.[25,32,35]

Limitations

One of the limitations identified during the development of this synthesis was the small number of Canadian studies (N=3) that addressed the influence of environmental factors on the prevalence of T2D. Over half of the investigations (57 %) were conducted in the United States. The small number of studies addressing Canadian environmental factors may limit generalizability of evidence on the association between the built environment and T2D within Canada.

Discussion and Conclusions

Overall, environmental features can contribute to the reduction of T2D. Results highlighted that increasing active and public transportation can influence physical activity, which in turn helps with lowering the incidence of T2D. Additionally, highly walkable neighbourhoods were associated with a reduction in T2D prevalence. Furthermore, having green spaces nearby can increase physical activity and help protect against T2D.

Findings of this brief showed that adequate public spaces that are well maintained can encourage residents to increase their physical activity. Safe neighbourhoods are associated with increased physical activity and decreased prevalence of T2D. In contrast, neighbourhoods with high crime rates can increase stress which in turn may increase the risk of T2D. In addition, households with a higher socioeconomic position were more likely to engage in healthy behaviours that help reduce T2D prevalence. Results showed that the food environment may play a considerable role influencing the risk of developing T2D; areas with too many unhealthy food options (food swamps) or too few healthy ones (food deserts) were associated with a higher T2D prevalence. Lastly, findings regarding equity considerations found that those who resided in under resourced neighbourhoods had the highest rates of T2D.

Several neighbourhood factors influence health, such as variations in neighbourhood density, the availability of public spaces and amenities, and community-level services. These factors influence health via physical and social settings, as well as individual actions.[61] The potential consequences of these impacts may be unequally distributed, which could result in disproportional health burdens among persons who are socioeconomically disadvantaged.[57] The socioeconomic position of a neighbourhood

has been shown to be a strong indicator of poor health across many geographic areas in Canada.[61] Specifically, communities that possess many resources and exhibit high levels of informal social control or cohesiveness are strongly linked to lower rates of depression, anxiety, lower body mass index, and overall better general health.[61] Nevertheless, relying on neighbourhood socioeconomic position as the only indicator for assessing the health of communities is not a reliable approach.[57,61]

There is a knowledge gap when it comes to understanding how the environment affects T2D. The important role of unfavourable social and environmental features in affecting disease burden and distribution is now more recognized.[57] Despite growing interest in the built environment as a mechanism for enhancing community health and reducing the risk of chronic disease, a limited number of quality studies examine this mechanism.[56] Many population-level strategies to prevent T2D involve changes in the food environment, thus, it is essential to recognize the connection between the food environment and diabetes.[58] Some approaches that can promote healthy nutritious habits and aid in reducing the prevalence of T2D include enhancing food availability and supply, bringing amenities closer to people's homes, and implementing educational and informational strategies such as food and menu labelling and mass media campaigns.[28,58]

Interventions for the built environment aimed at improving neighbourhood walkability, providing recreational areas, and improving transit infrastructure can help promote physical activity and reduce the prevalence of T2D in both children and adults.[56,58] This evidence brief adds to the growing body of research that the built environment, which includes creating activity-friendly routes (e.g., pedestrian, bicycle, or public transit access), reducing crime, improving land use, and increasing neighbourhood walkability can have a positive impact Canadian's health.[11,25,28]

Research shows that certain characteristics such as having low income, being unemployed, or living in under resourced neighbourhoods are associated with inequalities in T2D.[33] Further, the burden of disease disproportionately impacts groups based on the experiences resulting from identities and factors tied to race, ethnicity, and socioeconomic position.[25,56] These findings reinforce existing knowledge regarding the influence of systems of oppression, including but not limited to racism and colonialism, and other structural factors that sustain deep imbalances in power, wealth and opportunity, on built environments and consequently, the prevalence of T2D.[61,62] Thus, priority should be given to low-socioeconomic position neighbourhoods, whose residents are more likely to live in built environment that discourage physical activity and limit nutritious dietary options.[38] To reduce T2D, changes in local policy and infrastructure are essential.[19,38] Initiatives to enhance built environment features should be attentive to the needs and preferences of these racialized and low income communities.

Affordable housing, access to inexpensive healthy food, affordable transportation, nearby and connected green space, and safe community spaces that take into consideration the individual characteristics of each neighbourhood are all important aspects in fostering health equity in communities.[61] Community and neighbourhood grants are a tool that may help communities reclaim underutilized, abandoned, or badly maintained public places for community-driven activities, enhanced safety and aesthetics, or community programs.[61] In conclusion, creating healthy environments through upstream policy and infrastructure interventions, adopting an equity-based approach to governance, addressing diabetes as both a societal and a medical problem, and removing barriers to targeted diabetes prevention efforts can help to reduce the inequities associated with diabetes and improve health outcomes for all Canadians.[11,22,59]

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