Effect of walkability on the prevalence of diabetes in Toronto, ON.

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Abstract
Walkability describes whether an area is likely to encourage or discourage walking based on infrastructure. The association between walkability and the prevalence of diabetes exists because of exercise. Areas of high walkability are bound to have more pedestrians. These pedestrians are individuals who can much more easily obtain their regular exercise than people who primarily use motorized vehicles such as those living in areas of low walkability. The consequence of not attaining a weekly 150 minutes of moderate aerobic activity, which includes walking, is an increased risk of developing type 2 diabetes (National Health Service, n.d.). On top of this, exercise can also prevent hypertension, which increases an individual’s risk of developing diabetes by 52-58% (Emdin et al. 2015).

Purpose
This study aims to investigate the association between walkability and the prevalence of diabetes in Toronto, ON. By assessing this association, recommendations for potential interventions can be made to improve the health of citizens.

Introduction
An association between walkability (Figure 1) and prevalence of diabetes (Figure 2) is observed in several areas of Toronto. These include, but are not limited to, the areas within Steeles Ave, Pickering Town Line, Kingston Rd, Victoria Park Ave, Highway 401, and McCowan Rd (Figure 3). Many areas show a low walkability and a high prevalence of diabetes (red on Figure 3), while other areas show a high walkability and a low prevalence of diabetes (light blue on Figure 3), both of which represent the effect that walkability has on the prevalence of diabetes.

A walkability index is created by analyzing the nature of an environment to determine how likely it is to promote walking (Toronto Community Health Profiles, 2012). Places with a high walkability are likely to encourage walking, whereas places with a low walkability are likely to discourage walking (Toronto Community Health Profiles, 2012). Areas of low walkability lack infrastructure to facilitate walking and result in low numbers of pedestrians (Toronto Community Health Profiles, 2012).

Diabetes is a disease characterized by hyperglycemia resulting from the body’s inability to produce insulin or properly respond to the insulin that is produced (American Diabetes Association, 2010). There are many different types of diabetes, but the most common is type 2 which makes up about 90% of all diagnoses (American Diabetes Association, 2010). People with type 2 diabetes have insulin resistance and relative insulin deficiency (American Diabetes Association, 2010). Diabetes is a life-threatening illness that can lead to long-term complications such as retinopathy leading to potential loss of vision, nephropathy leading to renal failure, peripheral neuropathy leading to leg or foot amputations, and cardiovascular symptoms leading to heart attack or stroke (American Diabetes Association, 2010).

Figure 1. Walkability Index for the City of Toronto, by Census Tract

![Walkability Index for the City of Toronto, by Census Tract](image-url)
Associations
Areas of high walkability are bound to have more pedestrians who rely on walking as their primary means of transport on a daily basis. This means that the average person in a place of high walkability will be getting much more regular exercise than someone in an area of comparatively low walkability. Aerobic exercises have shown to be associated with a decreased risk of type 2 diabetes (Warburton et al. 2006). Although walking isn’t a high intensity aerobic exercise, it presents more benefits than just commuting in a motorized vehicle (National Health Service, n.d.). In fact, 21,271 male physicians reported that weekly physical activity that was enough to cause a sweat had reduced incidence of type 2 diabetes (Warburton et al. 2006). Moreover, walking on a regular basis helps maintain cardiovascular fitness unlike commuting in a vehicle. Having a maximal oxygen uptake (VO$_{2max}$) of 31 mL of oxygen per kilogram per minute has shown to prevent development of type 2 diabetes in middle-aged men (Warburton et al. 2006). As a general rule of thumb, adults should aim for 150 minutes of moderate aerobic activity per week which includes brisk walking (National Health Service, n.d.). Walkability highly impacts the amount of exercise citizens are achieving.

Exercise is considered to be the primary method of prevention for type 2 diabetes (Peirce, 1999). It can improve glucose uptake by increasing the sensitivity of insulin and lowering body adiposity (Peirce, 1999). Obesity increases an individual’s chances of developing type 2 diabetes, but it can also be prevented with exercise (Peirce, 1999). Individuals with hypertension are considered to have a 52-58% higher risk of developing new-onset diabetes (Emdin et al. 2015). This correlation is observed in Figure 4, a map of the prevalence of hypertension, which very closely matches the trends of Figure 2, a map of the prevalence of diabetes. However, exercise is a healthy life-style change that can prevent and treat hypertension (Björntorp, 1982). Exercise creates multiple hemodynamic changes in the body such as reduced sympathetic nervous system activity and increased adrenergic sensitivity (Björntorp, 1982). These changes ex-
plain why exercise may help decrease blood pressure, which often involves symptoms of increased sympathetic nervous system activity (Björntorp, 1982).

Proxy Variables
Social determinants of health, such as socioeconomic status, have interactions with the walkability index. Socioeconomic status is largely determined by income. Similarly, income is commonly determined by an individual’s level of education as studies have shown that higher education usually leads to higher employability and wages (Graham and Paul, n.d.). Families living in the same neighbourhood are usually close by in terms of socioeconomic status. Therefore, neighbourhoods of higher socioeconomic status often have greater resources and infrastructure which translates into a high walkability. Additionally, areas of high income also tend to show less prevalence of diabetes because the individuals in those areas have the economic ability to easily access nutritious foods. A major physical determinant that interacts with walkability is pollution. Areas with low walkability tend to produce more pollution because they proportionally have more vehicles that produce emissions in comparison to areas of high walkability (Douglas et al. 2011).

Recommendations
The infrastructure in low walkability areas should be remodelled and improved to essentially develop them into areas of high walkability, which should result in a gradual decrease in the prevalence of diabetes. This means having adequate sidewalks and making it convenient for people to walk to their necessities. Using walking as a means of transport largely benefits the individuals as they would save money on vehicle expenses, avoid traffic, and have improved health. These factors help reduce the friction that is involved in this lifestyle change. In addition, this creates opportunities to grow the economy as it will attract new businesses because they would want to be located in areas of high concentrations of pedestrians (Littman, 2018). Yonge-Dundas Square is an example of an area that has large clusters of businesses that are successful due to high walkability in that area. According to Statistics Canada, there has been a 23.4% growth from 1996 to 2016 in the number of people using walking as a means of transportation in metropolitan areas, which is shown in Figure 6 (Statistics Canada, 2017). However, proportionally there are less people walking in 2016 than in 1996, which is shown in Figure 5 (Statistics Canada, 2017). This is due to the fact that as transportation technology developed, many areas saw a decrease in walkability as walking no longer needed to be relied on as heavily for transportation. In relation to this, the prevalence of diabetes in Canada increased by 70%, from 3.3% in 1998 to 5.6% in 2009, which goes to show that by restoring the walkability, the prevalence of diabetes can be decreased (Government of Canada, 2011). That being said, the shortcomings of this intervention include the fact that building infrastructure, such as sidewalks, is a lengthy process that can cost $48,000 to $72,000 per kilometre of sidewalk (CNY Pathways, 2014).
An association between walkability and the prevalence of diabetes exists because of exercise. Areas of high walkability allow individuals to obtain their necessary regular exercise, which is able to prevent against the development of type 2 diabetes (Warburton et al. 2006). Exercise can also prevent hypertension, which increases the risk of developing type 2 diabetes (Björntorp, 1982; Emdin et al. 2015). Income interacts with walkability because neighbourhoods of high socio-economic status tend to have greater infrastructure meaning higher walkability. As an intervention, the infrastructure in areas of low walkability should be improved to increase walkability, decrease the prevalence of diabetes, and help grow the economy (Littman, 2018).

References