Putting Pedestrians First: Sidewalk Infrastructures, Width Patterns and COVID-19

Victoria Fast and Jiaao Guo
University of Calgary, Canada

Abstract

As the COVID-19 crisis has forced people to adhere to social distancing, the proximity to each other of pedestrians on the sidewalk suddenly becomes meaningful: do pedestrians have enough space to safely move within cities? With decades of urban planning prioritizing roads and automobiles, the answer is 'no'. Cities all over the world have been forced to make urgent changes to pedestrian infrastructure in order to make it safe for people to move about public spaces during the pandemic.

In this study, using the sidewalk infrastructure from the Canadian city of Calgary as an example, we model sidewalk widths and then analyse the spatial patterns across the city. Our results reveal that Calgary's sidewalk widths vary substantially and form clusters of narrow sidewalks among residential zones, while wide sidewalks are typically found in downtown, and in some parks and recreational areas.

We recommend that the City of Calgary, and all cities, re-evaluate their sidewalk and pathway development patterns, and upgrade sidewalk infrastructures in those narrow-sidewalk communities. By developing more robust methods for modelling and analysing sidewalk width, paired with adequate sidewalk data, cities can make informed decisions that lead to more inclusive, pedestrian-safe, cities.

Keywords:

sidewalk width, pedestrians, accessibility, spatial pattern, health equity

1 Introduction

The global COVID-19 pandemic has forced us to rethink the role of pedestrian spaces, such as pathways and sidewalks, in an urban environment to keep the community safe and healthy. Local governments across the globe are taking decisive action to support pedestrian safety during the pandemic. For instance, traffic signals are set to be automatic for pedestrians, without the need for their physical contact with the traffic light buttons, in Brisbane, Australia (Brisbane, 2020). The Mayor of London, England announced the 'StreetSpace Plan' creating temporary cycling lanes (Simon, 2020). Thousands of kilometers of temporary 'corona' cycleways have popped-up across Europe, and arguments are being put forward to permanently adopt these as improvements to pedestrian and cyclist infrastructure (Reid, 2020).

In Canada, local policies are also adapting to ensure pedestrian and cyclist safety in response to COVID-19. The City of Toronto has opened kerb-side pedestrian lanes in areas that are identified as walking hotspots (Rider, 2020); the City of Winnipeg is reserving some automobile lanes for pedestrians practising physical distancing (Frew, 2020); and the City of St. John's council voted to widen the lanes for pedestrians' and cyclists' safety (Mercer, 2020). As early as March 2020, the City of Calgary closed roads to vehicular traffic in order to accommodate pedestrians who were going out for fresh air (Castillo, 2020). More recently, the mayor of Calgary announced that only pedestrians and cyclists will be allowed on certain popular downtown streets (Knight, 2020). As part of their COVID-19 relief plans, some local governments have gone as far as limiting public access to pedestrian sidewalks and bikeways in order to avoid overcrowding (District of North Vancouver, 2020).

Who do, and do not, have access to safely use the pedestrian infrastructure varies geographically, and the patterns relate directly to health equity (i.e. fair access for all to reach their full health potential). Spatial health inequality occurs when fair and safe access is restricted by social, economic and cultural forces, such as income, gender, race and disability. For example, areas where there is a higher incidence of road traffic accidents involving pedestrians have been associated with low-income neighbourhoods, where there is already lower spatial accessibility to active modes of transit (Khakh et al., 2019; Khakh, Fast, and Shahid, 2019). In studying our often racist urban past, Klein (2020) observed that 90% of high-income areas have sidewalks, while less than 50% of low-income communities do. Scholars have attributed systemic inequality, rather than simply high density, to the spread of COVID-19 (Jacobson, 2020). Observationally, COVID-related pedestrian interventions, such as street closures to cars, have disproportionately favoured downtowns and frequently-used public spaces over suburban or lower-income areas.

Motivated by gaining a better understanding of the spatial inequality of sidewalk interventions, we ask: where do pedestrians have enough space to safely move within cities? To answer this question, we use the City of Calgary to model the width of sidewalks and pathways for pedestrians (Section 2). Next, using aggregates (Section 3.1) and clusters (3.2), we analyse sidewalk-width patterns in order to reveal the spatial distribution of sidewalk widths across the city. Overall, a better understanding of sidewalk systems can contribute to more equitable planning in response to the pandemic and beyond for local government.

2 Modelling Sidewalks

The sidewalk represents one of the most common infrastructures for pedestrian use in an urban setting. Typically, a sidewalk occupies the space between residential (or other) buildings and the roadway proper. In some extreme cases, residential sidewalks can be found in the middle of a ten-lane road in Calgary (Figure 1a), further highlighting that the movement of cars has been the focus of transportation engineering and urban planning.

One of the most simple but powerful indexes of sidewalk design, illustrated by the architect Meli Harvey for New York City (Harvey, 2020), is sidewalk width. In the context of the global pandemic, sidewalk width is a direct indicator of the potential for pedestrians to maintain appropriate social distancing. A distance of 2 metres or 6 feet was adopted by the City of

Calgary (2020), and cities and public health agencies across the world, as a safe distance to reduce the spread of COVID-19. However, before pandemic-distancing measures, sidewalk-width standards had already established 2 metres as being appropriate for people with disabilities and wheelchair users (see Table 1). This width classification system is also checked against the accessibility standards specified by the Americans with Disabilities Act (ADA; 2010) and the guidance by the Rick Hansen Foundation when taking wheelchairs into consideration (Rick Hansen Foundation, 2020).

Table 1: Classification scheme for sidewalk width

Width	Sidewalk Width Standard
< 0.9 m	Wheelchair inaccessible, difficult to maintain physical distancing
0.9-1.5 m	0.9 m (36 inches) is minimum sidewalk width legislated by the ADA (Americans with Disabilities Act, 2010)
1.51-2.0 m	1.5 metres is meaningfully accessible for people with disabilities because it enables 2 wheelchair users to pass each other (Rick Hansen Foundation, 2020)
2.1-3.0 m	2 metres required for COVID physical distancing (City of Calgary, 2020)
3.1-4.0 m	Enough pedestrian space
> 4.0 m	Abundant pedestrian space

We used the City of Calgary's 2019 sidewalk data, which include polygons of sidewalk shapes and sidewalk centrelines that were digitized from aerial surveys (Figure 1a). Open-source data such as OpenStreetMap's footway data were not used (as we had initially intended) due to their inconsistency and lack of width values. Inspired by Harvey & Whong (2020), we calculated the average sidewalk width by 1) creating a midpoint from each centreline segment using Feature Vertices To Points in ArcGIS (ESRI, 2020a); 2) using Split Line at Point in ArcGIS (ESRI, 2020b) to split each centreline segment into two parts; 3) repeating steps 1 and 2 until midpoints of centrelines could be found on all sides of street blocks; 4) converting sidewalk polygons into polylines (edges only) and calculating the 'Near' statistics (ESRI, 2019) from each point to the closest edge ($\frac{1}{2}W$); 5) multiplying the nearest proximity (perpendicular to the edge) of each point by two to get the full sidewalk width (W).

To facilitate viewing the sidewalk-width data in detail, we created a web-map application: <https://arcg.is/1fj4LK1>. While the map should not be used for navigation (the data is out of date, and the model does not represent all walkway types), an interactive view supports data browsing at 'pedestrian' level, and the data is useful for analysing overall sidewalk patterns throughout the city.

Figure 1: a) An aerial view of the sidewalks (yellow) and their centrelines (dashed line, red) in Silver Spring, Calgary; b) Sidewalk centrelines split by mid-points; c) sidewalk 'width' (W) generation from the mid-point of each segment of the centreline.

3 Analysing Sidewalk Patterns

Calgary is known for its unusual population density patterns due to its sprawling growth (Guo and Fast, 2019), especially compared to other major Canadian cities (Guo and Fast, 2020). Using aggregates and clusters, here we investigate how Calgary's sidewalk widths vary across the city.

3.1 Aggregated Sidewalk Widths

First, we analysed the average sidewalk widths by aggregating individual sidewalk segments into different enumeration areas: by community (a neighbourhood governed by a community association); 400 x 400m grid; and the finest-grained census unit in Canada, the dissemination

block (Statistics Canada, 2017). The average sidewalk widths in Calgary vary substantially (Figure 2). At all viewing levels, downtown Calgary contains the widest sidewalks in the city. At dissemination-block level, we observe many blocks that do not meet the threshold for meaningfully accessible sidewalks ($<1.5\text{m}$), or even the absolute minimum sidewalk width of 0.91m required for wheelchair access (in red). The instances of red blocks, especially in the northeast of Calgary, align with patterns of traffic accidents involving pedestrians observed in Calgary by Khakh et al. (2019). Further study is required to test the strength of the association between sidewalk width and road accidents involving pedestrians.

Figure 22: Calgary's average sidewalk width for three different aggregation units: community, 400m grid, and dissemination block.

3.2 Clusters of Similar-width Sidewalks

Recognizing that sidewalks vary not just across the city but within local neighbourhoods, we next applied spatial autocorrelation (SA) to test for local clusters of similar-width sidewalks. We used the average sidewalk widths at a $50 \times 50\text{m}$ aggregation level, with searching distances of $1,500\text{ m}$ and $3,000\text{ m}$. SA is a fundamental concept in spatial analysis: it reveals how geographical objects are correlated or uncorrelated with each other (Getis, 2008). Using Anselin Local Moran's I index (Anselin, 1995), SA can reveal the 'spatial inequality' of sidewalk width across a study area (Zhang, Luo, Xu & Ledwith, 2008) (see Figure 3). A positive local Moran's I value represents a location with a high or low value similar to that of its neighbours, which together are also known as 'spatial clusters' (Yuan, Cave, and Zhang, 2018). SA was calculated as follows:

$$I_i = \frac{z_i - \bar{z}}{\sigma^2} \sum_{j=1, j \neq i}^n [w_{ij}(z_j - \bar{z})] \quad (1)$$

where z_i represents the value of variable z at location i ; $\bar{z}$ is the average value of z with n samples; σ^2 is the variance of all z variables; z_j represents the value of z at all other locations within a certain radius; and w_{ij} is the weight as the inverse of distance d_{ij} between z_i and z_j (Zhang et al., 2008).

In this study, the high and low values are wide and narrow sidewalks, respectively. The results show that various sidewalk widths are clustered throughout the city, and that narrow or wide sidewalks are often surrounded by each other (Figure 4). In particular, clusters of wide sidewalks (high Moran's I value; green) can be seen distinctly in downtown Calgary and near large public green spaces (such as Fish Creek Provincial Park and Nose Hill Park), at both search distances. Neighbourhoods that have clusters of narrow sidewalks are found throughout the city limit, but they are typically located in suburban areas. These results suggest that different areas of the city are differently, and unequally, served by sidewalk infrastructure. Residents living in areas with narrow sidewalks would have to travel to a different part of the city to walk safely without worrying about physical distancing issues. Our analysis can be extended further by overlaying sidewalks with population distribution.

Figure 3: The spatial autocorrelation product of sidewalk widths using Anselin Local Moran's I with two searching distances at 50m x 50m resolution. Statistically significant positive Moran's I values are classified into: 1) wide sidewalks, and 2) narrow sidewalks. Statistically significant negative Moran's I values are classified into: 3) wide sidewalks surrounded by narrow sidewalks, and 4) narrow sidewalks surrounded by wide sidewalks. 5) Statistically non-significant Moran's I values (close to 0) are classified as random.

4 Discussion and Recommendations

During GI_Forum 2021, organizers asked how data and spatial analytics can support the achievement of Sustainable Development Goals (SDGs). Informed by this research, in order for urban data science to reduce inequalities (goal 10) and create more sustainable cities and communities (goal 11), we need: 1) better pedestrian-level data, and 2) to analyse the entire city system. We heard during the conference that many participants do not have access to sidewalk data, and often use roads as proxies in their city or community. Roads do not capture the pedestrian perspective, and even sidewalk width is an oversimplified way of understanding pedestrian space. Data and urban mobility analysis have served the automobile for far too long. It is time to put all pedestrians first. Data on sidewalks, ramps, stairs, public washrooms and pathway obstacles, among other features, are required to properly model pedestrian space. As spatial scientists, we need to create, share and advocate for data that are inclusive of the pedestrian perspective to make the SDGs measurable and to inform future urban interventions.

Second, we need to consider the entire city system in our analyses. In response to the COVID pandemic, the City of Calgary has prioritized pedestrian initiatives, such as road closures, only in only selected parts of the city (e.g. downtown). While an extensive network of pedestrian pathways and bridges have made the city's downtown iconic, the pandemic has reminded us that pedestrian mobility must extend beyond the core, because the city's historic development strategy has promoted the expansion of low-density, automobile-oriented communities. This is where the majority (80%+) of residents live. Wherever there are residents, there needs to be equitable sidewalk infrastructure to create a pedestrian-friendly environment. We suggest that the City of Calgary, and all cities, should re-evaluate – and prioritize – development plans for sidewalks and pedestrian infrastructure more broadly (e.g. pathways and bikeways) by taking into account population densities and distributions in the city. Overall, urban data science needs to measure and analyse the pedestrian infrastructure within our cities, with a view beyond the COVID-19 pandemic, to achieve urban livability improvements for all pedestrians.

Acknowledgements

We gratefully acknowledge that this work was supported by the Social Science and Humanities Research Council of Canada Grant 430-2018-00432: Accessible Mobility: Getting Around in the Smart City.

References

- Americans with Disabilities Act [ADA]. (2010). 2010 ADA Standards for Accessible Design. Retrieved from <https://www.ada.gov/regs2010/2010ADAStandards/2010ADAstandards.htm>
- Anselin, L. (1995). Local Indicators of Spatial Association—LISA. *Geographical Analysis*. <https://doi.org/10.1111/j.1538-4632.1995.tb00338.x>
- Brisbane. (2020). Updates to automatic pedestrian traffic signals. Retrieved from <https://www.brisbane.qld.gov.au/community-and-safety/community-safety/disasters-and-emergencies/coronavirus-council-updates-and-impacts/updates-to-automatic-pedestrian-traffic-signals>
- Castillo, C. K. de. (2020). Road closures planned for Calgary to give more room for pedestrians and cyclists, 28 March. Retrieved from <https://globalnews.ca/news/6744420/road-closures-calgary-cyclists-pedestrians-social-distancing-coronavirus/>
- City of Calgary. (2014). 2014 Complete Streets Guide. Calgary, Alberta, Alberta. Retrieved from <https://www.calgary.ca/content/dam/www/ca/city-clerks/documents/council-policy-library/tp021-complete-streets-policy.pdf>
- City of Calgary. (2020). COVID-19 - Physical distancing and self-isolation. Retrieved from <https://www.calgary.ca/csps/cema/covid19/safety/covid19-social-distancing-self-isolation.html>
- District of North Vancouver. (2020). Facilities, parks, and services impacted by COVID-19. Retrieved from <https://www.dnv.org/programs-services/facilities-parks-and-services-impacted-covid-19#Park>
- ESRI. (2019). Near. Retrieved from <https://desktop.arcgis.com/en/arcmap/10.3/tools/analysis-toolbox/near.htm>
- ESRI. (2020a). Feature Vertices To Points (Data Management). Retrieved from <https://pro.arcgis.com/en/pro-app/latest/tool-reference/data-management/feature-vertices-to-points.htm>
- ESRI. (2020b). Split Line at Point. Retrieved from <https://desktop.arcgis.com/en/arcmap/10.3/tools/data-management-toolbox/split-line-at-point.htm>
- Frew, N. (2020). City of Winnipeg to open 4 active transportation routes for pedestrians, cyclists early. Retrieved from <https://www.cbc.ca/news/canada/manitoba/city-winnipeg-active-transportation-routes-1.5516549>
- Getis, A. (2008). A history of the concept of spatial autocorrelation: A geographer's perspective. *Geographical Analysis*, 40(3), 297–309. <https://doi.org/10.1111/j.1538-4632.2008.00727.x>
- Guo, J., and Fast, V. (2019). Spatial insights on urban density: A case study of Calgary. *CEUR Workshop Proceedings*, 2323(3). Retrieved from <http://ceur-ws.org/Vol-2323/>
- Guo, J., and Fast, V. (2020). Growing up, growing out: comparing spatial patterns of urban populations in Canada. *Geomatica*, 74(1). <https://doi.org/https://doi.org/10.1139/geomat-2020-0003>
- Harvey, M. (2020). Sidewalk Widths NYC. Retrieved from <https://www.sidewalkwidths.nyc/#13/40.714/-74.005>
- Harvey, M., and Whong, C. (2020). Github: Sidewalk Widths NYC. Retrieved from <https://www.sidewalkwidths.nyc/#13/40.714/-74.005>
- Jacobson, A. (2020). “Idiocy of our current urban systems”: Inequality, not high-density cities, to blame for COVID-19's spread. Retrieved from <https://www.cbc.ca/radio/spark/idiocy-of-our-current-urban-systems-inequality-not-high-density-cities-to-blame-for-covid-19-s-spread-1.5544528>
- Khakh, A., Fast, V., Lee, C., Rogers, N., Nasca, F., and St.Pierre, M. (2019). Toward Active Neighbourhoods: Analyzing Pedestrian Collisions and Socio-Economic Status In Three Canadian Cities. In Canadian Association of Road Safety Professionals. Calgary, Alberta. Retrieved from

- <http://www.carsp.ca/research/research-papers/research-papers-search/download-info/toward-active-neighbourhoods-analysing-pedestrian-collisions-and-socio-economic-status-in-three-canadian-cities/>
- Khakh, A. K., Fast, V., and Shahid, R. (2019). Spatial accessibility to primary healthcare services by multimodal means of travel: Synthesis and case study in the city of calgary. *International Journal of Environmental Research and Public Health*, 16(2). <https://doi.org/10.3390/ijerph16020170>
- Klein, G. (2020, June). To fix our cities, we must reckon with our racist urban past. Retrieved from <https://www.washingtonpost.com/opinions/2020/06/12/fix-our-cities-we-must-reckon-with-our-racist-urban-past/>
- Knight, D. (2020). Calgary to limit vehicles on Stephen Avenue to make room for pedestrians, patios. Retrieved from <https://globalnews.ca/news/6998483/stephen-avenue-traffic-restrictions-patio-extensions-coronavirus/>
- Mercer, J. (2020). St John's council votes to widen lanes for pedestrian, cyclist safety during COVID-19 pandemic. *The Telegram*. Retrieved from <https://www.thetelegram.com/news/local/st-johns-council-votes-to-widen-lanes-for-pedestrian-cyclist-safety-during-covid-19-pandemic-446158/>
- Reid, C. (2020). Pop-Up Coronavirus Cycleways Deliver \$3 Billion In Annual Health Benefits Across Europe. *Forbes*. Retrieved from <https://www.forbes.com/sites/carltonreid/2020/08/18/pop-up-coronavirus-cycleways-deliver-3-billion-in-annual-health-benefits-across-europe/?sh=32a3728a6ad7>
- Rick Hansen Foundation. (2020). A Guide to Creating Accessible Play Spaces. Retrieved from <https://www.rickhansen.com/sites/default/files/2020-03/sch-35913-guide-creating-accessible-play-spacesen2020web.pdf>
- Rider, D. (2020). Toronto to open some traffic lanes to pedestrians in congestion 'hot spots.' Retrieved from https://www.thestar.com/news/city_hall/2020/04/27/toronto-traffic-lanes-to-be-closed-for-pedestrians-in-hot-spots.html
- Simon, M. (2020). Mayor announces "radical" plans for London. Retrieved from <https://lcc.org.uk/articles/mayor-announces-radical-plans-for-london>
- Statistics Canada. (2017). Dissemination block (DB). Retrieved from <https://www150.statcan.gc.ca/n1/pub/92-195-x/2011001/geo/db-id/db-id-eng.htm>
- Yuan, Y., Cave, M., and Zhang, C. (2018). Using Local Moran's I to identify contamination hotspots of rare earth elements in urban soils of London. *Applied Geochemistry*, 88, 167–178. <https://doi.org/10.1016/j.apgeochem.2017.07.011>
- Zhang, C., Luo, L., Xu, W., and Ledwith, V. (2008). Use of local Moran's I and GIS to identify pollution hotspots of Pb in urban soils of Galway, Ireland. *Science of the Total Environment*, 398(1–3), 212–221. <https://doi.org/10.1016/j.scitotenv.2008.03.011>