How street quality influences the walking experience: an inquiry into the perceptions of adults with diverse ages and disabilities

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Short title:

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Abstract

The benefits of walking are now well understood. However, there is still no consensus on what causes people to forego short walking trips.

This study examined users' perceptions on trips usually walked, as well as perceptions of desirable trips within walking distance but not walked. 56 adults with diverse disabilities and ages, living in Auckland New Zealand, were interviewed. Content analysis was used to discover the perceived difficulties of walking and what lies behind the decision to walk (or not).

Barriers to walking related to poor holistic quality of walking environments, including traffic, and infrastructure. The study confirmed the importance of the comparative qualities of transport alternatives in the choice of walking. Finally, disabled users suffer disproportionately from the burden of the transport system and often cannot travel spontaneously. Future research should focus on characterising barriers to walking perceived by users, which would provide useful insights for urban retrofit.

Introduction

Modernistic approaches to urban design have focused on motorised vehicle flows and infrastructure, creating a reliance on cars for everyday mobility [1, 2]. This reliance has led to adverse effects for public health [3–5], degradation of the natural environment [6, 7], and accelerated climate change. Addressing climate change requirements "rapid, far-reaching and unprecedented changes in all aspects of society" [8]. Cities and urban transportation can, and should, play a crucial role [9–11].

It is now well understood that leveraging walking, or walking combined with public transport, aligns with efforts towards less greenhouse gas emissions, better public health, increased equity, and more liveable places. Achieving that modal shift requires a better understanding of how walking is chosen, and what aspects of the urban environment might encourage or discourage walking [10, 12, 13].

Research on walkability has made significant progress in the last ten years. A previous umbrella review [14] identified some consensus amongst authors on the basic requirements for walking, namely: (a) the availability of destinations within walkable distance [15–17]; and (b) a certain quality of the walking environment (WE) *as perceived by people*, including absence of barriers [18, 19], and perceived safety [15, 20, 21]. There is, however, no consensus regarding what features of the WE might be perceived as difficult or unsafe, and ways such perceptions might vary between people [14, 15, 20, 22]. The lack of consensus reflects three central challenges of measurement. It is challenging to measure the quality of WE in a way that reflects people's experiences [20, 22] because we lack the metrics to do so. It is also challenging to capture and measure granular detail of the different ways characteristics such as disability influence perceptions and behaviours [14]. Finally, there is the challenge of assessing the quality of the WE in a systemic way which takes account of the available transport alternatives which we known influence walking levels [23]. A recent quantitative study identified the importance of considering how walking is perceived *in comparison with* alternatives one might have, or *together with* a companion mode such as public transport [22].

The draft Social Model of Walkability offers a framework that explicitly refers to people's perceptions, their individual characteristics, and the broader transport system. The model, building on previous research [24–26], is presented in detail elsewhere [14]. The name of the model acknowledges the Social Model of Disability and suggests the importance of WE for enabling walking across ages and abilities. The model posits that the WE influences people's perceptions, from the most basic (feasibility) to the more sophisticated (pleasure), and that perceptions in turn influence walking behaviour. These relationships are mediated by individual characteristics such as impairment, self-efficacy, or preferences; social factors; trip purpose, motivations, and availability of travel alternatives.

This study examines (1) what characteristics of the WE might be perceived as difficult, unpleasant, or appealing; (2) why trips within a walkable distance might be foregone; and (3) how environmental perceptions might vary between people who have some difficulty with one or more of the following: walking, seeing, hearing, remembering, or concentrating; and those who don't report any of these difficulties.

The inquiry is located in Tāmaki Makaurau (Auckland), Aotearoa New Zealand (New Zealand). Auckland is New Zealand's largest and growing city (1.5 million [27]) with typically car-centric infrastructure, land use [28], and mobility patterns [29], described by Jan Gehl as "a rush hour 'traffic machine'" [30]. Almost 90% of all distances travelled are done by car, 2% on foot and 5% by public transport [29]. The reliance on cars is not aligned with people's preferences [31] and is responsible for major inequities of access to destinations or opportunities impacting most on those having a low

income and/or being disabled [32, 33]. Further, the reliance on cars results in unacceptable levels of road trauma [34, 35] and greenhouse gas emissions [36, 37].

Auckland aims to become a city where walking and public transport are attractive choices, one where equity and health are promoted through genuine travel choices, and where safety and environmental protection are maximised [38]. Transitioning from a car-dominated environment and car reliance to walking as a choice requires systemic change. Making this systemic change requires a better understanding of what lies behind the decision to walk.

This study aims to determine how perceptions of WE are related to the choice and experience of walking, and to establish how these perceptions align with key dimensions of the draft Social Model of Walkability.

Methods

Design

This study is a naturalistic inquiry addressing the perceptions of diverse people of their environments, that is a "multiple, intangible, divergent, holistic" reality [39]. The inquiry assumes that the phenomena depend on the context, can be explained by multiple interacting factors, and that the inquiry is influenced by the inquirer and by the methods used [39]. The design is nomothetic (broad but not exhaustive), based on 1-1 structured face-to-face interviews. Data and analysis were both quantitative (collection of categorical items and numeric ratings, analysis of distributions and frequencies of mentions), and qualitative (open-ended questions and their content coding).

The methods are drawn from the enactive view of perceptions and the circumplex model of affect. An enactive view considers that perceptions are gathered through a recursive process involving sensorimotor knowledge, bodily skills and past experiences [40]. The circumplex model of affect understands perceived emotions as unique combinations of valence – a pleasure–displeasure continuum – and alertness [41]). The circumplex model of affect is supported by vast and growing evidence, and helpful in its recognition of emotions as "ambiguous and overlapping experiences" [41], and not clearly defined categories.

Ethical approval was obtained from Auckland University of Technology Ethics Committee (ref. 18-431, 12.12.18). All names appearing in this document are pseudonyms to protect participant identity.

Participants

Participants were a convenience sample of adults living in Auckland, New Zealand. The sample was selected so that half of the participants experienced at least some difficulty with one or more of the following: walking, seeing, hearing, remembering, or concentrating (further noted as disabled participants – see 'A note on language', below). Participants were required to be aged 18 and over, and self-declare that they used walking "at least sometimes for transport". The availability of destinations was controlled for by selecting participants living in areas with a pre-determined Walkscore® [42]. The Walkscore® ranges from 0 (non-walkable) to 100 ("walkers' paradise" [42]). Participants in this study lived in neighbourhoods with a score between 70 and 90. This range was chosen for two reasons: Firstly, as the aim was to talk about usual trips, this score meant that participants would have a high chance of perceiving destinations as being within walkable distance; second, working within a given walkability range related to the aim of examining the quality of WE, leaving the availability of destinations as an almost fixed parameter.

Participants were recruited via three methods: information posters displayed in public spaces with an invitation to information sessions; information sessions organised at local venues, presenting the research and providing additional information (answers to questions, participant information sheet available to those potentially interested); and researchers' networks (sharing the invite via email and social media). The recruitment methods are detailed in

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A.

A note on language

The choice of words is important, as it can perpetuate everyday marginalisation of disabled people [43]. The terminology "**disabled people"** is used, as it is recommended by disability researchers and advocates [43–47] and used in the name of New Zealand's Disabled Persons' Assembly. The words "walk" or "walking" also always include any mobility aid the person might use.

Measures/Interview design

Interviews covered three aspects: participant and overall insights, details of three usual trips and destinations desired but less accessed.

- **Participant and overall insights** included**:** demographic information (age, gender, living and employment situation, time of residence in the neighbourhood), possible impairments (using the Washington Group Short Set questions [48]), usual travel behaviour, satisfaction with own levels of walking, and perceptions of (a) the proportion of destinations that are

easy to reach, by any mode (all, most, some, a few, none), (b) the ease and pleasantness of walking in their own neighbourhood by day time and night time and (c) improvements noticed in their WE.

- **Three usual trips**: mode and reasons for choosing, availability of travel alternatives, purpose(s), destination(s) accessed and their importance, overall perceptions of ease, pleasantness and safety, route chosen (drawn on a paper map) and reasons to choose that route, aspects that might make the trip difficult, unpleasant or both (mapped and scored regarding difficulty/unpleasantness) and appealing aspects (mapped); if the trip hadn't been walked, the participants were asked to estimate if the distance would have been walkable and how easy and pleasant walking would be, if done.
- **Third, destinations desired but less accessed**: destination type, why they are difficult to get to, is the distance walkable and if walked, how would the ease, pleasantness and safety be rated.

The notion of "usual" was intentionally not strictly defined. The objective was to focus on trips participants felt familiar with, acknowledging and accepting that the absolute frequencies of these trips might vary. Participants were invited to talk about whatever trip they consider usual, according to their own standards. The questions (Supplementary file B) were worded identically to those of the Household Travel Survey [49] and the Auckland Active Modes Survey [50] wherever possible. Levels of perceived issues were scored out of 10 for instance, to echo the Auckland Active Modes Survey [50]. Participants were encouraged to expand on the any issues they raised. For instance, when participants rated something as difficult or unpleasant, they were invited to give details of the difficulties and unpleasantness. Before the start of the interview, participants were briefly reminded of the nature of the project – better understanding possible barriers to walking or wheelchair use. It was also specified that the words "walk" or "walking" always included any mobility aid the person might use.

Procedures

Individual interviews were undertaken by TB between December 2019 and March 2020, before the lockdown period (Alert Levels 3 and 4 – people advised to stay at home, schools and businesses closed with the exception of essential services) due to the COVID-19 pandemic. Participants were interviewed at a place of their choice, which could be their home or a local public space (e.g., library). Interviews were recorded and categorical answers were noted on a record sheet, on the spot, along with brief remarks (e.g., "crossing" and "complex traffic movements, fast speed") to describe the type of feature and the reason this feature is perceived as difficult. Interview data were revisited as needed, to complement the notes and/or transcribe specific quotes (e.g. an explanation

of why a certain feature is perceived as difficult), but not transcribed verbatim. This method allowed for more efficient data treatment [51].

Data analysis

Data were analysed using deductive content analysis. This technique is adapted to testing a theoretical framework [52] – in our case, the draft Social Model of Walkability [14]. The reported barriers to walking were coded using participants' descriptions of what the barriers are, but also their ratings of relative difficulty and unpleasantness. A coding protocol was established to achieve coding consistency (Supplementary file C).

Coding categories were related to the dimensions of the draft Social Model of Walkability, namely the hierarchy of needs [14], to enable reporting of the findings against the model. The categories had previously been developed based on a literature review and applied an umbrella review [53]. The environmental features used as labels and the rationale for including them are presented in Supplementary file C2. Spreadsheets were used for data capture and content analysis. Associations between difficulty and unpleasantness on the one hand, and trip characteristics on the other (purpose, availability of alternatives and type of barrier noted) were examined through Chi-squared tests using R with a significance level of $p < 0.05$ [54].

Results

Fifty-six participants consented to participate and were interviewed. Amongst them, 27 were disabled. Given the variety of techniques employed for the recruitment (e.g., posters and presentations at public meetings), there is no way of determining the study response rate. A total of 189 usual trips were reported, 163 of which were done on foot or by wheelchair, completely or in part. The characteristics of participants and reported trips are presented in Table 1.

Table 1: Characteristics of the participants and reported trips

		Non-disabled (1)		Disabled (1)		Total	p (2)
		N	%	N	%	N	
Respondents	Total	**29**		**27**		**56**	
	Age						
	18-29	8	28%	3	11%	**11**	ns
	30-44	14	48%	4	15%	**18**	*
	45-64	2	7%	7	26%	**9**	^
	65-79	2	7%	7	26%	**9**	^
	80+	3	10%	6	22%	**9**	ns
	Socio-demographic data						
	Sex: women	18	62%	13	48%	**31**	ns
	With drivers licence	28	97%	14	52%	**42**	^
	With car usually available	21	72%	6	22%	**27**	**
	With income <20'000 NZ$/y	9	31%	17	63%	**26**	^
	Difficulties experienced with						
	Seeing, even when wearing glasses	0	0%	19	70%	**19**	**
	Hearing	0	0%	10	37%	**10**	**
	Walking 500m unaccompanied	0	0%	8	30%	**8**	**
	Remembering or concentrating	0	0%	12	44%	**12**	**
	Two or more impairments	0	0%	19	70%	**19**	**
Trips	Total	**105**		**84**		**189**	
	Modes						
	Walking only	73	70%	52	62%	**125**	ns
	Walking and PT	12	11%	18	21%	**30**	^
	Running	3	3%	0	0%	**3**	ns
	Walking and running	88	84%	70	83%	**158**	ns
	Importance: high	69	66%	75	89%	**144**	^
	Purpose						
	Shopping	29	28%	26	31%	**55**	ns
	Exercise and recreation	23	22%	11	13%	**34**	ns
	Work or education	25	24%	8	10%	**33**	*
	Social	14	13%	11	13%	**25**	ns
	Other	14	13%	28	33%	**42**	**
	Ease						
	High (>6/10)	85	81%	62	74%	**147**	ns
	Low (<4/10)	2	2%	5	6%	**7**	ns
	Pleasantness						
	High (>6/10)	75	71%	59	70%	**134**	ns
	Low (<4/10)	4	4%	8	10%	**12**	ns

(1) see definitions above; (2) Chi2 test of independence: **: <0.01; *: <0.05; ^: <0.1; ns: ≥0.1

Disabled participants were older, had lower availability of driver's licenses/cars, and were more likely to have a low income. For non-disabled participants, the proportion of people satisfied with their own levels of walking or wanting to walk more were not significantly different (p =0.468) from that observed by Auckland Transport (45% and 41%, respectively) [55].

Below, we examine four questions of interest:

1. When and why is walking chosen?
2. What makes a walking trip appealing?
3. What do deterrents to walking look like?
4. What is perceived as unpleasant and/or difficult, when walking?

For each question, the relative role of the quality of WE is examined in more detail. The overall motivations, deterrents and barriers were coded against the dimensions and (sub)categories of the draft Social Model of Walkability. The results are presented in Figure 2**Error! Reference source not found.** and Supplementary file D.

When and why is walking chosen?

When speaking about walking in general ("What motivates you to walk?"), participants noted three aspects. **Firstly, internal-motivations** (34 participants, 61%) such as exercise and fitness, health, mindfulness or "me time". For instance, Barbara, 30, walks "when it feels like winning", and Glenn, 64, enjoys the slow pace and thinks that "walking is one of life's big blessings". **Second, convenience as compared to other modes of transport**, for instance, when walking is quicker than taking the bus or means avoiding parking hassles. **Thirdly, the quality of the walking environment**, explicitly noted by 13 participants who mentioned greenery and views of the nature, presence of other people and architectural quality. Lower levels of the hierarchy of needs (i.e. feasibility, accessibility, and safety) [14, 24] were not mentioned, with the exception of one participant noting accessibility issues. Disabled and non-disabled participants referred to the same environmental categories, for instance street design aspects were mentioned by three disabled and four non-disabled participants. Habit was noted by only one, non-disabled participant. The social dimension of walking (walking with friends or family, or just amongst strangers), was another important aspect, noted by 16 participants.

In relation to 'usual trips', almost 2/3 of the reasons to choose walking related to the broader transport system or walking compared to the alternatives. Convenience played a major role, often in comparison to other modes: walking was said to be more convenient than the bus for 18 trips, the

car for 17 trips, or bicycle for 8 trips. Convenience was related to the proximity of destinations. Internal motivations, responsible for 41 trips, all related to fitness, exercise, and health

Disability appeared as an important lens: non-disabled participants were more likely to note pleasure-related aspects, such as walking with friends (23 vs. 9, $p < 0.05$) and were less likely to walk because of a lack of choice (3 non-disabled vs. 22 disabled participants reported this barrier, $p < 0.05$). The results are presented in Figure 2 and Supplementary file D.

Participants also described 25 usual trips for which they chose not to walk; most of these trips (19) were considered as being within a walkable distance. An alternative mode to walking was chosen most often because it was perceived as more convenient, faster, or because it allowed the avoidance of obstacles (e.g., steep hill, absence of footpaths, a path that feels unsafe at night).

The choice of walking seemed largely individual. The difference is illustrated by the Jeremy's and Freddie's trips to the supermarket: both are aged 28, are non-disabled, live in the same area, have a car available, shop in the same supermarket and access it using a similar route (see Figure 1 below). Having "stuff to carry" is however presented by Jeremy as the reason for usually walking (instead of taking the skateboard), while Freddie drives for the same reason.

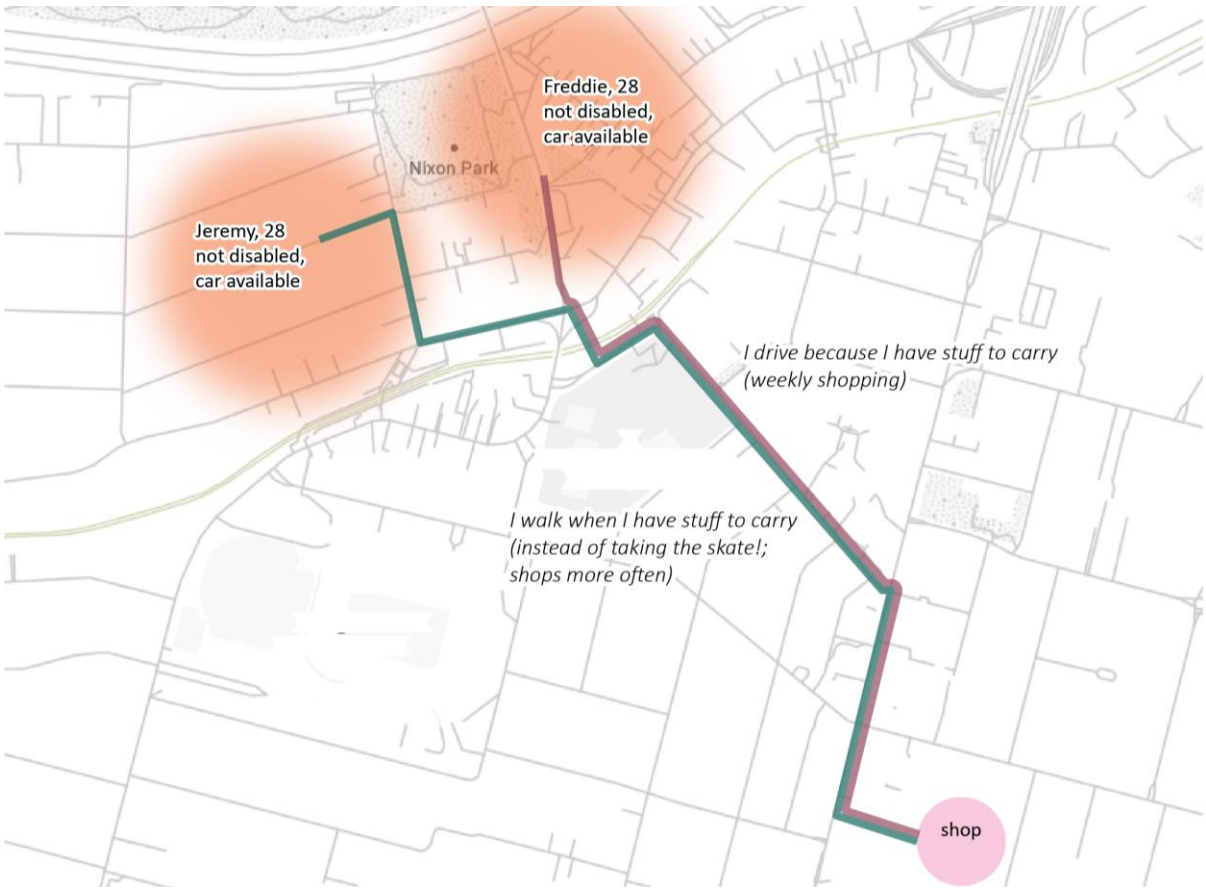


Figure 1: Modal choice, comparison between Jeremy's and Freddie's decisions; the places of residence are indicated approximately, for privacy reasons, and not centred exactly on home addresses

What makes a walking trip appealing?

Three aspects were noted as appealing or pleasant: **design and greenery** – for instance, streets with quiet traffic that can be “very pretty”, pleasant public spaces and good quality footpaths; **activity on the street**, relating to the pleasure of being with other people, even without interacting; and, to a lesser extent, **efficient combination of walking and public transport**. For instance, for Glenn, 64, buses “sailing past the traffic” contributed for instance to a usual trip being perceived as pleasant. Some participants noted topography (e.g., flat or downhill) or the fact that the route they were taking did not involve crossing streets.

Trips noted as appealing because of a street design features represented 58% of trips reported by disabled participants (43 trips) and 88% of non-disabled participants (78 trips). Disabled participants were more likely not to name any appealing aspect relative to trips walked (21 vs. 8, $p < 0.01$). For instance, Sam, 41, blind, seemed almost surprised by the possibility of appealing aspects, saying – "No, because I'm concentrating!".

Eight participants also spontaneously noted what makes the ranking of appeal lower than 10. All those aspects related to street design, and referred mostly to busy streets: Phoenix, 27, enjoys arriving in Ponsonby "but the motorway is pretty ugly"; Kit, 79, enjoys "everything apart crossing Dominion Road"; Dennis, 44, notes that "once you're there, it's pleasant, but Dominion Road is in the way!”.

What do general deterrents to walking look like?

When speaking in general about deterrents to walking, participants noted internal barriers (health issues/pain/fatigue), and external aspects related to accessibility, safety, comfort, and pleasure. Traffic, and traffic-oriented environments were noted 10 times, implicitly or explicitly. Examining why specific trips to desired destinations are perceived as being within walkable distance but not walked, provided rich insights into ways the quality of the walking environment can deter walking. Participants reported 27 instances of barriers to access, some being systemic (e.g., inconsistencies of design that caused blind participants to avoid any route that they have not learned previously, for fear of being exposed to dangerous situations).

The noted barriers of access fall under five categories: **(1) traffic, and traffic-oriented environments**: non-signalised crossings, environments designed for traffic; **(2) footpath design and quality**: insufficient width and obstructions either permanent or temporary; **(3) lighting**: absence of or poor quality, night time; **(4) people**, relating either to the discomfort of walking when “there is no one around” or else the presence of people perceived as potentially threatening (stranger danger); and

(5) broader transport system: inefficient bus services that mean longer distance trips cannot be done by a combination of walking and public transport. Most of the reported barriers (24 out of 27) correspond to the first four categories and relate to the quality of the walking environment.

Disabled and non-disabled participants spoke about slightly different environmental features: While both groups spoke about hills and/or indirectness of the walking network at similar rates ($p>0.05$); non-disabled people spoke more often ($p<0.05$) about destinations not being within reach and reported unpleasant street designs (car-oriented, grey) and too high traffic volumes; disabled people spoke of barriers to access such as difficult crossings, poor maintenance causing tripping hazards, or a lack of toilets and benches.

The most frequently noted aspects were non-signalised crossings (seven mentions) and environments designed for traffic (six mentions). They are illustrated through participants' quotes and in a short video: https://bit.ly/AKL_barriers.

Non-signalised crossings

Nora, aged 85, struggles to cross the road to access the bus stop. In theory, she could catch a bus every 15 minutes to go to the city centre, but "If you want to get your bus, you take your life in your hands. It puts you off to getting to town because you have to cross that road. You gotta be careful, you stand in the middle [on a narrow refuge], but the trucks are wider than you think ". She raised the issue with the Council but "they said they couldn't stop the flow of traffic or didn't want to." Dwight, 41, is active and athletic, but he noted that the restaurants and shops on Dominion road (very close to home) are inaccessible if they involve crossing the road with his two children. Hollie, an active 75-year old wheelchair user spoke of micro-level design features – abrupt gutters and kerb cuts, saying: "I can come to a crossing and think "I'm not even going to try!".

Environments designed for traffic

Participants reported avoiding environments that they perceive as designed for traffic: grey / asphalted and/or difficult to navigate. Wren (48) spoke of "hostile environments", Dover (20) of "bad intersections, places where it's not fun to walk, that are not easy". For Kamaal, 28, any destination that involves going over the motorway overbridge "feels like a bit of a project; a very prominent divider for anyone who would want to cross on foot. You don't see a lot of people walking that street".

> *Have you seen the Khyber Pass? [laughs] A lot of cars and parkings, motorway on/offramp, no trees, there isn't anything happening, people there walk from A to B. – Phoenix, 27*

Dev, 77, is legally blind and described significant difficulties right outside his house: traffic, speeds, narrow footpaths - it's a hostile environment. He is "basically home-bound", he says, "for his own safety", adds his wife. Systemic barriers could also mean that whole areas are inaccessible.

What is perceived as unpleasant and/or difficult when walking?

Participants were asked what they perceive as difficult and/or unpleasant on the trips they usually walk (alone, or in combination with public transport). After filtering those inputs to include only features having ratings of >6/10 for difficulty and/or unpleasantness, the study identified 134 barriers (60 noted by disabled participants, 74 by non-disabled participants).

Features noted as difficult (80 mentions, of which 40 were noted by disabled participants) relate to four categories: (1) **traffic, and traffic-oriented environments**: non-signalised intersections difficult to navigate, traffic, signalised intersections with long waiting times or a short time available to cross, or traffic infringing on the footpaths to access parking lots; (2) **footpath design and quality**: footpath design, maintenance or quality of execution; (3) **hills**; and (4) **availability of toilets.** The last two categories were noted only once (availability of toilets) or twice (hills).. Interestingly, the environmental features perceived as difficult are the same as those that reported as general deterrents to walking, the only exception being the absence of people (no one around, or stranger danger, noted as general deterrent but not difficulty).

Disabled and non-disabled participants reported similar numbers of barriers per trip, both overall (respectively 0.84 and 0.87 barriers per trip) and when examining trips perceived as difficult and unpleasant (0.94 and 0.95). However, the features reported by both groups were different (detail below), and disabled participants rated the difficulty of their trips higher (Table 2).

Table 2: Barriers per trip and ratings of difficulty for disabled and non-disabled participants

		Number of barriers reported per trip		**Rating of difficulty of the trips walked [scale, 1- 10]**
Participants	**Overall**	**Trips perceived as both difficult and unpleasant**	**Median**	**Standard deviation**
Disabled	0.84	0.94	6.8	2.1
Non disabled	0.87	0.95	5.9	2.4

Availability of destinations was mentioned by 10 non-disabled participants (37%) and three disabled participants (10%). Traffic along the path was mentioned by five non-disabled participants (19%), but

not mentioned by disabled participants. The frequencies of mentions of other environmental categories was not significantly different between the two groups at $p < 0.05$.

Within the environmental categories (e.g., street design), it is interesting that some features were mentioned by both disabled and non-disabled participants, while some were specific to those groups. Namely, within the trips considered as difficult and unpleasant, non-signalised crossings, footpaths (materials, execution, and maintenance), and traffic across footpaths were mentioned by everyone, whereas only non-disabled participants spoke of waiting times at signalised crossings and holistic design quality (streets designed for cars). Conversely, while disabled participants mentioned the width and obstruction of footpaths, the traffic volume and speeds, and the use of footpaths by e-scooters and non-disabled participants did not. Detailed results data for this topic is provided in Supplementary file F.

Non-signalised crossing facilities were the most prominent feature causing difficulties to walking (29 mentions). Participants noted the difficulties caused by complex/fast traffic movements and often very wide infrastructure layout.

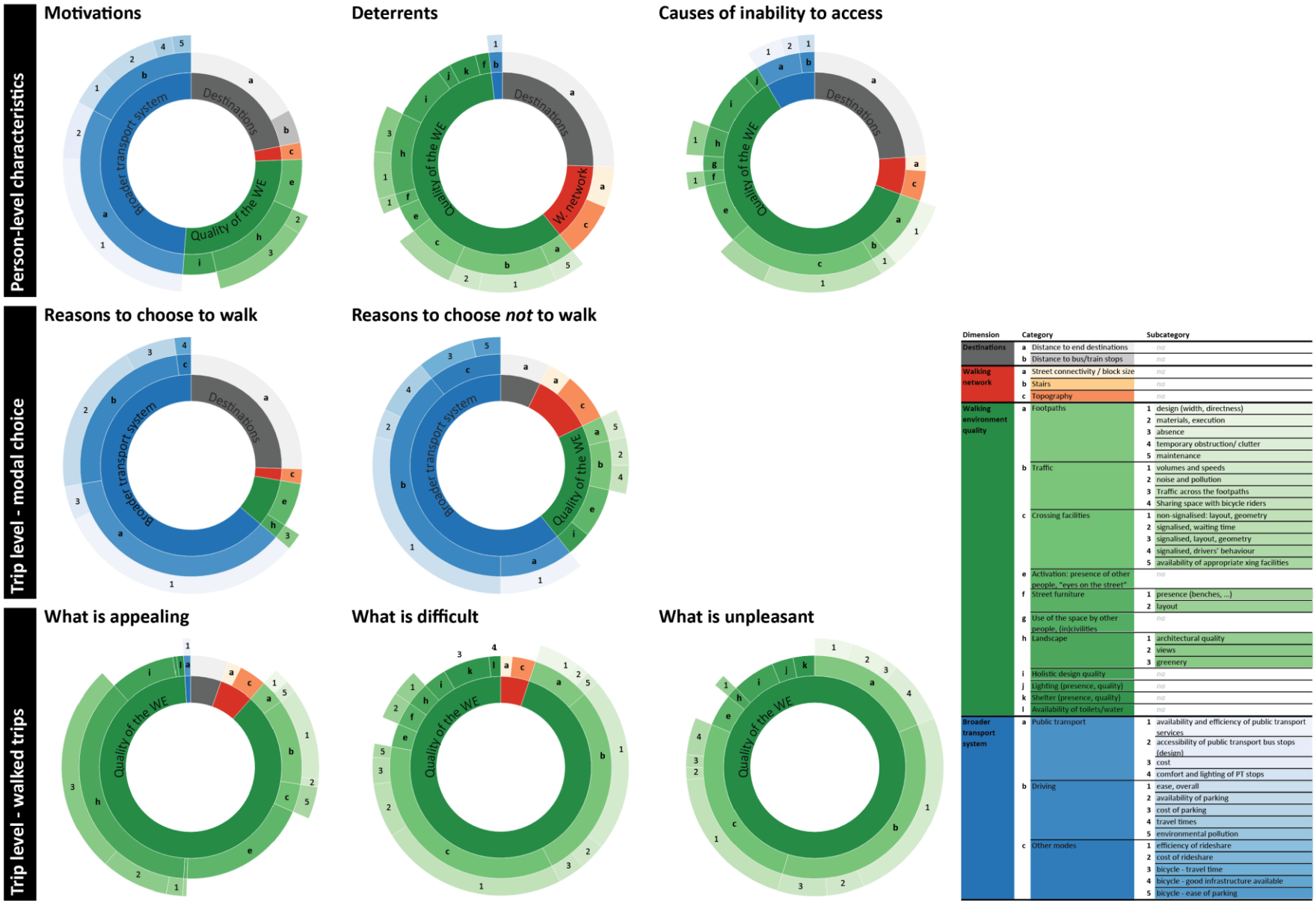
> *[Newton overpass on/off ramp] is the motorway onramp and offramp, and there's a lot of traffic going really fast, trying to figure itself out. Being a pedestrian around there is pretty dangerous. I really... I hate getting out of the city. Once I get on Dominion Road it's ok, but getting out of the city – – there's traffic, noise, car exhausts, bad smells, buses, all that kind of gross car stuff. And that bit is particularly bad" – Morgan (40)*

> *Church road [Mangere Bridge] is a bugger to cross, it's really busy. […] So on a bad day, it can take 10 minutes to cross. […] There are crossing points, where there are tactiles, but you know […] Auckland Transport seems to be a lot into what they call *refuges* in the middle of crossings, where you're meant to stand and go forward again. They don't work for blind people. A, you don't know if you're right in the middle, B, it's difficult to delineate each side by sound, so I have to wait till both sides are clear, really. So I would favour a controlled or at least a zebra crossing, where the traffic will stop. I would prefer controlled, I always prefer controlled, you know, where you press the button and you get the sounds, but a zebra would at least be helpful. – Lenny (49), blind*

The results for these comparisons are included in Supplementary file E. An overview of the frequency of mentions of different barriers for disabled and non-disabled participants is presented in Supplementary file F.

Roles of the walking environment in the perceptions of walking and the walking behaviours

Participants were free to indicate any aspect pertaining to their choice of walking or the perceived difficulties of accessing destinations. In doing so, participants indicated that WE (destinations, walking network and quality of the street environment) was an important topic. Different features were often associated with different outcomes for different participants, for instance, some features perceived as “cannot do” barriers by some participants were perceived as ‘difficult’ by others. An overview of these associations is provided in Figure 2, while Figure 3 provides more detail on the causes of severance, difficulty, and unpleasantness.



Dimension	Category	Subcategory	
Destinations	a	Distance to end destinations	na
	b	Distance to bus/train stops	na
Walking network	a	Street connectivity / block size	na
	b	Stairs	na
	c	Topography	na
Walking environment quality	a	Footpaths	1 design (width, directness)
			2 materials, execution
			3 absence
			4 temporary obstruction/ clutter
			5 maintenance
	b	Traffic	1 volumes and speeds
			2 noise and pollution
			3 Traffic across the footpaths
			4 Sharing space with bicycle riders
	c	Crossing facilities	1 non-signalised: layout, geometry
			2 signalised, waiting time
			3 signalised, layout, geometry
			4 signalised, drivers' behaviour
			5 availability of appropriate xing facilities
	e	Activation: presence of other people, "eyes on the street"	na
	f	Street furniture	1 presence (benches, ...)
			2 layout
	g	Use of the space by other people, (in)civilities	na
	h	Landscape	1 architectural quality
			2 views
			3 greenery
	i	Holistic design quality	na
	j	Lighting (presence, quality)	na
	k	Shelter (presence, quality)	na
	l	Availability of toilets/water	na
Broader transport system	a	Public transport	1 availability and efficiency of public transport services
			2 accessibility of public transport bus stops (design)
			3 cost
			4 comfort and lighting of PT stops
	b	Driving	1 ease, overall
			2 availability of parking
			3 cost of parking
			4 travel times
			5 environmental pollution
	c	Other modes	1 efficiency of rideshare
			2 cost of rideshare
			3 bicycle - travel time
			4 bicycle - good infrastructure available
			5 bicycle - ease of parking

Figure 2: Frequency of citation of the characteristics of the walking environment in relation to person-level views (motivations, deterrents, difficulties) and trip-level characteristics (reasons to choose a mode, and contributors to appeal, difficulty or unpleasantness) are indicated by the proportion of the shape they occupy. For each "donut", the dimensions (e.g. quality of the walking environment) ore on the inner circle, and further split across categories (middle circle) and subcategories (outer circle).

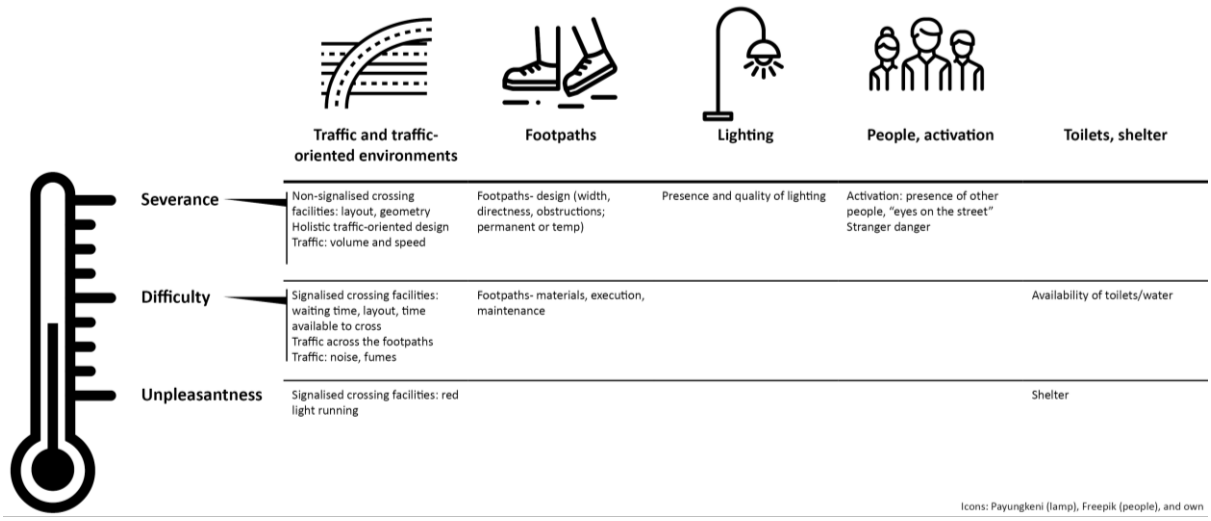


Figure 3: Features of the walking environment reported as causing barriers to access and/or being detrimental to the quality of the walking experience

Consequences of experienced barriers

The barriers experienced had a series of consequences: **(1) impacts on the way people travel**; **(2) increased stress**; **(3) trips foregone**; **(4) risk taking**.

640 *Table 3: Consequences of experienced barriers*

Type of consequence	Examples reported by participants
Impacts on the way people travel	Leaving home early to allow 10 minutes or more to cross a single street, for Lenny and Sam, both blind; taking the bus for part of a trip that would take about 10 minutes on foot, specifically to avoid having to cross a certain road (Sam) or leaving home 45 minutes earlier to cross the road before the traffic peak – Morgan
Increased stress	Aiko, 28, said "I almost need to plan in advance how I get around it [roundabout with heavy traffic]". The blind participants seemed especially impacted by the difficulties encountered, and reported big efforts put into learning the necessary routes and planning their trips. For instance, Jacqui, 65, plans all her routes to use the safest crossings, and appears to be navigating quite a hostile environment. Older participants seemed particularly inclined to take responsibility of their own safety – for instance, Leigh, 83, feels safe because she is "always on alert", and Amareki, 72, because she is "well aware" and "won't cross where it's unsafe". Lee, 85, thinks it's crucial to watch the traffic because "the road belongs to the cars, doesn't it?"
Trips foregone	This was the case for participants lacking alternatives: Nora, 85, goes into town less because of reported difficulties accessing the bus (see quote above). She described this as a loss, given that she would like to visit the library or the theatre
Risk taking	Complex non-signalised intersections or long waiting times at signalised intersections might provoke people to take risks. Non-disabled participants reported that they often weighed safety against convenience, and potentially putting themselves in danger: *You know, when you try to get into St Luke's from that side and you just have to walk around like, every single crossing, to get in, or you just have to run across the road and hope that you don't die [laughs]. I absolutely hate that entrance to St Luke's, it's a nightmare. […] There's signs now, to say "please don't cross if there's no crossing" and I'm like "well, you don't really give people much of an opportunity!" – Robin, 38* *There's nowhere to cross the road here. So you just have to walk out into the middle – because it's so busy, you can't wait for there to be no cars – so you just have to walk out into the middle and stand in the middle hoping that no one hits you [laughs]. So in day time it's not too bad (!) but in the night time I'm really worried that I'm not visible enough. I always thing that – how would someone with limited mobility, how would an old person who walks really slowly or whatever it might be, how would they – because I don't even know where the next crossing is, how far you would have to walk to find a crossing. – Robin, 38*

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643 # Discussion

This study examined individuals' experiences of walking in car-dominated environments. Specifically, it considered the ways people's perceptions relate to their choice and experience of walking, using the draft Social Model of Walkability [14] as a theoretical framework. Features of WE and transport system were a key focus, as these aspects can be modified through planning and design. The results provided rich insights relative to the choice of walking and the three research questions:

(1) What characteristics of the walking environment are seen by users as difficult, unpleasant, or appealing?
(2) Why might trips within a walkable distance be foregone?
(3) How might environmental perceptions vary between people who have some difficulty with one or more of the following: walking, seeing, hearing, remembering or concentrating; and those who don't report any of these difficulties

The choice of walking

Others have previously outlined the motivators for walking identified in this study (namely: internal motivations [26, 56, 57]; the qualities of the walking environment [25, 26, 58, 59]; the broader transport system, considering the comparative convenience of walking relative to other modes [60–62] or the lack of choice). It should however be noted that the current evidence base is somewhat heterogeneous. For instance, Barnett and colleagues' systematic literature review, examining older people's walking levels, found a large proportion of non-significant findings for greenery and aesthetically pleasing environments (19 out of 29) [59]. The existing evidence has significant gaps with regard to considering or accounting for the effects of participants' health status and functionality [59].

The literature also tends to ascribe less importance to broader transport systems, examining WE (e.g., distance to destinations or quality of footpaths) but not necessarily the attractiveness of walking as compared to alternatives available. Barnett and colleagues noted for instance the lack of consideration for the participants' driving status / car ownership (2/100); or examined the availability of public transport, as measured (8) or perceived (10) [59].

The availability of destinations was not a major theme in the responses and appeared mostly implicitly, when participants noted the convenience of walking to nearby destinations as compared to other modes of transport. This result could seem at odds with the importance of the destinations in the walkability literature – for instance as reported by Frank and colleagues or Cervero and Kockelman [63, 64]. The study design targeted participants with relatively high measured availability of destinations. Perhaps, by their ubiquity, these features are rendered invisible to participants who take this availability for granted.

Interestingly also, habits, that had been associated with modal choice [57, 65], were almost absent from both the reported motivations to walk (both when talking in general and about specific trips). This absence

could be explained by the status quo bias, that is the not necessarily conscious way of preferring habitual choices [65–67]. Pooley and colleagues wrote on this and posited that walking might not be recognised as a choice or a mode of transport because it is such an ubiquitous aspect of everyday life [68]. Participants who have alternative transport modes appeared to compare the options available and choose the most convenient one depending on their needs.

Question 1: features seen as difficult, unpleasant, or appealing

The ease and pleasantness of the walking experience were good conversation starters, readily understood by participants of all ages and backgrounds. Participants' inputs provided further detail that (in most cases) allowed their perceptions to be matched with the hierarchy of walking needs (core element of the draft Social Model of Walkability). For trips that participants undertook on foot / by wheelchair, there was a palpable sense of stress related to interactions with traffic. While practitioners might perceive pedestrian distraction as a safety issue [69], our participants showed high levels of vigilance and displayed strategies to deal with complicated environments and avoid or mitigate danger.

The quality of WE was significantly more important than the roles of high-level attributes (destinations, walking network connectivity and transport systems), for the walking experience. Traffic volumes, speeds and traffic-oriented infrastructure were mentioned as topmost among those difficulties experienced by almost all participants, no matter their age or disability status. These findings align with previous evidence that associated people's walking experience with the qualities of their environment, namely the traffic volume along the path [70–72], the ease and safety of crossing, including crossing devices and traffic [73–75] or the availability and condition of footpaths, especially for older people [73, 76, 77]. Pooley and colleagues note that walking is generally enjoyed as a (social) activity, but that the enjoyment can be counter-balanced by difficulties due to a non-supportive environment (e.g., difficulties to cross; traffic noise and pollution; multi-lane roads seen as grey and unappealing; or poor quality footpaths) [68]. Walking was described as "simply something that you did to carry out the tasks necessary for everyday life" and "most people were very accepting of the constraints imposed by the environment through which they passed" [68]. As the current study focused only on usual trips, it is possible that the perception of difficulty might be lessened (the reported trips appeared to be curated, participants having often chosen a route or even the side of the road with care, minimising difficulty). This suggests that the barriers reported are significant: firstly, because participants remembered them, despite the familiarity of the trips and the fact that by virtue of them being trips often taken, regardless of how unpleasant, they are inherently walkable "on auto-pilot" [78], and second because encountering similar barriers in less familiar contexts might cause a greater difficulty.

Although the findings appear as non-surprising in light of previous research, a recent literature review suggested that the current evidence base was gathered using diverse non-standardised methods, and without sufficiently controlling for individual differences such as disability types and levels [14]. Therefore, in

relation to the difficulties experienced by disabled people, the findings of prior research might be non-conclusive and worse, lose visibility of those experiences completely [19, 73, 79].

Question 2: characteristics of trips foregone

Reported barriers to walking (features associated with the inability to access a desired destination) were both specific and systemic in nature. Specific barriers included obstacles encountered on a certain trip) whereas systemic barriers were things like knowing that the design is inconsistent prompting blind participants not to walk anywhere without having previously learned a route and its obstacles. Systemic barriers are understood to have a higher impact on a person's mobility, as they can deter them from undertaking several potential trips. For instance, it has previously been shown that people who report difficulties crossing the street were 8.25 times more likely to have fewer than one trip outside their home per month than people of the same age group not reporting difficulties [80]. Barriers related to safety, comfort, and pleasantness, consistent with recent findings based on virtual exposure and photo-elicited interviews [81]. However, in our study, disabled people reported mainly on issues relative to the most basic walking needs (feasibility, safety, accessibility), not including aesthetic features, for instance a boring street design.

For those participants without transport alternatives, barriers to walking could discourage people from making the trip altogether, unless the trip is necessary, such as for work or education. The notion of absence of barriers is not surprising and was for instance discussed in a recent systematic reviews examining disabled people's needs [79, 82]. Interestingly however, Barnett and colleagues did not associate the absence of barriers with older people's walking levels ($p = 0.38$) [59]. Failing to identify barriers is possibly associated, as mentioned earlier, to the noted lack of controlling for functional limitations [59] and the lack of evidence regarding specific needs (e.g., people with cognitive disabilities [79] or users of less common assistive devices [82]). Thus, "averaging" the results relative to mostly non-disabled participants with those of people with diverse types and levels of disability, and using diverse mobility devices, could lead to losing sight of specific features some groups of people struggle with. Barnett and colleagues noted also a wide variety of geographical areas considered, with the risk that those areas would not necessarily correspond to the users' "playgrounds" [59]. In the present study, asking people about their usual trips ensured that each participant was talking about the area familiar to them, no matter how large or distant to home it was.

Question 3: disability as a moderating factor

Half of the participants had some type of impairment regarding seeing, hearing, walking or remembering and concentrating. It can seem surprising that disabled participants reported similar numbers of difficulties per trip as non-disabled participants. These reports differed in their detail. Disabled participants reported some specific issues such as the difficulty to orient by sound in high traffic areas and disabled participants tended

also to rate the difficulty of trips higher than the non-disabled participants. Two hypotheses could explain comparable rates of difficulties. Firstly, disabled study participants described numerous strategies for accessing their destinations, sometimes taking longer routes in order to avoid specific barriers. Therefore, their usual routes could be considered as carefully curated, bypassing barriers that would have been encountered elsewhere. The planning and curation effort aligns with previous findings, raising the question of the burden of mentally noting and avoiding difficulties by planning several steps ahead [32, 83]. A second explanation could be under-reporting of barriers due to a certain weariness with previous unsuccessful experiences of advocating for change. Oliver, for instance, reported that disabled people felt "at the mercy of an ideologically driven government with no-one to defend [them] except the big charities who are driven by self-interest" [84]. This could suggest a weariness in participating in engagement and a perception that participation is unlikely to trigger change on the ground, an aspect pointed out by Arnstein in her landmark paper on planning and citizen participation [85].

When considering those trips that were both difficult and unpleasant, disabled participants reported certain types of features that had not been noticed by the non-disabled participants (e.g., footpath obstructions). This finding aligns with results from Moura and colleagues, having shown that the same environments can be perceived differently across age groups, physical ability, and trip purpose [73]. The barriers reported by disabled people tended to be real challenges to overcome, while non-disabled people sometimes reported barriers rather linked to convenience (long waiting times at signalised intersections) or enjoyment of the route (lessened by roads designed for cars). It was observed that disabled people were putting significant time and effort into strategies to overcome obstacles. Blind participants reported learning the routes to memorise specific attention points or even using buses for parts of short trips to avoid certain obstacles. Wheelchair users paid special attention to the geometry of kerb drops and steepness of inclines. Barriers also had more severe potential consequences for disabled participants, for example leading them to alter routes, use of other modes of transport or avoidance of trips altogether.

In 2018 the New Zealand Transport Agency reported that in the previous week 75% of interviewed disabled people had not been able to make a journey that would have been beneficial as compared to 23% for the overall population [86]. As the interview investigated up to three trips per participant, the total volume of travel was not assessed, and it is therefore possible that disabled participants made fewer trips altogether than the non-disabled participants. As mentioned earlier, non-disabled participants were also impacted by the traffic-oriented environments, although these impacts led to an unpleasant experience that as not necessarily a major difficulty. When they were taken, trips involving unpleasant or unsafe environments were walked because of higher-order motivations. At other times, unpleasant or unsafe environments sometimes led non-disabled participants to avoid journeys. For instance, participants' desire to avoid crossing certain roads with children might mean not accessing an array of local destinations.

Methodological considerations

In 2010, Middleton and colleagues reported that while pedestrian behaviours were sometimes counted and captured, important gaps persisted in experiential data [78]. Eleven years later, studies have progressed the understanding using diverse techniques such as walk-along interviews [77, 87]; participatory action research [88, 89]; rating of pre-defined environments, in situ [73, 90] or virtual [81]; a combination of different types of interviews and ethnographies [68]; measures of behaviour used as experiential proxies (e.g., head movements and fixation points [91, 92]; or physiological responses, an approach recently reviewed by Zanwar and colleagues [93]). There does not seem to be consensus on how to capture experience, and it is possible that methods will complement each other. The approach taken in this study (sit-down interview) does not allow for participant observation in their milieu or measurement of their reactions. However, it presents some significant advantages: firstly, instead of assuming a psychological response from a physiological measure (e.g., gait), it asks participants to name it; second, instead of measuring the responses or reactions of people present in a certain environment, it interrogates participants about those destinations that are too hard to reach, and therefore captures perceptions regarding trips which are not possible but desirable; and third, instead of taking the visual input as a proxy for the overall experience (as done in studies considering eye tracking for instance), it encompasses all senses and captures the insights of participants who do not rely on sight for orientation.

Significance for transport planning and urban design

Identifying aspects of the built environment that are problematic is important as a decision-support tool for improving built environments. Certain aspects of the WE (e.g., intersection layout, traffic-oriented environments) were prominent among the interviews. These are related to severance, difficulty and unpleasantness, for all ages and disabilities. Any given city will have many occurrences of these problematic features (such as non-signalised intersections). Targeted retrofit will require specifying the characteristics that should be altered to facilitate systemic assessments of walking networks. This work should relate the experiences of diverse users (e.g., aspects perceived as difficult or features discouraging a local walk) to objective measures of the WE (e.g., traffic volumes or geometry of crossing points). Given the diversity of potential perceptions of similar environments, noted here and previously, it will be important to examine specific user groups separately, identifying what might be an obstacle for at least some people (e.g., blind, long cane users).

Strengths

This study has five major strengths. Firstly, it examined trips that are usually walked vs. potentially walkable and addressed dimensions of lived experience, controlling for familiarity and habits, which can potentially influence the choice and experience of walking [57, 65, 68]. Second, it included adult participants with a

wide range of ages and physical abilities, responding to the requirement for better understanding the particular needs of people with different types and levels of disabilities [19, 79]. Third, it included trips combined with public transport, an area that is under-researched [22]. Fourth, this research contributes to addressing the emotional experience of walking, an aspect studied less than practical experience and often through proxies and not direct insights [22]. Fifth, we provided practical insights into what aspects of the walking environment can discourage walking.

Limitations

All participants reside in urban or suburban areas of Tamaki Makaurau Auckland, Aotearoa New Zealand. Therefore, while findings can be helpful for other car-dominated environments (e.g., US, Canada, Australia), they cannot necessarily be generalised to areas with radically different street design and transport system characteristics (ease of driving, efficiency of public transport). Second, while half of the participants are disabled, the numbers of participants when split by disability, assistance used, and age are low (for instance, only one participant is helped by a guide dog, and the study did not include any Deaf participants). Third, the interviews were structured and may have lacked depth in some respects. The interview sought to understand what matters, but answering this question fully confronts the problem of identifying and verbalising one's feelings [41]. Fourth, basic dimensions of experiential quality (ease/difficulty and pleasantness/unpleasantness) were tentatively mapped across the dimension of the hierarchy of walking needs, using a structured coding framework, but there is inherent difficulty categorising perceptions [41].

Conclusions

This study outlined the importance of three major dimensions in research examining walking environments and users' perceptions. Firstly, the quality of the street environment (including traffic speed, volumes and infrastructure) contributed significantly to perceived barriers to walking across all ages and disability status. Second, the broader transport system was related to the choice of walking, particularly when walking was perceived as more convenient than other options. Thirdly, disabled participants deployed a range of strategies to overcome obstacles they encountered. Despite these strategies, they were more likely to experience severance, and inconsistency of design, making most spontaneous trips unfeasible. Future research should characterise the features of the walking environment that impede the ability to access destinations (e.g. non-signalised intersections). This will enable planners to systematically examine cities' networks and identify instances of those features that should be redesigned.

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