Responses to electric bikes (e-bikes) amongst stakeholders and decision-makers with influence on transportation reform in Toronto, Canada

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Introduction

The need for innovative reform in transportation behaviour, policy, and infrastructure is one of the most pressing sustainability challenges afflicting international cities. Urban transportation systems in North America have become almost exclusively auto-dependent resulting in transportation becoming the largest and fastest growing source of greenhouse gas (GHG) emissions (Newman & Kenworthy, 1999). Additional challenges associated with auto-dominated transportation include energy insecurity, accidents and fatalities, congestion, chronic disease associated with air pollution and sedentary lifestyles, and unaffordability (Blumenberg, 2002; City of Toronto, 2007; Cherry *et al.*, 2009; Anderton, 2010; Nilsson *et al.*, 2012; Buekers *et al.*, 2014; Hilbrecht *et al.*, 2014). Consequently, advocacy and planning for alternative modes of mobility are gaining traction and reflecting the changing state of commuter behaviour, stakeholder interests, and available infrastructure (Marsden & Rye, 2010; Jin *et al.*, 2012; Nilsson *et al.*, 2012). Electric bikes (commonly referred to as e-bikes) are quickly becoming one of the fastest growing segments of the global transport market with potential for disruptive impact on existing mobility patterns (Fishman & Cherry, 2016; Jones *et al.*, 2016). In Ontario, e-bikes are broadly defined as "motorized bicycles that can look like conventional bicycles, scooters, or limited-speed motorcycles" (Ministry of Transportation Ontario, 2015a). This classification encapsulates both the 'e-scooter' and 'pedal assist' options, the latter (known as a pedelec) look like a conventional bicycle, are similarly powered by human muscle but are also equipped with a battery that enables the option of electric assisted propulsion, [*Figure 1*]. A global e-bike adoption forecast model predicted 35 million units would be sold in 2016, and yet the uptake of e-bikes in Canadian cities is heavily lagging behind international counterparts likely due to inconsistent policies and regulations, prevailing urban forms and infrastructure that privilege car dependency, and adverse winter weather conditions for riding (Weinert *et al.*, 2007; Cherry *et al.*, 2009; Jin *et al.*, 2012; Du *et al.*, 2013).

Figure 1. E-bike model classification– 'e-scooter' (left), 'pedal assist' (right)

We currently know very little about the willingness and capacity of governance stakeholders to promote, plan and/or advocate for increased e-bike usage in Canadian cities (Edge *et al.*, forthcoming). Planning for the influx of e-bikes in urban centres is challenging given their ambiguity as a motor vehicle and unique performance characteristics (i.e. they are faster and heavier than regular bikes, smaller and quieter than cars), all of which raises uncertainties over how they should be integrated into already crowded systems of transportation infrastructure. Furthermore, the governance and regulation of e-bikes is fragmented and inconsistent. Uncertainties remain over how their uptake may be facilitated or constrained by influential governance stakeholders that possess different understandings of transportation challenges, priority goals, technological and infrastructural preferences, and resource access (Anderton, 2010; Marsden

& Rye, 2010; Roetynck, 2010; Baumann & White, 2012; Dill & Rose, 2012; Rose, 2012; City of Toronto, 2013; Marsden *et al.*, 2014; Baumann & White, 2015; Edge *et al.*, forthcoming).

In this paper our objectives are to:

1. Analyze the current state of knowledge and perspectives of diverse governance stakeholders towards e-bike technology adoption including related risks and benefits to sustainability;
2. Synthesize key areas of consensus, difference and uncertainty across stakeholders;
3. Identify factors (i.e. physical, political, economic, social) that shape e-bike uptake and impacts in the City of Toronto.

Literature Review

The state of literature pertaining to e-bikes and related policy and infrastructure remains in its infancy due to the recent commercialization of the product (Fishman & Cherry, 2016). E-bike technology is developing faster than the policy intended to govern its growth (Van der Kujip, 2013; Weiss *et al.*, 2015). While little attention has been paid to perceptions held by the broad range of stakeholders with significant influence over transportation reform, there is a small but growing literature on the beliefs and experiences of e-bike riders themselves. Existing data suggests that auto-dependent individuals, aging populations, or others with restricted mobility are likely to benefit the most from e-bikes (Cherry *et al.*, 2009; Roetynck, 2010; Dill & Rose, 2012; Johnson & Rose, 2013; Langford *et al.*, 2013), particularly given they may be an effective tool in enabling active transportation amongst these groups (Gojanovic *et al.*, 2011; Popovich *et al.*, 2014). North American studies indicate that e-bike users are typically older, well-educated, and earning a higher income compared to the general population (MacArthur *et al.*, 2014; Popovich *et al.*, 2014).

E-bikes have noted benefits that are widely understood to reduce car dependency (Johnson & Rose, 2013). These include the ability to travel longer distances and uphill at faster speeds, exert less energy, bear heavier loads, reduce one's carbon footprint, avoid the need to shower after commuting, and maintain control over personal travel timing and route selection (Gojanovic *et al.*, 2011; Dill & Rose, 2012; Rose, 2012; Johnson & Rose, 2013; Langford *et al.*, 2013; MacArthur et al, 2014). The electric assist can help those commuting less than 15 kilometers by car, conventional cyclists commuting long distances, and those dissatisfied with public transit options (Weinert *et al.*, 2007; Johnson & Rose, 2013). E-bikes were found to also increase conventional cycling uptake (MacArthur *et al.*, 2014). In China, as the national economy and socio-economic status increased, more citizens switched from traditional bikes to e-bikes (Cherry & Cervero, 2007). Other literature suggests that e-bikes are a less expensive endeavor particularly in comparison to owning a car (Papoutsi *et al.*, 2014; Clark & Curl, 2016).

The challenges of e-bikes reflect those of other emerging technologies. Riders are likely to face hostility when confronted with sharing congested urban road space with other modes (Langford *et al.*, 2015; Fishman & Schepers, 2016). For example, e-bikes have been found to move at an average of 40% to 50% faster than regular bicycles in shared bicycle lanes (Lin *et al.*, 2008; Cherry & He, 2009; Yang *et al.*, 2014). So far many North American cities have not undertaken the mass investments needed for implementing supportive infrastructure for the technology compared to developments being made in other parts of the world such as China (Cherry & He, 2009). Generating the political will to improve cycling infrastructure in Canadian cities like Toronto is particularly challenging given the prolonged winter conditions (Glazier *et al.*, 2012). There are also difficulties in the enforcement and regulation of infrastructure use. Toronto, similar to most North American cities, does not require registration or insurance for e-bike owners, which has contributed to perceived safety issues (Langford *et al.*, 2013; Popovich *et al.*, 2014).

Methodology

This qualitative study consists of a document analysis and semi-structured key informant interviews (n=24). The document analysis focused on transportation and energy policy and planning text that outlines strategic priority areas for the City of Toronto and other governance stakeholders. Key informant interviewees were identified through the document analysis and snowball sampling techniques. Participants represented an array of areas of expertise including, but not limited to, engineers, transportation planners, public health specialists, cycling advocates and lobbyists, academic researchers, retailers, and politicians [*Table 1*]. Interviews were audio recorded and transcribed. Results were thematically coded using NVivo qualitative data analysis software package and subjected to processes of inter-coder reliability.

Table 1. Coding system for (n=24) qualitative interviews

Organization category and number of organizations represented	Participant code
Academic – ACA: (3)	ACA-1; ACA-2; ACA-3
Advocacy professional – ADV: (1)	ADV-1
Funding agency professional – FPR: (2)	FPR-1; FPR-2
Municipal transportation management – MTM: (2)	MTM-1; MTM-2
Non-governmental organization professional – NGO: (5)	NGO-1; NGO-2; NGO-3; NGO-4; NGO-5
Police service – POS: (2)	POS-1; POS-2
Politician – POL: (1)	POL-1
Provincial transportation management – PTM: (2)	PTM-1; PTM-2
Public health management – PHE: (1)	PHE-1
Retail management – RET: (1)	RET-1
Service provider management – SEP: (1)	SEP-1
Transportation consultant – TRC: (2)	TRC-1; TRC-2
Transportation planner – TRP: (1)	TRP-1

Results and Discussion

Benefits and opportunities

The perceived benefits of using an e-bike by study participants were mostly central to the belief that the technology could assist individuals trying to travel moderate distances that would otherwise be travelled in a private automobile. E-bikes were often described as an underexplored option for populations with mobility challenges (i.e. seniors, individuals with physical disabilities) or restricted access to transit networks (suburban dwellers). Participants acknowledged performance and convenience factors that could have positive economic and environmental benefits. There was also interest in e-bikes being integrated into existing transport networks to promote multi-modal travel and reduce car dependency.

Active transportation and health outcomes

There was general consensus that e-biking "sort of" fell into the category of active transportation. The pedal assist models specifically were perceived as a potential tool for encouraging individuals to take up and/or continue cycling, especially those who are aging or afflicted with physical limitations who otherwise would not typically maintain physical activity. Further, e-bikes were perceived as being useful for encouraging riders to commit to cycling even when they are faced with challenging terrain (ACA-1; MTM-1; NGO-5; SEP-1; TRC-1; TRP-1).

"I love the idea of electric assist and I think it could be handy even for someone like me, if I had to do some longer distance regular rides based on a new job or commute, I might consider getting an electric assist on my bike. I think it is going to allow a lot more people to take up cycling when they know they have that little bit of extra juice to get them home or to decrease the sweat factor." (TRC-2)

"Navigating some of the hills in our city with a little bit of a pedal assist, makes it a lot more of an appealing option for people." (MTM-1)

Performance characteristics and convenience factors

E-bikes were perceived to have advantages that could attract a variety of users dissatisfied with their current modes of transportation. Virtually all participants were supportive of diversifying transportation options to encourage modal shift away from the car. There was a belief expressed by participants that e-bikes could enhance the cycling experience by allowing riders to travel further distances (ACA-1; FRP-1; FRP-2; MTM-1; NGO-1; NGO-3; POL-1; RET-1; SEP-1; TRC-2; TRP-1). This was considered especially useful to speed up and/or ease commutes (ACA-3; TRC-2; TRP-1). Some participants spoke to the potential of the e-bike to reduce congestion through their smaller size (when compared to a car) (FPR-2; MTM-1; MTM-2; NGO-5; REP-1; SEP-1; TRP-1). E-bikes were also seen as a less expensive purchase compared to car ownership (ACA-1; ACA-2; FPR-1; NGO-5; POL-1; RET-1). A participant with experience in selling e-bikes to many first-time owners stated that often times the consumer has sold their car thereby pocketing a net profit (RET-1). The e-bike was perceived by some as efficient in allowing users to travel with greater volumes of cargo or dependents (MTM-1; POL-1; SEP-1; TRC-2).

Environmental benefits

Any transportation technology (including e-bikes) that is propelled by electricity was perceived by essentially all participants as more sustainable than those reliant on fossil fuels. Participants felt this was particularly true in Ontario given electricity is mainly derived from renewable sources, particularly nuclear and hydro (as opposed to coal) (ACA-2; NGO-1; NGO-4; POL-1; NGO-5). Furthermore, Ontario currently has an underutilized surplus of electricity in off-peak hours (nights, weekends) that could charge e-bikes using relatively clean electricity (ACA-2; ACA-3; FPR-1; NGO-1; TRC-1; TRC-2). Nevertheless, many transportation stakeholders felt that classifying e-bikes as environmentally positive was entirely dependent upon which mode of transportation they were displacing. Displacing cars and motorcycles was viewed as positive, while displacing a conventional bike was viewed as negative both from a health and environmental perspective (FPR-2; NGO-1). E-bikes also offer the potential to reduce congestion through needing less road space, compared to larger cars (ACA-2; ACA-3; ADV-1; FPR-1; FPR-2; TRC-1; TRC-2).

"It [e-bikes] may be a meaningful building block in the sustainability agenda, but it depends on a lot of different behavioural elements – how people make decisions on whether to commute and whether to use bicycles in general and e-bikes in particular and whether that means that they are substituting bike trips, conventional bike trips or whether they are substituting auto trips or transit trips." (ACA-3)

Encouraging multi-modal integration and modal share

E-bikes were perceived by many as an ideal tool for enabling first- and last-mile solutions to transit users looking to optimize the connectivity of their commute (ACA-2; FPR-1; NGO-3; SEP-1; TRC-1; TRP-1). Interestingly, the majority of participants who expressed hopes for transit organizations to integrate e-bikes into their transit hubs to enable multi-modal options for riders did not actually work for transit companies (ACA-2; FPR-1; NGO-3; SEP-1; TRC-1). One individual who worked for a public transit organization commented on the challenges of achieving this objective, which included but was not limited to being unable to support rider demand (i.e. bringing a bicycle on a train during rush hour), the need for greater security to prevent theft, and the costs involved in funding e-bike charging or storage infrastructure (TRP-1). Another respondent from an agency that funds transportation innovations indicated that they are beginning to see evidence of some transit companies grappling with the challenges of how to actually integrate e-bike technology into their existing networks (FPR-2).

The possibility of adding e-bikes to existing bike share fleets was also raised repeatedly (ACA-1; FRP-2; NGO-1; NGO-3; POL-1; SEP-1; TRC-1; TRP-1). For example, as one bike share provider commented:

"I think that it is probably the next frontier of bike share, primarily because it broadens the appeal, so it gives more distance, it gives us a larger demographic, as there is people that would say, you know what, I don't know if I want to go up the hill." (SEP-1)

Nevertheless, this was also met with skepticism due to the costs associated with implementing necessary and compatible infrastructure or docking stations, and uncertainties over which transportation authority or level of jurisdiction should be responsible for shouldering those costs (SEP-1).

Opportunities for disadvantaged or vulnerable populations

E-bikes were praised as a well-suited mobility option for individuals of a lower socio-economic status who may otherwise be unable to afford a car, but whom would value the autonomy to maintain personal control over travel time and routes which transit does not allow (MTM-2; NGO-5; POL-1). Groups such as newcomers (ACA-1; NGO-4) and suburban women (ACA-1) were flagged as potential future e-bike users as they currently experience barriers to car ownership.

"If you look at car ownership in the suburbs, it isn't that high. And there are many suburban women who live in large households where there is only one car, guess who gets to drive it? Not her!" (ACA-1)

"I know one person [newcomer] who got an e-bike. It was gifted to him [by his son], and you know he really wants to have a car [that he could not afford], like that is his thing… The father is 55. He was really excited about it and he was riding it on the sidewalk." (NGO-4)

In addition, those with physical limitations (MTM-1; NGO-3; NGO-5; POL-1; SEP-1; TRC-2) and aging populations (FPR-2; MTM-1; NGO-3; PHE-1; POL-1; TRC-1; TRC-2) were seen as optimal candidates to benefit from e-bikes.

"Maybe you have got some bad knees, you still want to be able to cycle, so my sense is that you know that e-bikes play a really important role and should play an important role." (NGO-3)

"They [seniors] were able to go places. It helps with social skills. Cohesion. If you are out and interacting with the community. I think if you can cycle then it might be a reasonable alternative." (PHE-1)

Challenges and barriers

The perceived challenges of e-bike ownership were often focused on the interactions and contentious relationship between e-bikers and those operating more common modes of transportation, particularly within the context of a poorly informed public and auto-centric built environment. These difficulties may be exacerbated by the fact that policy lags behind rapidly changing e-bike technology. As a result, there have been barriers to accelerating the public adoption or acceptance of e-bikes.

Safety, operational concerns and co-existence with other modes of transportation

A major concern that arose across the stakeholder interviews was the sharing of limited road space and resulting concerns related to safety, infrastructure use and modification (ACA-1; ADV-1; FPR-1; FPR-2; MTM-2; NGO-1; NGO-2; NGO-3; NGO-5; PHE-1; POL-1; SEP-1; TRC-1; TRC-2). Some participants emphasized that the city was designed to accommodate automobiles (ACA-3), which poses a substantial challenge in allocating areas specifically for bicycles let alone differentiating between spaces for traditional bicycles and e-bikes (ACA-1; FPR-2; MTM-2; POL-1). This was perceived as leaving riders open to dangerous conditions (ADV-1; FPR-1; NGO-2; POS-1; POS-2).

"How do we effectively get rid of the car, or radically reduce the speeds with which cars can travel, and the rest of the roadway, making it safe for these larger e-bikes to use roadways (while) liberating space for bicycles that are pedal driven or just e-assist?" (FPR-2)

Participants discussed the need for improved bike infrastructure in general to support a more diversified transportation network (ACA-1; MTM-1; MTM-2; NGO-2; NGO-3; TRC-2; TRP-1). Integrating e-bikes brings the additional challenge of deciding where to situate and how to fund public charging stations (SEP-1; TRP-1). Many identified that there is inadequate political will when it comes to allocating funding towards cycling infrastructure in general (ACA-3; ADV-1; FPR-1; FPR-2; MTM-2; NGO-2; NGO-5; RET-1; PHE-1; TRC-1), with harsh winter weather conditions and a shortened ideal riding season adding to such difficulties (ACA-1; ADV-1; MTM-1; SEP-1; TRC-2).

Determining how to divide up existing travel space is a particular challenge to decision-makers that are responsible for implementing regulations and by-laws that encourage road safety.

"The municipalities are left sort of holding the bag in terms of trying to figure out how to integrate them, integrate it safely is my biggest concern into the transportation system." (MTM-2)

"When and if there are issues with public safety for another form of transportation, either cyclists or pedestrians, or for drivers for that matter, then we are ending up in a difficult situation that we have to look at where does this particular technology fit in the scheme of existing stakeholders." (POL-1)

Many respondents pointed towards the fact that it is difficult to enforce speed limit restrictions. Issues of speed differentials in bike lanes were of particular concern where individuals riding conventional bicycles may be vulnerable when sharing space with e-bikes or e-scooters that are larger or may be travelling at significantly faster speeds (NGO-2; NGO-5; POL-1; TRC-1; TRC-2). Most e-bikes are manufactured to automatically turn off the electrical motor so they do not exceed speeds of 32 km/h. Nevertheless, it was perceived that there are many instances of riders modifying the technology on their own thereby tampering with speed capabilities. While this is restricted it is difficult to monitor and enforce (ACA-1; MTM-2; NGO-1; NGO-2; NGO-5; POL-1; POS-1; POS-2; SEP-1; TRC-1; TRC-2; TRP-1).

"An electric scooter is a motor vehicle. I mean it is so clear to anybody who is looking at it, and the fact that they put speed limits on them. They put weight limits on it. The speed can easily be tampered with. There may be restrictions on how fast they can go, but almost anyone that knows a thing or two about electronics can figure that out, and they can go faster." (TRC-2)

Some civil servants identified a lack of comprehensive collision data that delineates whether a regular or electrified bike was involved in a crash, and under what circumstances, which makes it challenging to adapt planning or regulatory ordinances (MTM-1; POL-1). The City of Toronto has recently responded to this concern by implementing compelling police responding to accidents to document the type of bike involved in addition to the standard practices of detailing the circumstances that led to the accident.

Furthermore, law enforcement has begun to use digital documentation methods with more specific standardized descriptive categories when responding to accidents which could further enable data sharing and more informed evidence-based decision-making (POS-1; POS-2).

Uncertainties around conflating or distinguishing between models of e-bikes in the regulation of their use

Additional safety concerns were raised, such as the fact that e-bikes can be acquired without a license, driver's test, and registration (ACA-1; ADV-1; FPR-2; MTM-2; NGO-1; NGO-3; NGO-5; POL-1; SEP-1; TRC-2). This issue was closely related to other voiced concerns around e-scooters and pedal assist bicycles being conflated despite significant differences in performance characteristics (mass, speed).

"I don't know how we don't regulate those when we regulate electric cars. We treat an electric car different than a gas powered car, but for some reason we have a free for all on e-mopeds, but the minute you put an internal combustion engine, you have to have a license, insurance, all those type of things, so it seems like there is an anomaly in our practice in how we treat you know electrically, or battery powered bicycles we missed naming them as a bicycle, they are not a bike, there are an electric motorcycle… we have taken something and misrepresented it." (SEP-1)

A lack of clarity between the distinguishing characteristics of e-bike models was noted as a barrier by many participants to achieving higher rates of adoption, effective public education, and stakeholder acceptance. At both the federal and provincial level, e-scooter and pedal assist bicycles are lumped into one category. The issue of whether e-bike models should be further differentiated by weight or speed was frequently mentioned by participants of various backgrounds (ACA-1; ACA-3; MTM-1; MTM-2; POL-1).

"I think if they are a motorcycle, then they need to be licensed. If they are a bicycle, then they don't. They are not fitting in either category right now." (POL-1)

In the case of e-bike regulation municipal governments have been provided with federal and provincial definitions of what an e-bike is yet have the jurisdictional authority to implement by-laws that amend those definitions so the technology is compatible with their unique systems of transportation infrastructure currently in existence. As one transportation manager articulated:

"We were put in a situation by sort of the province and Transport Canada… we were forced to accommodate them [the joint definition of e-bikes] …but there was not good guidance about all the parameters that do not lead to what I believe in many cases would be the safest operation." (MTM-2)

Conclusions

This paper examined how governance stakeholders with influence over transportation reform are perceiving emerging e-bike technology and related risks and benefits. Study participants by and large viewed e-bikes as promising technology for encouraging diversification of mobility and modal shift away from private automobiles. Our findings are consistent with literature indicating e-bikes are perceived as having the potential to encourage a wider range of individuals to incorporate cycling into their commutes instead of relying on a car. E-bikes were also seen as promising for enabling more active modes of travel amongst individuals that may otherwise find cycling unappealing due to challenging terrain, or mobility restrictions brought on by aging or physical limitations. Some governance stakeholders believed the technology could help enable autonomous mobility amongst lower-income demographics who cannot afford a car, in addition to encouraging households to refrain from purchasing a second car. Interestingly, merging evidence in North America suggests e-bike riders are typically white-collar, commuting males earning higher incomes relative to the general population (MacArthur *et al.*, 2014; Popovich *et al.*, 2014). Future research should focus more closely on demographics that have consistently been identified as most likely to benefit from this technology, and factors inhibiting adoption amongst these groups. Most respondents believed that e-bikes could assist broader agendas to electrify transportation systems to reduce GHGs. Yet the willingness of stakeholders to classify e-bikes as environmentally "friendly" is dependent upon how electricity is being generated in the first place, and which mode e-bikes are displacing. If transportation stakeholders are to advocate for broader uptake of e-bikes it is imperative to better understand whether individuals are giving up their cars or abandoning cleaner, more active modes.

There was a general consensus that e-bikes are an ideal tool for enabling first- and last-mile solutions for transit users looking to optimize the connectivity of their travel. Many argued that opportunities for integrating e-bikes into existing transit networks as a means of encouraging multi-modal travel should continue to be explored. Nevertheless, concerns were raised over the costs of building seamless, integrated and compatible infrastructure, and which institutions should shoulder these costs. Other reservations raised by study participants related to safely governing the sharing of limited road space to avoid negative interactions between modes. Many spoke about how North American cities were designed to accommodate cars and the difficulties of reserving space for cycling in general, let alone e-bikes if additional distinct space is warranted. Our study sample argued that from a regulatory perspective there are problems with conflating e-scooters and pedelec models, suggesting that these technologies need to be further differentiated according to their performance characteristics and related hazards. There is need for appreciating the unique transportation contexts that exist across cities (e.g. varying size, density, citizen needs) which sometimes demands regulatory flexibility. Nevertheless, inconsistency poses challenges and confusion for broader adoption and/or acceptance of e-bikes amongst key stakeholders and the broader public. As urban transportation systems undergo significant overhaul many competing technological innovations and associated interests are being weighed. This makes it difficult for decision-makers to determine what infrastructure and behavioural modifications to prioritize within planning and resource investment. Our findings suggest decision-makers and interest groups require further data on modal displacement, e-bike rider demographics and usage patterns, how and what infrastructure is being used, and related interactions between e-bike riders and other modal users in order to better understand both their potential and disruption within changing urban transportation systems.

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