TRR
JOURNAL OF THE TRANSPORTATION RESEARCH BOARD

Transportation Research Record
2019, Vol. 2673(5) 1–11

DOI: 10.1177/0361198119837158
journals.sagepub.com/home/trr
SAGE

Industry Stakeholder Perspectives on the Adoption of Electric Bicycles in British Columbia

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Abstract

Electric-assist bicycles (e-bikes) are an emerging mode of transportation that offers a sustainable alternative to automobile use in urban areas. Past research on e-bike adoption has focused on user perspectives. Understanding other stakeholder perspectives is also essential to implementing effective e-bike policy. The objectives of this research are to identify alignments and misalignments in perspectives on e-bike adoption across industry stakeholders in British Columbia (BC), including e-bike retailers, manufacturers, cycling coalitions, and government agencies, and to provide recommendations for e-bike policy that account for those perspectives. An online survey was distributed to industry stakeholders to examine perceived barriers to adoption, expected impacts of adoption, and effects of policy on adoption. Questions about regulations discriminated between five e-bike types: pedal-assist, throttle-assist, scooter-style, electric recumbents, and enclosed electric recumbents. Results indicate strong agreement among industry stakeholders that scooter-style e-bikes require separate and additional regulation from other types of e-bikes and from existing regulation in BC. In contrast, there was misalignment in the expected mode shift resulting from e-bike adoption, with government agencies least optimistic about diversion of automobile trips. Industry stakeholders broadly agreed on the need for speed regulation and viewed higher speeds as one of the least important benefits of e-bikes, which contrasts with past research on user perspectives. Policy recommendations include reclassifying scooter-style e-bikes, rebate or tax programs to reduce e-bike costs, further research on optimal e-bike speed limits, and continued support for improvements in general cycling infrastructure (a top priority for industry and user stakeholders).

Ambitious goals have been articulated to reduce automobile dependence in many North American cities, such as non-auto mode shares of two-thirds and one-half in the city and metropolitan region, respectively, of Vancouver, Canada (*1*, *2*). Achieving these types of ambitious goals requires "strong policies…at both the local and national levels of government" (*3*). Electric bicycles represent a unique opportunity to accelerate the transition away from automobile use for some urban trips.

Electric-assist bicycles (e-bikes) are an emerging form of urban transportation with the potential to blend some of the convenience of private automobiles with some of the benefits of traditional non-motorized bicycles, such as: lower emissions, less congestion, lower travel cost, and increased physical activity. The e-bike market is growing rapidly in many parts of the world, but growth varies greatly by country. The market for e-bikes up to now has been dominated by China and other Asian countries (*4*). In North America, e-bike riders can still be characterized as early adopters (*5*). Canada's e-bike market has been estimated to be approximately one-tenth of the U.S. market, which was around 185,000 sales in 2013 (*6*). More recently, e-bike sales in Vancouver in 2014–2016 experienced "a sharp uptick…ranging from 100- to 500- per-cent growth" (*7*).

The literature on e-bikes extends back more than a decade, but a recent review stated "research on e-bikes is still in its infancy" (*4*). The limited literature has contributed to a nebulous public policy landscape regarding e-bike regulation, infrastructure, and incentives (*8*, *9*). Many government agencies have yet to include e-bikes as a travel mode in travel- and collision-related surveys and databases. Existing e-bike policy is inconsistent across geographies and focuses on vehicle standards (*8*, *10*).

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Regulations such as maximum speed can impact the attractiveness of e-bikes, but with potential trade-offs in safety and conflicts with conventional bicycles, pedestrians, and other road users (*9*, *11*). Cycling infrastructure is a positive factor for adoption (*11*, *12*). E-bikes are expected to increase the throughput capacity of bicycle facilities (*13*). But conflicts between electric and non-electric bicycles is a concern for travelers, especially on bicycle facilities (*8*, *9*).

Most of the existing e-bike research has examined adoption and impacts from the perspective of the traveler. Relatively little is known about the perception of different industry stakeholders regarding e-bike adoption and e-bike impacts. User perspectives are central to predicting uptake and use of e-bikes, but understanding other stakeholder perspectives is also essential to overcoming institutional barriers and implementing effective policy support for e-bikes (*14*). Alignments among people who provision e-bikes (manufacturers and retailers), regulate e-bikes (governments and agencies), and promote e-bikes (cycling coalitions) is important for the creation of e-bike policies that can be agreed upon and implemented.

The objectives of this research are to identify alignments and misalignments in perspectives on e-bike adoption across industry stakeholders in British Columbia (BC), and to provide recommendations for e-bike policy that account for those perspectives. First, a market review was conducted to characterize relevant industry stakeholders and the e-bike market in BC. Second, an online survey was administered to those stakeholders to examine perceptions and attitudes toward e-bikes, including questions related to: barriers to adoption, expected impacts of adoption, and the effects of policy on adoption. Third, the survey findings were applied to the current policy context in BC and compared with past work examining the perspectives of existing and potential e-bike users.

Method

Classification of E-Bikes

In BC, the Motor Vehicle Act and the Insurance Corporation of British Columbia (ICBC) classify e-bikes as "Motor Assisted Cycles", clearly segregated from "Limited Speed Motorcycles" (i.e., electric scooters and mopeds) which require registration and licensing (*15*). Common to regulations in other geographies, e-bikes are required to have pedals and do not require registration and licensing. Although licensing is not required, riders must be at least sixteen years old. Other e-bike requirements include a speed restriction of 32 km/h "on level ground without pedaling" and an electric motor restriction of 500 watts.

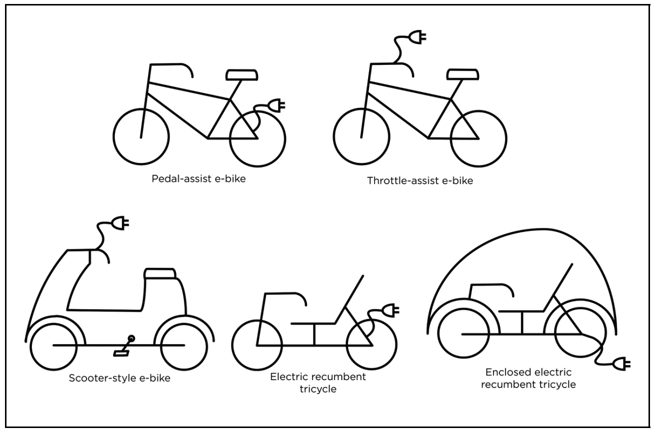

Figure 1. Illustration of e-bike typology.

On the national scale, the Government of Canada defines a power-assisted cycle under the Motor Vehicle Safety Regulations (*16*). The federal regulations are essentially the same as those of BC, without the age requirement. These requirements are also similar to U.S. regulations (*5*). The main difference in regulation between Canada and the U.S. is the maximum motor power, as the Consumer Product Safety Act requires an electric motor less than 750 W, while Canada's Motor Vehicle Safety Regulations assign a limit of 500 W.

A variety of vehicles with substantially different size, weight, power, and operating characteristics are currently sold within the regulatory category of an e-bike (*8*). To examine perceptions of different types of e-bikes in this research, five e-bike types are defined (illustrated in Figure 1) based on a review of commercially available vehicles meeting the definition of an e-bike in BC: pedal-assist e-bikes, throttle-assist e-bikes, scooter-style e-bikes, electric recumbent tricycles, and enclosed electric recumbent tricycles. Pedal- and throttle-assist e-bikes are physically similar to traditional bicycles (with the rider's feet on working pedals); the former requires pedaling to engage the motor, and the latter allows the motor to be engaged manually. Both are common in BC e-bike retail outlets. Scooter-style e-bikes effectively operate with a throttle-only electric motor; pedals are attached, but impractical to use, and the rider's feet typically rest on a baseboard. They are physically similar to electric scooters, which are classified as Limited Speed Motorcycles in BC. Scooter-style e-bikes are different from e-assist push/kick scooters, which were not widely available in BC at the time of the survey, and are not classified as Motor Assisted Cycles in BC. Scooter-style e-bikes are commercially available, but less common than the first two types of e-bikes. Electric recumbent tricycles are included because of a new enclosed pedal-assist "velocar" being introduced in BC by a Vancouver-based company, VeloMetro. Non-enclosed electric assist recumbent tricycles are not commonly sold in BC, but they are included in the study to isolate the effect of the velo-car shell on perceptions of e-bikes. Photo examples of the cycles can be found at http://www.velometro.com/ or in (*8*, *10*).

Identification of E-Bike Industry Stakeholders

E-bike industry stakeholders are defined in this study as: entities involved in e-bike retailing; entities involved in e-bike manufacturing; cycling coalitions; campus planning agencies; transit agencies; or planning, engineering, or transportation departments in municipal, regional, and provincial government agencies. These categories were determined based on a market review to identify stakeholders (other than end-users) involved in creation of or affected by e-bike policy.

Transit agencies are included because of their role in enabling multimodal trips with e-bikes. TransLink, the regional transit operator in metropolitan Vancouver, allows e-bikes on sea and rail transit (following the standard bicycle regulations), but not on buses (*17*). Buses run by BC Transit in the rest of the province do permit loading of (non-scooter-style) e-bikes on the front-of-bus racks, but they must weigh less than 25 kg, have the battery removed, and only e-bikes with lithium batteries are permitted (*18*).

Survey Administration

The study population was all entities in the defined stakeholder categories and located in BC. Initial contacts were obtained from publicly available email addresses on websites of each entity. For entities without a publicly-listed email address, email addresses for general inquiries were used for initial contact. In total, 371 contacts were acquired through publicly listed contact information for eligible organizations. Prior to distributing the survey, the study content and procedure details were approved by the University of British Columbia's Research Ethics Board. A single reminder email was sent to contacts that had not completed the survey after one week. The survey opened on August 1, 2017 and closed on August 22, 2017. Before release, a pilot survey was distributed within the authors' professional network, and revisions made including the addition of example photos of facility types and wording clarifications.

The survey questionnaire was designed and administered using Fluid Surveys, an online survey tool. The survey consisted of 28 questions (excluding branching questions) that consisted of Likert scale, multiple choice, ranking, and open-ended questions for additional comments. Of the 28 questions, six were to characterize the stakeholder type, four addressed e-bike regulations, five addressed e-bike adoption, five addressed impacts of e-bikes, four addressed e-bike policy, and four determined the respondent's personal cycling experience (in that order). Five-point Likert scale questions were used to measure level of agreement, level of importance, and likelihood of outcomes (all including a neutral central value). A four-point Likert scale question was used to measure the perceived level of barriers ("Not a barrier", "Slightly a barrier", "Moderate barrier", "Extreme barrier"). The prompts in the questions for potential barriers, benefits, and impacts of e-bikes were based on a review of e-bike adoption literature. Participants were given sample images of each facility and vehicle type, with "throttle-assist" and "scooter-style" e-bikes defined as "Does not require pedaling", and all other as "Requires some pedaling".

Survey responses were downloaded from Fluid Surveys and analyzed in R software. Reponses were qualitatively checked for protest answers. Open-ended question responses were inspected for confusion or clarifications by respondents. Email address domains were used to confirm associated organizations. Likert scale responses were inspected both in relation to the percent that agreed (or equivalent) and mean values after converting ordinal responses to an integer scale (1 through 5). Results below are presented as percent agreed or strongly agreed for Likert questions in the disagree/agree domain, and as numerical averages of integer scores for other domains (unimportant/important, unlikely/likely, and ineffective/effective).

Results

Survey Responses

A total of 116 survey responses were submitted out of 371 invitations, giving a 31% overall response rate. Item non-response was under 10% for all questions except open-ended questions for additional comments/explanations. Invitations and responses by stakeholder type are summarized in Table 1. The largest share of responses (49%) was affiliated with planning, engineering, or transportation departments in government agencies, the majority of which were municipalities (45 of 57) and the rest regional (11) and provincial (1) governments. Given the few responses in the "other" category, those stakeholders were grouped with government agencies for the following analysis, under the assumption that they have a similar role and perspective in the e-bike industry. This assumption was supported by responses to the question "My organization plays the following role in regards to e-bikes" (strong promoter to strong protester), for which responses of campus planning and transit agencies were most similar to government agencies (neutral to

Table 1. Number of Responses by Stakeholder Type

Organization	Invitations	Complete responses	Response rate (% of invitations responding)	Distribution (% of responses)
Retailer	63	23	37	20
Manufacturer	15	15	100	13
Cycling coalition	18	13	72	11
Government agencies	253	57	23	49
Other (campus planning, transit agencies)	22	8	36	7
Total	371	116	31	100

promoter), versus the other three stakeholder types (promoter to strong promoter).

Of the responding entities, 42% were based in the Greater Vancouver Regional District and Fraser Valley Regional District (i.e., the "Lower Mainland"), 13% in the Capital Regional District (Victoria region), and 45% from other areas. Based on 2016 census data, the Lower Mainland and Capital Regional District constituted approximately 59% and 8%, respectively, of the total provincial population (*19*). Most respondents (83%) personally owned a conventional bicycle and 23% owned an e-bike (13% owned both). A high level of e-bike ownership was expected because of the large share of e-bike manufacturers and retailers in the dataset.

Regulation of E-Bikes

Figure 2 gives the percent of respondents that agreed that each type of e-bike should be regulated the same as conventional bicycles (given two categories: "Regulated as bicycles" and "Regulated separately from bicycles"). There was general agreement across stakeholders in the types of e-bikes that should be regulated the same as conventional bicycles. Most respondents in all stakeholder groups agreed that pedal-assist e-bikes should be regulated the same as conventional bicycles, and scooter-style e-bikes should not. Perspectives on the other e-bike types were more mixed, with manufacturers and cycling coalitions most supportive and retailers and government agencies least supportive of grouping the other types of e-bikes with conventional bicycles for regulatory purposes.

Figure 3 gives the percent of all respondents that agreed that each e-bike type should be allowed to operate on six types of facilities: mixed-traffic roads, unseparated (painted) bike lanes, separated bike lanes, unpaved off-road trails, shared-use pathways (with pedestrians), and sidewalks (checkboxes for "on which facility type(s) should each type of e-bike be allowed?", with example photos of each facility). Respondents were decreasingly accepting of e-bikes operating on facilities shared with

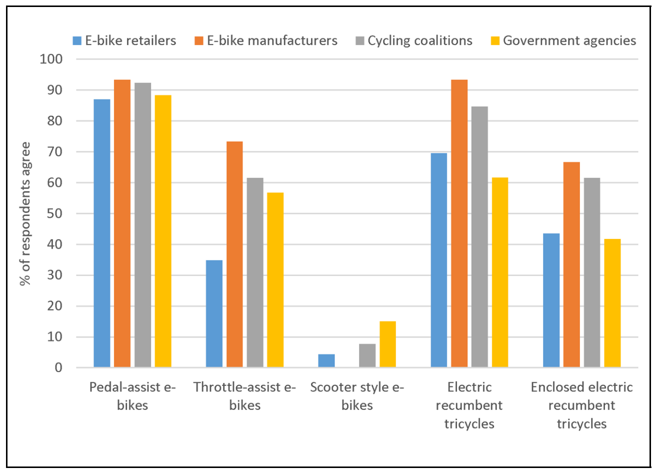

Figure 2. Percent of respondents agreeing that each type of e-bike should be regulated the same as conventional bicycles.

motor vehicles, conventional bicycles, and pedestrians, in that order. The differences by e-bike type align with Figure 2 in that respondents were most accepting of pedal-assist and least accepting of scooter-style e-bikes operating on dedicated bicycle and pedestrian facilities (with the other e-bike types falling in between). Perceptions of appropriate facilities varied somewhat among stakeholders. Consistent with Figure 2, manufacturers and cycling coalitions were most supportive (and retailers and government agencies least supportive) of allowing non-scooter-style e-bikes on bicycle and shared-use (pedestrian/bicycle) facilities, particularly for throttle-assist e-bikes.

Figure 4 illustrates the positive agreement between perceptions of e-bike types that should be regulated as conventional bicycles and types that should be allowed on shared-use pathways. The same pattern emerges for separated and non-separated bike lanes as well.

Figure 5 shows the percent of respondents agreeing that three specific regulations should apply to each type of e-bike: speed regulation, licensing, and age restrictions

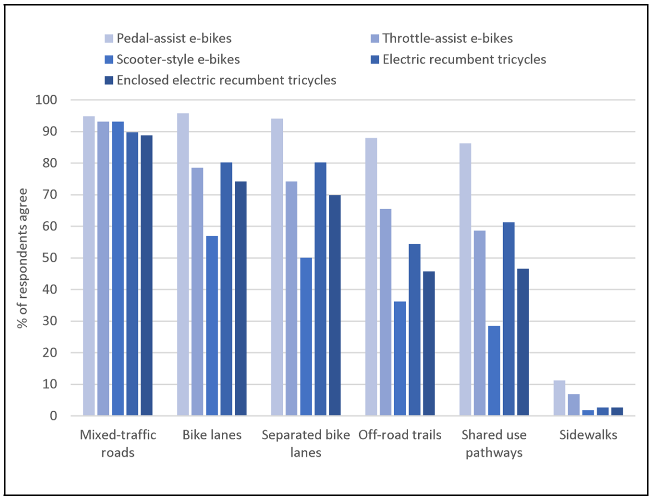

Figure 3. Percent of respondents agreeing that each type of e-bike should be allowed to operate on various facilities.

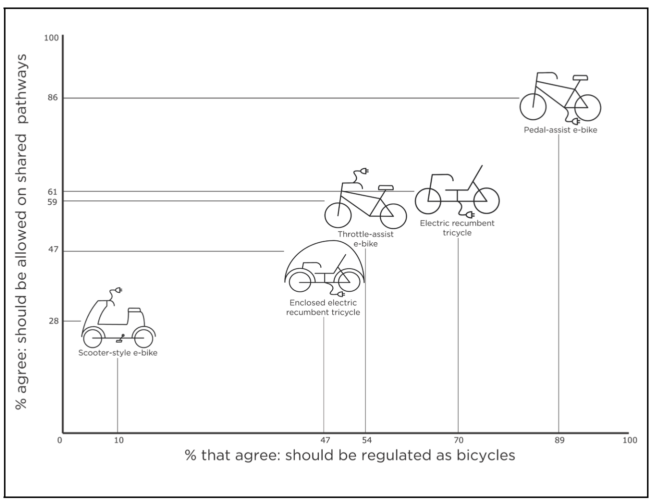

Figure 4. Perspectives on e-bike types that should be regulated as conventional bicycles and that should be allowed on shared-use pathways.

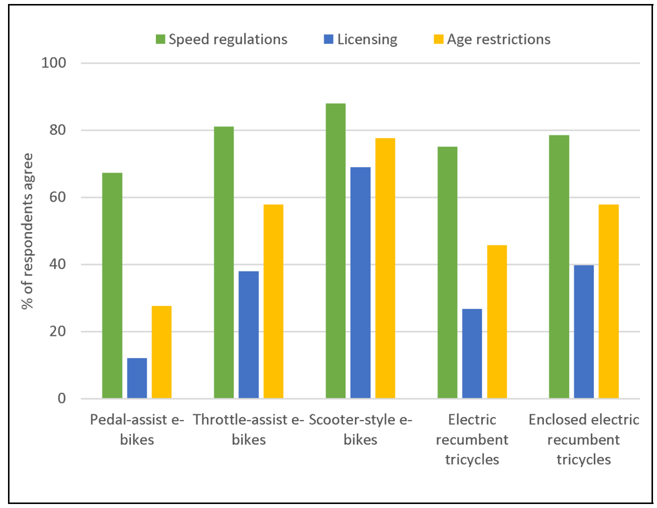

Figure 5. Percent of respondents agreeing that speed regulation, licensing, age restrictions should be required for each type of e-bike.

("Please indicate which regulations should be applied for each type of e-bike"). Speed regulation is the most broadly supported, followed by age restrictions and licensing. The differences by e-bike type follow the same patterns as above, with pedal-assist e-bikes viewed as requiring the least regulation, scooter-style the most, and the other three e-bike types clustered in between those. These patterns among e-bike types and regulations held across stakeholder types. Cycling coalitions were least supportive of age and licensing regulations, but most supportive of speed restrictions, whereas retailers were most supportive of age and licensing restrictions. Government agencies were least supportive of speed regulations and moderately supportive of age and licensing restrictions.

Expected Impacts of E-Bike Adoption

Perceived likelihood of several potential impacts of increasing e-bike adoption was examined using the question "If e-bikes were more widely adopted in BC, how likely would you consider each of the following to occur", with responses on a five-point Likert scale from very unlikely (1) to very likely (5). Table 2 gives average scores within stakeholder types for each question. Retailers and manufacturers perceived travel mode shifts as highly likely, whereas government agencies were more neutral on mode shift. Cycling coalitions were the most optimistic, with the largest perceived difference in likelihood of automobile versus conventional bicycle and transit mode shift. Government agencies were the only stakeholder type that attached higher likelihood to mode shift from conventional bicycles than from automobile or transit; for the other three stakeholder types, mode shift from conventional bicycles was reported as least likely.

Regarding expected changes in cycling demographics, a wider diversity of cyclists is generally expected, although less so by government agencies compared with other stakeholder types. An increase in high-income cyclists is also broadly seen as likely among surveyed stakeholders, while an increase in low-income cyclists is seen as unlikely by most stakeholders, except manufacturers who also state a slightly expected increase in that group. With regard to safety and security, government agencies and cycling coalitions see increased conflicts with other road users as somewhat likely, while manufacturers and retailers see them as less likely. Interestingly, increased conflicts with automobiles was generally seen as more likely than increased conflicts with other cyclists.

Table 2. Perceived Likelihood of Impacts of E-Bike Adoption by Stakeholder Type; Average Score on a Likert Scale from Very Unlikely (1) to Very Likely (5)

	Retailers	Manufacturers	Cycling coalitions	Government agencies
Travel mode shift				
From automobiles to e-bikes	4.1	4.3	4.0	3.3
From conventional bikes to e-bikes	3.9	4.1	3.2	3.5
From public transit to e-bikes	4.3	4.4	3.5	3.3
Cycling demographics				
Wider diversity of cyclists (age, gender)	4.7	4.5	4.7	3.8
More high-income cyclists	4.2	4.2	4.2	3.8
More low-income cyclists	2.9	3.3	2.2	2.4
More cyclists without a driver's license	4.2	4.2	3.5	3.4
Safety and security				
Increased conflicts with automobiles	3.5	3.0	3.6	3.8
Increased conflicts with pedestrians	3.0	3.1	3.5	3.7
Increased conflicts with other cyclists	2.9	3.1	3.2	3.6
Increased bicycle theft	3.7	3.7	4.2	3.6

There was broad agreement across stakeholders that bicycle theft will be an increasing issue.

Perceptions of potential safety risks of e-bikes were also examined by asking respondents whether they agree or disagree (on a five-point Likert scale from strongly disagree to strongly agree) that e-bikes will "pose safety risks" to: e-bike riders, other cyclists, pedestrians, and motorists. For all four types of potential safety risks, government agencies most strongly agreed, followed by retailers, cycling coalitions, and manufacturers (consistent with the expected conflicts in Table 2). Average responses by stakeholder type ranged from neutral to agree, with average scores of 2.9 to 3.8 for cyclist and pedestrian safety risks within all four stakeholder types (27–75% agree or strongly agree). Risks to motorists were perceived as lower, with average scores of 1.9 to 3.0 (disagree to neutral): 7–37% agree or strongly agree. Hence, stakeholders generally viewed increased conflicts with automobiles as likely, but with safety risks for e-bikes, not motorists.

Promotion of E-Bikes

Respondents were asked to rate the importance of six commonly cited benefits of e-bikes (versus conventional bicycles) on a five-point Likert scale from very unimportant (1) to very important (5): "To what extent do you consider each of the following an important benefit for e-bike users compared with users of conventional bicycles". Three benefits were broadly viewed as highly important, with average scores of 4.2 to 4.6 for all stakeholder types: "Provides assistance for riding on hilly terrain", "Provides assistance for riders with physical limitations", and "Allows longer distance trips". One benefit, "Requires less energy and reduces sweating", was consistently seen as less but still important, with average scores within all four stakeholder types of 3.6 to 3.7.

There was less agreement among stakeholders for two other potential benefits. The perceived importance of "Increasing cargo hauling capacity" ranged from 3.5 for government agencies to 4.5 for cycling coalitions. The perceived importance of "Allows higher speeds" was the lowest among the six benefits, ranging from 2.9 for government agencies to 3.9 for manufacturers. Higher speeds were seen as slightly unimportant (below 3.0) by both government agencies and cycling coalitions, on average.

Stakeholders were asked the extent to which they agree that e-bikes will be increasingly adopted in BC "under the current policies, programs, and infrastructure," with responses on a five-point Likert scale from strongly disagree (1) to strongly agree (5). Retailers and manufacturers were most optimistic, both with average scores of 4.2 (83% and 87% agree or strongly agree, respectively); cycling coalitions and government agencies were more neutral but still agreed, with average scores of 3.8 and 3.5 (69% and 53% agree or strongly agree, respectively). Only 13% of all respondents disagreed that e-bike adoption would increase with existing systems, while 65% agreed, and the rest were neutral.

Respondents were asked to rate nine commonly cited barriers to e-bike adoption on a four-point Likert scale from not a barrier (1) to extreme barrier (4) ("To what extent do you consider each of the following an important barrier to adoption of e-bikes in British Columbia"). Figure 6 gives the resulting average scores by stakeholder type. Lack of bicycle facilities, purchase cost, and fear of theft were the highest-ranked barriers. Several barriers were perceived differently among stakeholder types: cycling coalitions saw parking and riding infrastructure

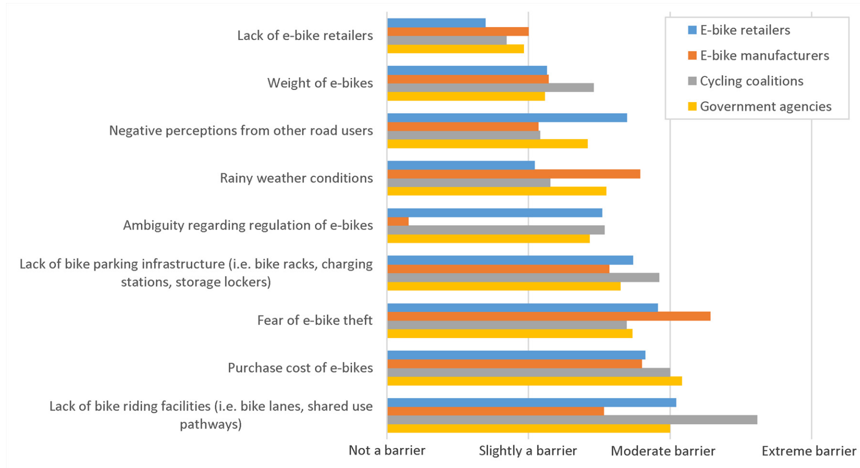

Figure 6. Perception of barriers to e-bike adoption, averaged by stakeholder type.

as larger barriers than other stakeholders, whereas manufacturers saw theft and weather as larger barriers than other stakeholders.

When asked about promotion, 48% of retailers, 38% of cycling coalitions, and 12% of government agencies reported an e-bike promotion policy or program at their organization. If applicable, respondents were asked to rate promotion effectiveness on a five-point Likert scale from highly ineffective (1) to highly effective (5), and those scores were averaged by stakeholder type. Retailers (3.5) and cycling coalitions (3.4) indicated those efforts were generally seen as somewhat effective, whereas government agencies were neutral (3.0). Separating further into educational programs, financial incentives, rentals/demos, cycling policies, and other, programs with e-bike rentals/demos had the highest average rated effectiveness (4.4), followed by educational programs (3.9), other (3.2), financial incentives (2.8), and cycling policies (2.8). Government agency promotion most often took the form of general cycling promotion policies, whereas retailers and cycling coalitions held educational events and implemented financial incentives that more specifically targeted e-bike use.

To examine perspectives on the potential of specific policy interventions, respondents were asked to rate the effectiveness of various measures on a five-point Likert scale from highly ineffective (1) to highly effective (5) ("How effective do you think the following…could be in increasing e-bike usage"). Figure 7 summarizes those responses with average perceived effectiveness by stakeholder type. General cycling infrastructure improvements were broadly seen as effective measures across all stakeholder types. Strategies that specifically target e-bikes such as incorporating e-bikes in bike-share systems and increasing public e-bike charging stations were scored as slightly less effective. These results are consistent with the perceived barriers presented above.

Other than infrastructure strategies, all stakeholder types responded that allowing tax exemptions for e-bike purchases was an effective strategy. This result aligns with the high perceived barrier of e-bike purchase costs. Every stakeholder type perceived promotional programs, events, and materials to be more effective than e-bike training. For security measures, all stakeholder types perceived publicly available bike lockers to be more effective than implementing anti-theft policing programs.

Regarding differences among stakeholders, manufacturers saw less potential benefit from charging infrastructure and more potential benefit of anti-theft programs than others, consistent with their greater concern about theft (Figure 6). Interestingly, other stakeholders expected greater effectiveness of including e-bikes in plans than government agencies (possibly because of a lack of familiarity with the planning process). Government agencies were less optimistic about the effectiveness of almost all the strategies than other stakeholders (with the sole exception of increased charging stations).

Discussion

Points of alignment and misalignment in e-bike perspectives among surveyed stakeholders are summarized in Figure 8, based on a qualitative generalization of the results presented above. There was alignment among stakeholders in the perception that e-bike adoption will continue to increase in BC under the current policies, programs, and infrastructure, and that it will attract a wider diversity of cyclists. Still, lack of adequate riding facilities was seen as one of the largest barriers to e-bike

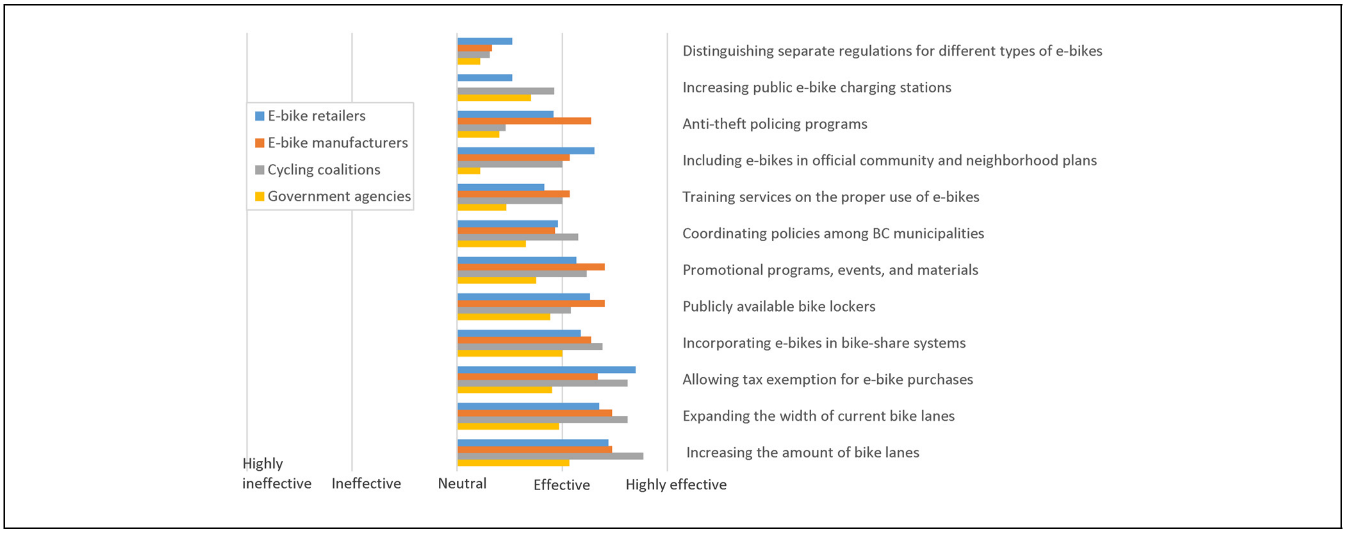

Figure 7. Perceived effectiveness of e-bike interventions, averaged by stakeholder type.

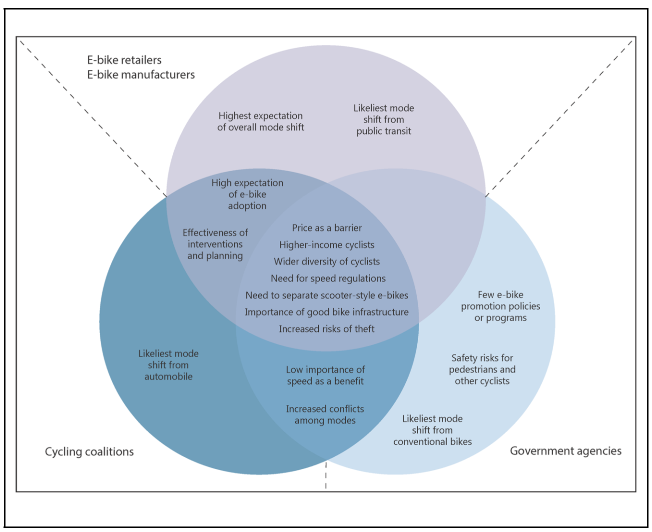

Figure 8. Summary of key alignments and misalignments in perceptions among stakeholders.

adoption, and potentially the most effective strategy for increasing adoption. Purchase cost was also broadly seen as a barrier to adoption, with cost-reduction strategies as a potentially effective approach to increase adoption.

Another area of alignment was the perception of scooter-style e-bikes as separate from all other types. Most respondents identified scooter-style e-bikes as an e-bike type that should be regulated separately from conventional bicycles. There was also stronger support for licensing and age restrictions for scooter-style e-bikes than other types. In an open comment section to identify any other regulations seen as important for e-bike adoption, 8% of responses highlighted the need to separate scooter-style e-bikes from other e-bike types (for example, by prohibiting scooter-style e-bikes from using bicycle riding or parking facilities). It seems that the lack of required pedaling was the dominant feature to distinguish a separate vehicle type (even more than the shell of the enclosed pedal-assist e-bike).

While nearly all stakeholders were supportive of regulating pedal-assist e-bikes the same as conventional bicycles, there was less agreement about other types. Manufacturers and cycling coalitions were most supportive of treating e-bikes the same as conventional bicycles (and allowing them on bicycle and pedestrian facilities), while retailers and government agencies were least supportive. Government agencies were also most concerned (and manufacturers least concerned) about conflicts with and risks to other road users.

A notable area of misalignment among stakeholders was the difference in expected mode shifts; retailers, manufacturers, and cycling coalitions viewed shifts from public transit and automobiles as most likely, while government agencies saw shift from conventional bicycles as most likely. Mode shift is a crucial question for evaluating e-bike benefits, and these findings reflect generally greater optimism about e-bike benefits from industrial stakeholders than government agencies. Past research suggests mode shift varies greatly by country and context, with higher automobile mode substitution in car-dominated countries like Canada and the United States (*4*, *20*).

Comparison to E-Bike User Perspectives

Research conducted by Dill and Rose provides a comparison of the perspectives of e-bike users in Portland, Oregon (a city with similar cycling levels to Vancouver) (*9*). There is some alignment in the perceived benefits of e-bikes for users between the industry stakeholders in this study and the surveyed users from Portland. Surveyed riders in Portland indicated a "limited ability to ride a conventional bike, either because of age or because of health factors." In addition, some respondents indicated using direct routes that had more hills with their e-bikes. These benefits align with the highest-rated perceived benefits of e-bikes for users among the industry stakeholders in this study. The potential of e-bikes to facilitate a more diverse array of cyclists was also recognized by both riders in Portland and stakeholders in this study.

Regarding promoting e-bike adoption, users in Portland suggested that general cycling promotion should be implemented, rather than strategies specifically targeting e-bikes (*9*). This also aligns with industry stakeholder perspectives of rating general cycling improvements among the most effective strategies to increase adoption. Wolf and Seebauer support this notion in recommending that "any dedicated e-bike campaign should equally target bicycling in general" (*12*).

An area of misalignment between e-bike users and the surveyed stakeholders was the perception of speed benefits. The interviewed e-bike users regarded increased speed as an important positive factor (*9*). One-third of respondents indicated that e-bikes "allowed them to travel more like they travel with a motor vehicle." Another study found that avid cyclists were more confident on mixed-traffic roadways when riding an e-bike because they were able to travel "at higher speeds and blend with the flow of traffic" (*21*). In contrast, the surveyed industry stakeholders perceived higher speed as the least important benefit of e-bikes, and broadly supported speed regulations. The concern over potential conflicts with other road users is also related to higher e-bike speeds compared with conventional bicycles. The difference in perspectives could be a challenge for developing e-bike regulations that address industry concerns with speed without reducing the attractiveness of e-bikes to potential users. The manufacturers were most aligned with users with respect to perceptions of speed benefits, likely because they are exclusively serving an e-bike market, whereas most of the other stakeholders engage in both conventional and e-bike activities.

Recommendations for E-Bike Policy

Recommendations are made in three areas: infrastructure, incentive programs, and regulation. Firstly, cities that wish to promote e-bike use must develop their general cycling infrastructure. Bicycle riding and parking facilities were broadly seen as important areas for e-bike promotion. Moreover, dedicated cycling facilities can help mitigate concern over conflicts with pedestrians by separating the modes. Wide, high-quality riding facilities can also help mitigate conflicts between e-bikes and other cyclists who may be travelling at slower speeds.

E-bike incentive programs should aim to mitigate the purchase cost barrier for e-bikes. These incentives could take the form of eliminated or reduced sales taxes, retail discounts, rebates, or inclusion of e-bike travel in commuter benefit/reimbursement programs. In addition to reducing cost barriers, simple public education is a well-regarded strategy by stakeholders, with rental/demo and education programs ranked as the most effective of existing programs. This outcome reflects that e-bike users are still early adopters in BC, and general public familiarity with them is low. In comparison with the other recommendations, these programs pose the least barrier to implementation as the survey showed effective programs are already being implemented by retailers and manufacturers, which can be increasingly adopted as the e-bike market continues to grow. In addition, these programs do not require policy or regulatory changes which can take longer to implement.

The results indicate a need to revise current e-bike regulations in BC, at a minimum by removing scooter-style e-bikes from the same category as pedal-assist e-bikes. There is also industry support for finer categorization of e-bikes based on size and throttle. The general alignment of perspectives on regulations among retailers, manufacturers, cycling coalitions, and government is important for implementing effective policy changes. Scooter-style e-bikes could be re-classified as limited speed motorcycles, instead of motor assisted cycles, which would activate licensing and registration requirements. However, limited speed motorcycles have a maximum speed of 70 km/h in BC, much higher than maximum speeds of scooter-style e-bikes of 32 km/h (*15*). This speed difference could create new safety issues if scooter-style e-bikes are only allowed to operate on facilities shared with much faster motor vehicles. The re-classification may also impact the e-bike market if added regulations deter potential adopters only interested in scooter-style e-bikes.

Further discrimination of e-bikes types would allow more tailored regulation of maximum speeds (commensurate with the mass and potential crash severity of each vehicle type) and which facilities they are allowed to operate on (to separate road users with significantly different sizes and speeds). For example, past research in China recommended varying e-bike speed limits on different types of facilities (*22*). Further research on the perception and safety of different types of e-bikes is necessary, particularly as new forms of e-bikes (such as enclosed electric recumbent tricycles) become more prominent.

Limitations and Future Work

The first limitation to acknowledge is the limited scope of this study, which only included stakeholders in British Columbia. At 31% the overall response rate was good, but the sample size was 116 and, as in any survey, a larger sample would have improved the study. This sample size would be small for a survey of users, but as a survey of industry organizations, it is considered sufficient and representative of the population of interest. Still, it was not large enough to develop a statistical model of stakeholder perceptions and perspectives, which would have added another facet to the results and help refine the findings.

Response bias is always a concern in these types of surveys. Strategic responding, in particular, could have been an issue for e-bike manufacturers and retailers concerned about possible government policy changes or interventions. The survey was completed by individuals within these organizations, and so the responses do not necessarily reflect their official positions. Framing effects of question wording were also not tested within the survey, although it is not expected that these would vary substantially among stakeholder types.

Foxon defines a co-evolutionary framework for transitions to sustainable practices with interactions among "ecosystems, technologies, institutions, business strategies and user practices" (*23*). Within this framework, previous work has focused on the technology–user dimensions, while this study examined the institutional and business dimensions for a broader understanding of how e-bikes are integrated into transportation systems. Future work should examine the two-way causality of these relationships, in particular the influence of institutional and business perspectives and practices on the development of e-bike technology. For example, adopted policies and regulations will influence the e-bike market in addition to usage of e-bikes.

The results are only directly applicable to the study context (BC), and transferability to other parts of North America are uncertain. Industry perspectives on other continents are likely different, particularly in Asia where the e-bike market is more mature. Further research should explore stakeholder perspectives in other locations. Another key research need is for e-bike sales and usage data by type. Limited information on e-bike adoption is available, and almost none of the data are segregated by e-bike type. Given the substantial differences in perceptions of e-bike types found here, there is clearly a need for more differentiated data. Future work could also investigate e-bike perceptions at an individual level, instead of the stakeholder level used here, using a survey designed for principal components analysis, for example. This study provides a representative portrait of industry perspectives on e-bike adoption in BC, and insights that can help develop strategies to accommodate and promote e-bikes in Canadian cities.

Acknowledgments

Support from the Social Sciences and Humanities Research Council (SSHRC) of Canada (Grant 430-2016-00019) is gratefully acknowledged. Four anonymous reviewers provided helpful comments to revise the manuscript.

Author Contributions

The authors confirm contribution to the paper as follows—study conception and design: AB, SA; data collection: SA; analysis and interpretation of results: SA, AB; manuscript preparation: SA, AB. All authors reviewed the results and approved the final version of the manuscript.

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The Standing Committee on Bicycle Transportation (ANF20) peer-reviewed this paper (19-00466).