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Exploring commonalities and disparities of seattle residents' perceptions on dockless bike-sharing across gender

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ABSTRACT

In recent years, dockless bike-sharing programs have been introduced to either substitute or complement docked bike-sharing programs. Riders of these devices always have perceived differences of one system over the other, which could vary across gender. This study applied a text network approach to explore the residents' perceptions of the dockless bike-sharing program across gender. The study used over 700 responses collected between February and March 2018 in Seattle, Washington. The results revealed that ease of use, convenience, safety, pricing, and quality areas make a tremendous difference in the perception of dockless over docked bike-sharing systems. The perception of ease of use and convenience does not vary significantly across genders. On the other hand, male respondents were more aligned on the better pricing scheme and the bikes' quality than female respondents. Conversely, female respondents did care more about safety in terms of helmet use. Moreover, female respondents were more explicit in explaining the negative characteristics of the dockless bike-sharing system over docked ones. Study findings can help policymakers and operators of dockless bikes to provide equity in service for both genders.

1. Background

Bike-sharing programs are designed for trips that are short to drive and long to walk. Like any other shared micro-mobility device, users check out and return bikes at a designated location. Primarily, two operating models of bike-sharing programs-docked and dockless, do exist. The docked bike-sharing system is the oldest model by which a user is required to checkout and return a bike at a designated docking station. For this model, operators primarily optimize docking stations' locations, considering a trade-off between the serviceability of the maximum demand and rebalancing costs. The preferred locations for docking stations are near train/bus stations, college campuses, and downtown (Boniphace Kutela & Teng, 2019; Shaheen, Guzman, & Zhang, 2010).

The docked bike-sharing systems have several challenges, including the overflow of docking stations, rebalancing, and repositioning, among others. As a result of these challenges, a dockless bike-sharing system was established originally in China, then Singapore, the United States, the Netherlands, and other areas across the world (Mooney et al., 2019; Shen, Zhang, & Zhao, 2018). The availability of dockless bike-sharing systems has significantly affected people's everyday mobility due to the easiness of picking up and dropping within a defined area (Boniphace Kutela, Langa, et al., 2021; Peters & MacKenzie, 2019). However, residents are not very impressed with the way dockless bikes are operated, especially the blockage of sidewalks and less usage of helmets (Boniphace Kutela, Langa, et al., 2021).

It has been long known that there are differences in preferences across gender for several transportation aspects, including travel behavior, general and recreational cycling, and docked bike-sharing usage (Beecham & Wood, 2014; Fishman, Washington, Harworth, & Mazzei, 2014; Gordon, Kumar, & Richardson, 1989; Heesch, Sahlqvist, & Garrard, 2012; Lusk, Wen, & Zhou, 2014; Murphy & Usher, 2015;

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Wang & Akar, 2019). A study by Wang and Akar (2019) evaluated the factors associated with the gender gap in cycling using the Citi Bike-sharing system data. The study used a logistic regression model to associate the gender gap and other predictors. They found that installing more bicycle racks increased ridership for female riders than males by about 1.18%. Some other studies explored the gender association in bike-sharing programs and other cyclists (Beecham & Wood, 2014; Fishman et al., 2014; Murphy & Usher, 2015). The findings of a study in Dublin showed that women accounted for merely 22% of docked bike-sharing users (Murphy & Usher, 2015). However, the study did not provide the possible reasons for such a low riding rate. A study of Australian bike-sharing programs Fishman et al. (2014) found that 23% and 40% of the docked bike-sharing annual members for Melbourne and Brisbane, respectively, were women. The findings justified that gender diversity applies to bike-sharing schemes but did not elaborate on the perspective of each gender towards the two types of bike-sharing schemes. Contrary to Fishman et al. (2014), a study by Buck et al. (2013) in Washington DC revealed that Capital Bikeshare riders are more likely to be women. Besides, previous research Beecham and Wood (2014) analyzed over 10 million journeys made by participants of London's Cycle Hire Scheme. The study suggested that female users of London's Cycle Hire Scheme engaged more in recreational cycling (such as visiting parks) than commuting travel, whereas men use it for commuting purposes. A similar finding on the use of bikes for recreational purposes among female riders was reported by another study in Baltimore, Maryland (Nickkar, Banerjee, Chavis, Bhuyan, & Barnes, 2019).

A few studies have linked dockless bike-sharing systems and gender (W. Li, Tian, Gao, & Batool, 2019; Ma, Cao, & Wang, 2019; Murphy & Usher, 2015). W. Li, Zhang, Ding, and Ren (2019) analyzed the effects of the dockless bike-sharing system on the public bike-sharing system at the user and station levels. Among other findings, the study reported that trip duration for the dockless bike-sharing system was not significantly affected by gender differences. Another study showed that female respondents were open to using dockless bikes compared to male respondents (Hirsch, Stewart, Ziegler, Richter, & Mooney, 2019). The same group of respondents was also familiar with and had positive opinions on dockless bikes. Conversely, a survey-based study by Sherriff, Adams, Blazejewski, Davies, and Kamerāde (2020) reported that similar to males, females are likely to be interested in using dockless bikes but are deterred from using them. However, the study did not describe the specific details of the bike quality that was assessed. Regarding the quality of the dockless bike-sharing program, a previous study conducted in China reported no statistically significant difference in ratings across gender (J. Liu, 2020).

It can be observed that there is scarce literature that focused on both dockless and docked bikes across gender. Further, none of the previous studies has compared either utilization or perception of dockless and docked bikes across gender. However, the two systems differ significantly in terms of their advantages and disadvantages (Boniphace Kutela, Langa, et al., 2021; Peters & MacKenzie, 2019). Besides, previous studies were based on either actual ridership data (Beecham & Wood, 2014; Fishman et al., 2014; W. Li, Tian, et al., 2019; Lusk et al., 2014; Murphy & Usher, 2015; Wang & Akar, 2019) or survey data (Sherriff et al., 2020) to attain their objectives. While the use of actual ridership data provides better service utilization estimates, these ridership data are generally not available at the planning stage. On the other hand, the survey questionnaires have typically been prepared to collect structured data, which does not provide the respondents' flexibility to express their views. Currently, the advancement in text mining techniques has opened an alley for exploring unstructured data (Das, Sun, & Dutta, 2016; Boniphace Kutela, Langa, et al., 2021). For example, one recent study that used unstructured text data to evaluate the public perception of bike-sharing systems found several insights that could not be determined using closed-ended survey data (Boniphace Kutela, Langa, et al., 2021). However, the study did not evaluate whether the perceptions differ across genders.

1.1. Study objective and contribution

Our study explores the differences in perceived characteristics of dockless over docked bike-sharing systems across genders, using Seattle residents as a case study. Our findings can be used by operators, policy makers, and researchers. While policymakers normally develop policies that apply to the entire community, their effectiveness may vary significantly across genders. Thus, it is imperative for bike-sharing operators and policymakers to understand the influence of gender on the perception of the services they provide to tackle gender-specific setbacks that would hinder the smooth running of the program. These gender-specific attributes can be on the pricing scheme, convenience, accessibility, as well as safety. A smooth-run dockless bike-sharing system is advantageous to the operators and the city as it showcases a better image of the city. On the other hand, a failed run dockless bike-sharing system destroys the image of the city as scattered and uncontrolled bikes can turn into a source of environmental pollution. Further, the body of literature will benefit from the added findings from this study as it applied a unique approach to exploring the commonalities and disparities of perceived characteristics of dockless bike-sharing systems. To avoid generic words that do not provide flexibility to the respondents to express their perceptions, this study utilizes narratives written by the respondent in their own words when responding to the open-ended questions.

This study contributes to the body of literature by extensively evaluating the disparities and commonalities perception of dockless bike-sharing across genders. Currently, there is a growing need to understand and promote gender equity in various initiatives. However, to our best knowledge, none of the existing studies have investigated this topic and provided practices to address equity in bike-sharing systems focusing on genders. More specific, the use of natural language processing tools to understand the users perceptions has not been well applied. Our findings indicate that regardless of the gender, ease of use, convenience, safety, pricing, and quality areas are the main topics that have been extensively discussed. Both gender found that dockless bikes are easy to use, while male respondents were more aligned on the better pricing scheme and the bikes' quality than female respondents. On the other hand, female respondents put forward safety as indicated by insisting on the helmet use. These findings can be used to set policies that would yield more benefit to women to encourage them to participate in the emerging mobility options such as dockless bikes. The remaining section of the manuscript covers methodology followed by results and discussion. The conclusion and future work are then presented in the last section.

2. Methodology

This section discusses the nature of the data used in this study and the analytical approaches. It was essential to put forward the data description to guide the reader on the reason to apply the data analysis methodologies.

2.1. Study data

This study uses Seattle residents' views about various characteristics of dockless bike-sharing systems (Spin, LimeBike, and Ofo) compared to the docked system (Pronto). Seattle experienced both dockless and docked bike-sharing systems at two different periods. The docked bike-sharing system branded as Pronto started operating in October 2014 and ended its operations in March 2017. It had a total of 50 stations and about 500 bikes (Sun, Chen, & Jiao, 2018). Users were supposed to pick up and drop off bikes at one of the docking stations. On the other hand, a dockless bike-sharing program that constitutes Spin/LimeBike and Ofo started operating in 2017. The system started with 1000 bikes which grew up to 2000 within a week (Kroman, 2017). Being dockless bikes, users may pick up and leave bikes within the geofenced area defined by operators.

The study uses data collected by Peters and MacKenzie (2019) between February and March 2018. A total of 773 responses were collected through several online platforms, including the University of Washington (U.W) Today, U.W. News, the Seattle Bike Blog, and various social media platforms. Readers are referred to Peters and MacKenzie (2019) for a detailed discussion on the approach used to collect the data. The residents in Seattle experienced both bike-sharing systems at two different times. The docked bike-sharing program (Pronto) operated between 2011 and 2014, while the dockless bikes started running in 2017. While dockless bikes are thriving, the docked bikes' operations failed and were terminated.

Peters and MacKenzie (2019) evaluated the reasons for the fall and rise of the two bike-sharing systems in Seattle; however, the study did not focus on gender differences and did not use unstructured data. In addition to the closed-end questions, we analyze the survey questions where respondents had the freedom to explain their views regarding what worked well and what did not for dockless bike systems. The five closed-end questions regarding the use of dockless bike-sharing that were analyzed are.

1. What is your gender? (Male, Female)
2. Did you ever use Pronto Bike Share? (Yes, No)
3. Have you used dockless bike share in Seattle (Spin, LimeBike, ofo)? (Yes, No)
4. To what degree do you find dockless bike share in Seattle (Spin, LimeBike, ofo) easy to use? (Easy, slightly easy, neutral, slightly difficult, difficult)
5. Do you wear a helmet when you ride dockless bike share in Seattle (Spin, LimeBike, ofo)? (Always, sometimes, never, I haven't ridden)

Furthermore, the two exact open-ended questions that we analyze are.

1) Why do you think that dockless bike-sharing companies in Seattle (Spin, LimeBike, Ofo) are doing better than Pronto?
2) Why do you think that dockless bike-sharing companies in Seattle (Spin, LimeBike, Ofo) are doing worse than Pronto?

We present the relevant summary statistics of the demographic characteristics of 740 (327 female and 413 male) respondents in Table 1. The statistics are grouped into two major groups by gender. Three demographic characteristics-income, generation, and race were of interest. The income was divided into four groups: low income (up to $49,999), middle income ($50,000-$99,000), upper middle income ($100,000-$149,000), and high income (above $150,000). For all income categories except low income, males have a higher proportion of the observations than females. Male respondents with high incomes have the highest proportion of observations (60.6%). On the other hand, female respondents with low income have a higher proportion of the observations (51.3%) than males (46.1%). In terms of the generation of the respondents, millennials (36 years or younger) and generation X (37–52 years) have a relatively large proportion of respondents compared to the baby boomers (53 years and above).

The different lifestyles of these generations can affect their usage of and perceptions towards different bike-sharing systems. Considering age, males from generation X and millennials have a higher proportion of the observations than females. On the other hand, female baby boomers have a slightly higher proportion of the observations (48.4%) than males (47.8%). Furthermore, males who are not white by race have a higher proportion of the observations (55.2%) than females (39%). Similarly, white males have a higher proportion of the observations (53.8%) than females (45%).

2.2. Data analysis approaches

In this study, two approaches-descriptive analysis and text mining are utilized. The descriptive analysis is used on the closed-end questions to understand the perception of the users, which vary by gender. On the other hand, a text network is used for the two open-ended questions to supplement the understanding of the perceived characteristics of dockless bikes across gender.

2.3. Descriptive analysis

The descriptive analysis involved comparing the frequency distribution of the ease of use of dockless bikes and the stated helmet use across gender. The histograms are used to compare the distribution of the two aspects across gender.

2.4. Text network analysis

Text network analysis is a branch of text mining that uses nodes and edges to uncover hidden relationships in unstructured data (Yoon & Park, 2004). It is a relatively new method in the transportation engineering field. Notably, a few studies have utilized text networks for micro-mobility studies (Boniphace Kutela, Das, & Dadashova, 2021; Boniphace Kutela, Langa, et al., 2021), safety and operations (Boniphace Kutela & Teng, 2021; Kwayu, Kwigizile, Lee, Oh, & Oh, 2021), and review analysis (Jiang, Bhat, & Lam, 2020).

The text network analysis involves four major steps, which are i) normalization of text, ii) transformation from unstructured to structured

Table 1
Demographic characteristics of the respondents.

Variables	Overall	Male		Female		No response	
		Count	Percent	Count	Percent	Count	Percent
Income							
Low	115	53	46.1	59	51.3	3	2.6
Middle	201	110	54.7	86	42.8	5	2.5
Upper Middle	148	76	51.4	70	47.3	2	1.3
High	203	123	60.6	76	37.4	4	2.0
No response	105	51	48.6	36	34.3	18	17.1
Generation							
Baby boomers	159	76	47.8	77	48.4	6	3.8
Generation X	269	149	55.4	108	40.1	12	4.5
Millennial	320	178	55.6	138	43.1	4	1.3
No response	24	10	41.6	4	16.7	10	41.7
Race							
White	613	330	53.8	276	45.0	7	1.1
Non-White	105	58	55.2	41	39.0	6	5.7
No response	54	25	46.3	10	18.5	19	35.2

data, iii) generation of nodes and links, and iv) development of quantitative indexes for in-depth analysis (Kim & Jang, 2018; Boniphace Kutela, Magehema, Langa, Steven, & Mwekh'iga, 2022; Paranyushkin, 2011; Yoon & Park, 2004). The first two steps are common for almost all text mining approaches. They involve removing all the connecting words, converting all capital letters to lowercase letters, and creating a corpus of text, which is structured data. The third step, which is unique for text networks, involves network creation. In this step, the corpus of text is transformed into a matrix of co-occurred keywords, which are then plotted. During plotting, the two keywords that appear for the first time are recorded as new nodes and are connected by an edge. The algorithm then continues searching for additional two consecutive keywords. If the two words appear, the algorithm first checks if one of the keywords exists. If it does not exist, the algorithm sets a new node with a new edge, but if one keyword exists, the algorithm adds the other keyword and the new edge.

The *nodes* are also referred to as *clusters*, representing the keywords of interest, while *edges* represent the keywords' co-occurrence. A group of connected nodes with similar patterns is referred to as a *community*. The size of the node corresponds to the frequency of the keyword, while the frequency of co-occurrence of the clusters is represented by the thickness of the edge between the clusters. Fig. 1 illustrates key components – *nodes* and *edges* – that make the text network.

The node with the highest number of edges, which connects to other nodes within the same community, is said to have the highest *degree of centrality* (Kim & Jang, 2018). The higher the co-occurrence frequency of keywords, the higher the weight of the connecting edge (Paranyushkin, 2011).

After the network is complete, the final step involves extracting the quantitative indexes to perform an in-depth analysis for making decisions (Yoon & Park, 2004). In this study, the analysis is based on three performance metrics of the network, which are keyword frequency, collocation analysis, and *degree centrality (D)*. Degree centrality measures the connectedness of one node to others. Such connectedness indicates that the node has a strong influence within the network (Kim & Jang, 2018; Paranyushkin, 2011; Punel & Ermagun, 2018). Degree centrality is computed as the sum of edges that originate from the node (refer to Equation (1)).

$$D(i) = \sum_{j=1}^{l} c_{ij} \tag{1}$$

whereby, c_{ij} takes a value of 1 if nodes i and j, are connected, and 0 otherwise.

In addition to the keywords co-occurrences, keywords collocations play a great role in drawing insights from the text network. Contrary to keywords co-occurrences, the keywords collocations analysis deals with the adjacent keywords (Blaheta & Johnson, 2011; Boniphace Kutela, Novat, Adanu, Kidando, & Langa, 2022). Moreover, the keywords collocations analysis helps in determining the associations between the keywords. The association between the collocations is determined using the association coefficient (λ) and the Wald test statistic (z) as detailed in previous studies (Benoit et al., 2018; Blaheta & Johnson, 2011).

The analysis was performed in the R 4.0.2-environment (R Core Team, 2020) using the *quanteda* and *igraph* packages (Benoit et al., 2018; Csárdi, 2020) for creating the text network and extracting the network performance parameters. Since the analysis results in large networks, only the top 50 keywords for interpretations.

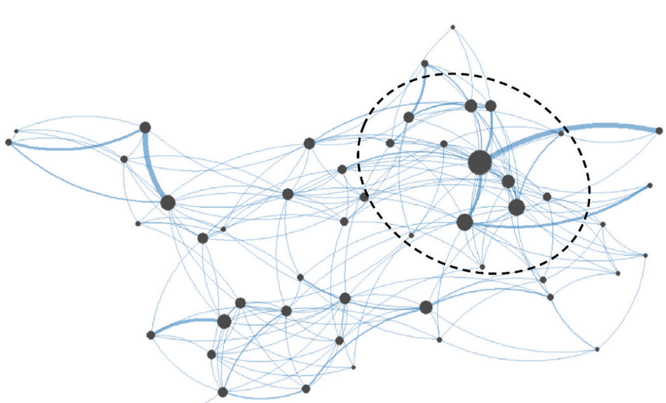


Fig. 1. A conceptual skeleton of the text network (B. Kutela, Novat, & Langa, 2021).

3. Results and discussions

This section presents the results and discussions of the descriptive analysis and text networks of open-ended questions across gender. The descriptive analysis results intended to portray the general feel of the perceived characteristics of the bike-sharing systems. Further, the discussion of text network results considers only the top 40 keywords since low-frequency keywords do not give many insights. The discussion of the results is divided into two, i.e., positive and negative perceptions. In each group, the contrast between male and female perceived characteristics of the dockless over the docked bike-sharing system is made.

3.1. Descriptive analysis results

The descriptive analysis focused on the four closed-end questions. The first two questions were intended to understand the variation in the level of utilization of bike-sharing systems across gender. On the other hand, the other two questions focused on the perceived ease of use and safety consciousness. Fig. 2 presents the distribution of bike-sharing experience across the two types of bike-sharing systems (docked and dockless) and gender. It can be observed that a high proportion of respondents (40.6%) have used dockless bikes only. Amongst, 22.4% are male, and 18.2% are female respondents, leaving about 4% who did not disclose their gender. A similar distribution across gender is observed on the experience with both docked and dockless bike-sharing systems. Contrary to that, a high percentage of females have had experience with docked only (1.8%) than males (1.2%), but the difference is minimal (0.6%). Also, most females had no experience in any type of bike-sharing system (16.8%) compared to males (13.8%), making a gap of 3%.

Regarding the ease of use of dockless bikes, Fig. 3 shows that both males and females perceived that dockless bikes were easy to use as revealed by the high proportion of respondents who selected either easy or slightly easy.

For the two categories, the proportion of male respondents is relatively higher than that of female respondents. On the other hand, the proportion of female respondents is higher for either neutral, slightly difficult, or difficult. However, the overall percentage difference is relatively small.

Another aspect of interest was the helmet use for dockless bike riders. Studies indicate that helmet use can reduce the risk of head injury (Robinson, 1996; Thompson, Rivara, & Thompson, 2001). Thus, it is assumed that people who wear helmets are safety conscious as they have a better understanding of the importance of helmets on their safety. Fig. 4 shows that a large proportion of respondents did not use helmets. Across gender, male respondents comprise the large proportion of riders who never use helmets. This observation is backed up by other survey studies that suggested that most male riders feel uncomfortable wearing helmets (Skalkidou, Petridou, Papadopoulos, Dessypris, & Trichopoulos, 1999). Further, about the same proportion of males and females did sometimes use a helmet. On the other hand, most female respondents showed that they always used helmets.

The descriptive statistic results indicated that, in general, residents considered dockless bikes as easy to use. Furthermore, a gap in helmet usage across gender is observed. About 48% of male respondents never use helmets, while only 32% of female respondents did the same.

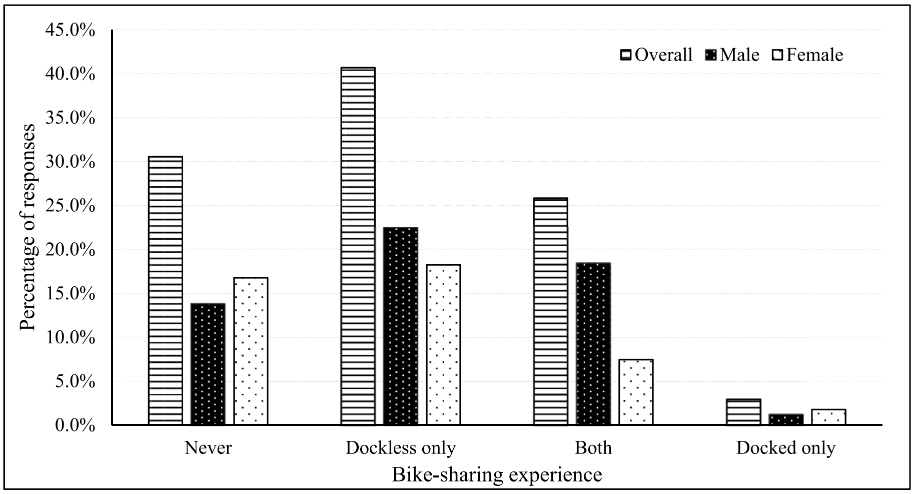


Fig. 2. Bike-sharing experience across gender.

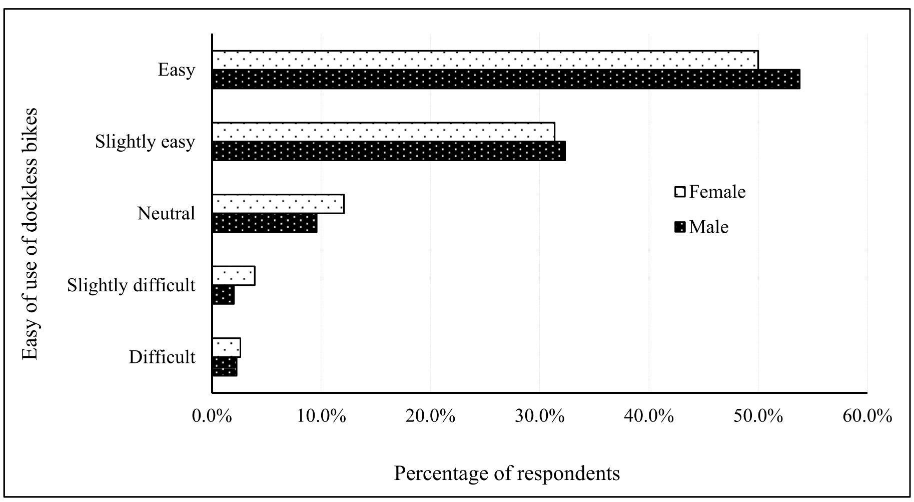


Fig. 3. Ease of use of dockless bikes across gender.

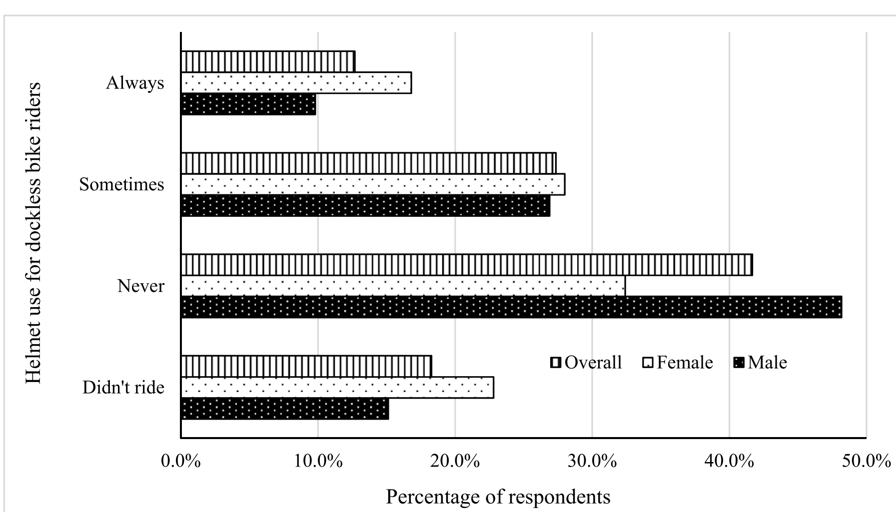


Fig. 4. Helmet use for dockless bike riders across gender.

However, respondents did not have an opportunity to provide more details on their selections. Thus, it was necessary to utilize text-mining approaches to understand the detailed responses. The following section presents the text network results and discussions.

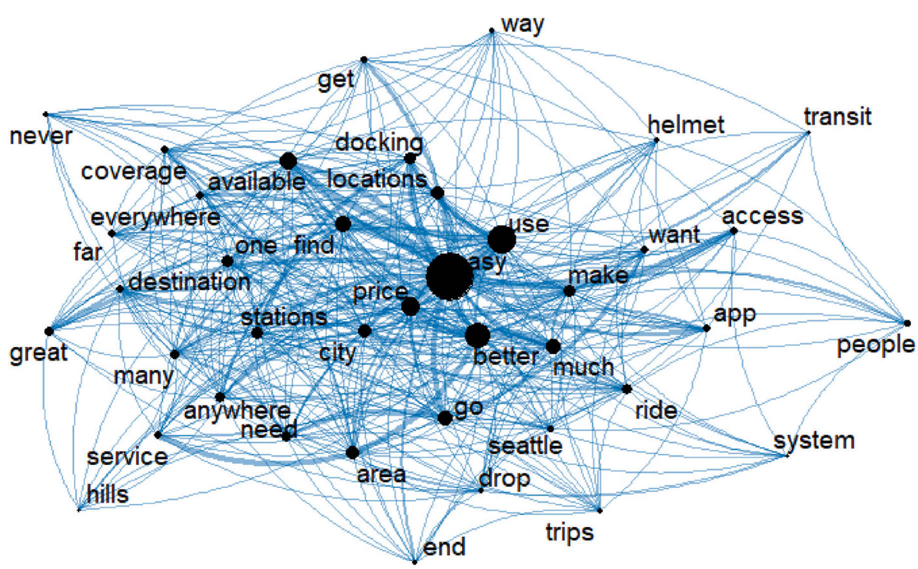
3.2. Text network analysis results

The text network results cover two aspects-the positive and negative characteristics of the docked bike-sharing systems. For both aspects, the similarities and differences across gender are discussed. To get consistent results, only comments from respondents who have experienced either dockless bikes, docked bikes, or both systems were used.

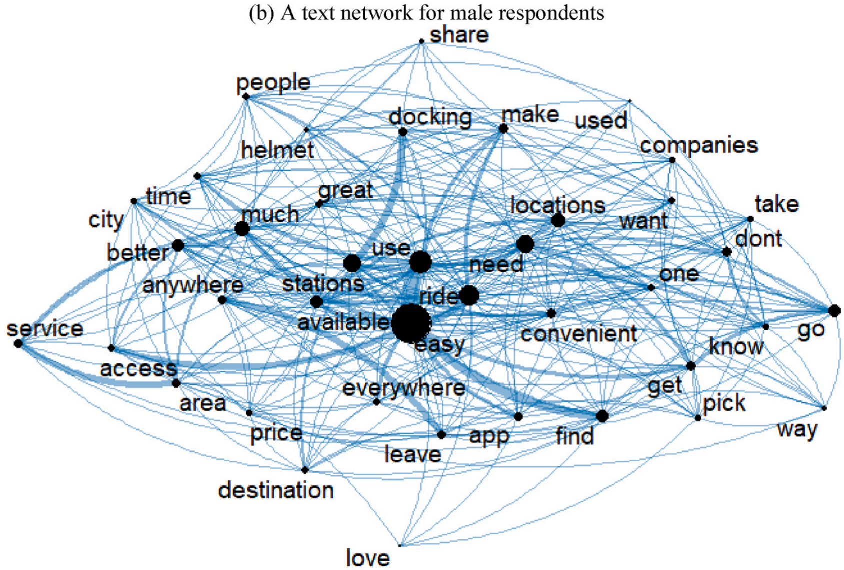
3.3. Perceived positive characteristics of dockless bikes across gender

Fig. 5 and corresponding Table 2 show the text network and the associated performance metrics for the perceived positive characteristics of the dockless bikes by male and female respondents. Several similarities and differences can be deduced across the gender. The major topics discussed by the respondents are ease of use, convenience, and safety. Both female and male respondents consider dockless bikes as easy to use and find. The observations can be deduced from the central keyword *easy* for both networks. This keyword appears more frequently for both networks, as indicated by keyword frequencies in Table 2.

According to the results in Table 2, the keyword *easy* appears 77 times from 68 male respondents and 60 times from 50 female respondents. The keyword *easy* is strongly linked to keyword *use* for both networks. The top collocated keywords for both networks are *easy use* as shown in Table 2. For instance, one of the respondents wrote, "*Because are extremely easy to use because have because you go to any destination not docking and are easy to find*". Other studies had similar findings (Ai et al., 2019; Ma et al., 2019; Shen et al., 2018). The convenience of dockless bikes is deduced from several keywords, including *available, everywhere, anywhere, docking, station, find, destination, service area, access, and locations*. 43 out of 347 male respondents praised dockless bikes as *available*, while 31 out of 289 female respondents did the same. Similarly, the keyword *anywhere* was mentioned by 23 out of 347 male respondents and 16 out of 289 female respondents. Respondents from other survey studies expressed their preference for dockless bikes based on their locational availability (Boniphace Kutela, Langa, et al., 2021; M.



(b) A text network for male respondents



(b) A text network for female respondents

Fig. 5. Text networks for perceived positive characteristics of dockless bikes by gender.

Table 2
Network metrics for perceived positive characteristics of the dockless bikes by gender.

Rank	Text Network Metrics for Male Respondents								
	Frequency			Degree centrality		Collocation			
	Keyword	Score	Respondents	Keyword	Score	Keyword	Count	μ	Z-score
1	easy	77	68	easy	36	easy use	25	3.56	10.93
2	use	46	44	use	36	easy find	14	3.74	8.28
3	available	44	43	price	34	much better	9	3.84	8.14
4	better	41	34	better	34	service area	9	6.25	8.12
5	locations	36	36	find	30	leave anywhere	7	5.26	7.61
6	price	31	31	stations	29	docking stations	6	3.82	7.10
7	stations	26	26	available	29	easy access	9	3.51	6.69
8	anywhere	24	23	make	29	need go	4	3.89	6.24
9	docking	23	22	city	28	tied stations	4	5.03	6.11
10	find	23	23	one	28	coverage area	4	3.53	5.85

Rank	**Text Network Metrics for Female Respondents**								
	Frequency			**Degree centrality**		**Collocation**			
	Keyword	**Score**	**Respondents**	**Keyword**	**Score**	**Keyword**	**Count**	**μ**	**Z-score**
1	easy	60	50	easy	33	easy use	15	3.34	8.54
2	available	31	31	use	33	leave anywhere	7	5.03	8.01
3	use	30	28	ride	31	docking stations	10	5.96	7.90
4	ride	27	22	need	30	service area	7	6.99	7.72
5	locations	25	24	stations	26	much better	6	3.52	6.60
6	stations	23	21	locations	23	easy access	8	3.63	6.42
7	need	23	21	much	22	dont know	4	5.37	6.34
8	much	22	20	convenient	22	pick drop	3	5.39	6.30
9	better	21	20	available	21	never used	3	6.49	5.98
10	anywhere	16	16	find	21	leave wherever	3	4.79	5.86

*μ: association parameter; and z-value: the value of the Wald test statistic.

Liu & Xu, 2018, pp. 445–450). Furthermore, *leave everywhere, easy find, docking station,* and *easy access* are among the collocated keywords that occurred more frequently and have high z-scores (Bieliński & Ważna, 2018; Fuller, Waitt, & Buchanan, 2018). A relatively small number of respondents showed some safety consciousness. The keyword *helmet* in the text network underlines that several respondents were conscious of the helmet use for dockless bike riders. However, the absence of strong links to this keyword makes it difficult to provide meaningful interpretations.

Although the networks and associated performance metrics appear to be similar, several differences can be observed. One of the key differences between the networks is the pricing of the services of the dockless bike. It can be observed that male respondents perceived that dockless bikes were better priced than docked bikes. The observation can be deduced from the larger size of the keyword *price* in the male network compared to the female network. This keyword appears 31 times from 31 different male respondents (Table 2), while it appears less frequently in the female respondents' network. Another observed difference is the easy to ride and easy to find. The observation is deduced from the co-occurred keywords *easy ride* that is top-ranked in the female respondent network but rarely visible in the male network. Similarly, *easy find* collocated keywords are highly ranked for the male network but are not in the top ten collocated keywords for the female network.

3.4. Perceived negative characteristics of dockless bikes by gender

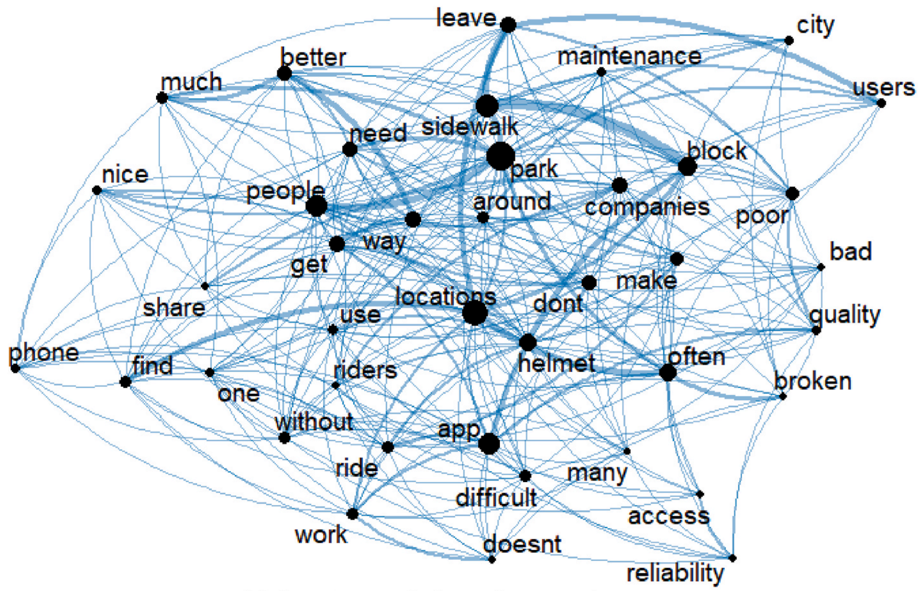
The text network shown in Fig. 6 and the associated performance metrics in Table 3 describes the perceived negative characteristics of dockless bikes by both gender groups. The two networks and the corresponding metrics depicted several similarities and differences.

The first perspective that both male and female respondents did not like about the dockless bikes is the way they are parked. Several keywords, co-occurred keywords, and collocated keywords were used to express this negative perception. The co-occurred keywords such as block sidewalk, leave sidewalk, leave everywhere, leave locations, People Park, and random locations were used to express dissatisfaction with the parking of dockless bikes. In fact, among the top ten keywords, four for male respondents and five for female respondents are directly linked to the parking of dockless bikes. A similar observation is revealed in the degree centrality scores, which shows that the parking-related keywords are strongly linked to other keywords. Other studies that justify this nuisance in their findings include (James, Swiderski, Hicks, Teoman, & Buehler, 2019; Schmidt, 2018).

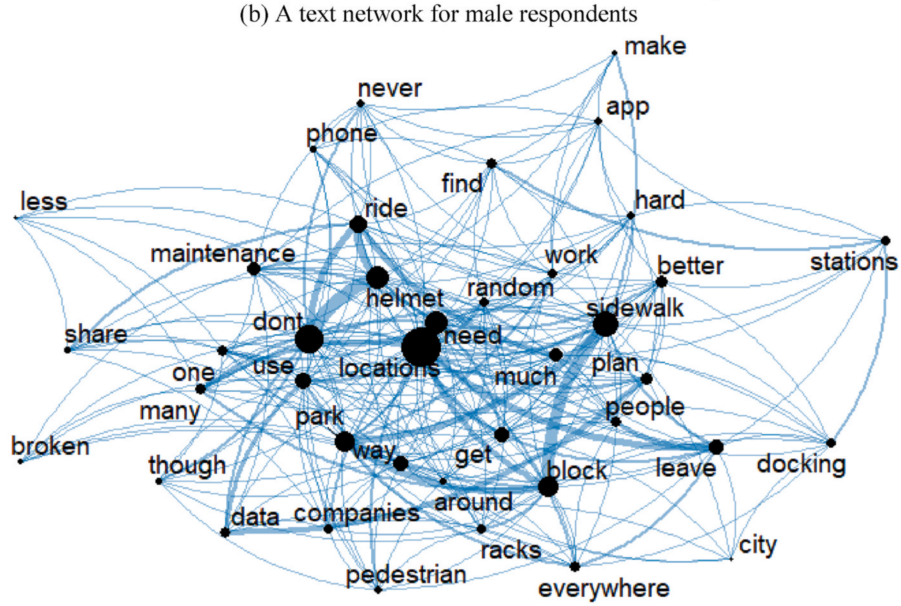
Safety in terms of helmet use is also one of the concerns that both females and males do share. The observation is indicated by the keywords *helmet* and the associated linked keywords such as *often, don't* and *need*, which shows that most of the time, the dockless bike riders did not wear helmets. The findings from the descriptive analysis support those from the text networks. Lastly, the phone apps used to unlock dockless bikes and the lack of maintenance were also common concerns for males and females. Other studies justify this finding by suggesting that some users are limited by the difficulties in using the ridership apps (Dudley, Banister, & Schwanen, 2019; Nikiforiadis, Chrysostomou, & Aifadopoulou, 2019).

Although the network and associated metrics look similar for both male and female respondents, several key factors differ across the genders. The *quality* and *reliability* of dockless bikes are observed in the male text network but not in the top keywords in the female network. The keywords such as *bad quality, poor quality, access, reliability,* and *often broken* suggest that male respondents cared more about the quality than female respondents. For instance, one respondent had the following comment on dockless-bikes- "*Lime are definitely the highest quality to be consistently broken when I use them*". Such a statement indicates that residents perceived that dockless are of better quality but are susceptible to malfunctioning. This limitation of broken and vandalized bikes is discussed by (Chen, van Lierop, & Ettema, 2020; H. Li, Zhang, et al., 2019). The authors propose sustainable ways to protect these devices, including constructing demarcating barriers at parking spots.

A comparison of the helmet-associated terms indicates that female respondents cared more about helmets than male respondents. 25 out of



(b) A text network for male respondents



(b) A text network for female respondents

Fig. 6. Text networks for the perceived negative characteristics of dockless bikes by gender.

413 male respondents mentioned the helmet, while 34 out of 327 female respondents mentioned the same term. Furthermore, "helmet available" appears more frequently in the collocation results for females than for males.

4. Conclusion and future work

Individuals' perceptions regarding the characteristics of bike-sharing systems are essential for planning and operation purposes of the bike-sharing system. These perceptions might differ across different demographic factors, including age and gender. The users' perceptions may also vary across different bike-sharing systems, i.e., docked vs. dockless. Further, people do differ in the way they express their concerns/excitement. Thus, the use of closed-end questions might not capture all the variations of the emotions. Thus, this study introduced the text network approach to elicit the perception of the dockless bike-sharing system in Seattle, Washington across respondent's gender. The text network approach provides more insights than the traditional approaches that use the frequency of keywords alone.

The descriptive analysis showed that irrespective of gender, dockless bikes are considered easy to use. Contrary to female riders, most male riders did not wear a helmet when riding dockless bikes compared to when riding docked bikes. The text network analysis results revealed some similarities and disparities between males and females in the dockless bike-sharing program compared to docked ones. Ease of use, convenience, safety, pricing, and quality was the center of the discussion for the characteristics of dockless bikes over docked bike-sharing systems. Both genders praised the dockless bikes for easy accessibility, easy to find, and coverage, among other qualities of the dockless system. However, male respondents showed to care more about the pricing scheme and the quality of the bikes than females. On the other hand, female respondents did care more about safety in terms of helmet use than male respondents. Moreover, female respondents were more explicit in explaining the negative characteristics of dockless bike-sharing over docked ones. This observation was also observed in the descriptive analysis, where we learn that a high percentage of females

Table 3
Topmost negative characteristics of the dockless bikes in seattle by male respondents.

Rank	Performance Measures Male Respondents								
	Frequency			Degree centrality		Collocation			
	Keyword	Score	Respondents	Keyword	Score	Keyword	Count	μ	Z-score
1	park	36	32	locations	26	block sidewalk	6	4.44	7.56
2	nothing	34	34	park	25	users leave	4	4.85	6.73
3	locations	28	27	people	24	seat height	3	6.54	6.64
4	helmet	26	25	helmet	23	good job	3	6.29	6.60
5	sidewalk	24	21	companies	21	doesn't work	3	5.33	6.55
6	maintenance	21	20	app	21	around city	3	4.44	6.13
7	people	20	18	get	21	don't good	3	4.53	5.96
8	leave	18	15	around	19	often broken	3	4.16	5.83
9	app	18	14	block	19	lower quality	3	5.95	5.81
10	don't	17	16	need	19	get helmet	3	3.89	5.66

Rank	**Performance Measures Female Respondents**								
	Frequency			**Degree Centrality**		**Collocation**			
	Keyword	**Score**	**Respondents**	**Keyword**	**Score**	**Keyword**	**Count**	**μ**	**Z-score**
1	helmet	40	34	locations	34	block sidewalk	7	3.90	7.28
2	locations	29	25	don't	27	people leave	4	4.49	6.46
3	park	27	24	need	25	never used	3	5.61	6.29
4	sidewalk	24	22	helmet	24	helmet available	5	4.69	5.94
5	don't	22	17	way	23	don't know	4	4.44	5.91
6	need	18	14	sidewalk	23	data plan	2	5.86	5.63
7	nothing	17	17	use	22	spin never	2	7.22	5.49
8	block	17	16	park	21	lack stations	2	5.41	5.46
9	leave	15	15	get	19	docking stations	2	5.07	5.44
10	maintenance	15	12	maintenance	18	hard find	2	5.07	5.44

*μ: association parameter; and z-value: the value of the Wald test statistic.

have had a preferred experience with the docked system (56.5%) than males (39.1%).

The findings from this study could benefit dockless bike operators as well as micro-mobility curb space management policy formulation and enforcement. In addition to taking care of the general negative aspects that co-exist for both female and male respondents, the operators may focus on the gender-specific characteristics found in this study to provide more optimal solutions. For instance, improving the pricing scheme and the quality would make more males to be interested in the program. On the other hand, enhancing safety characteristics, especially the use of helmets, would increase the utilization of the system by female users. Additionally, this study described how policy formulation and operations may affect both male and female users. Such as ensuring dockless bikes are properly parked, equitably, and safely operated throughout a community, and not impeding pedestrian or disabled user's access. For example, a policy can be formulated to ensure that micro-mobility devices are properly parked in the public right-of-way to avoid notable challenges for people with disabilities. Such policy can commonly affect the perception of both male and female users as indicated by their common interest in improper parking of dockless bikes. Furthermore, policies formulated to ensure that micro-mobility devices disbursed throughout the community do not impede pedestrians might be useful for both males and females. Conversely, policies related to safety aspects, such as strictness in wearing helmets may be considered more impactful/beneficial by female than male respondents. This may have consequences on the utilization of micro-mobility devices as people who do not want to wear helmets may decide not to use micro-mobility devices.

Considering that text mining studies and specifically text network analysis studies are relatively few and emerging, future studies may focus on the sample size as well as the minimum text length for text network analysis.

CRediT authorship contribution statement

Boniphace Kutela: The authors contributions towards the preparation of this manuscript are as follows, study conception and design. **Angela E. Kitali:** Writing – original draft, All authors reviewed the results and approved the final version of the manuscript. **Emmanuel Kidando:** Formal analysis, and, interpretation of results, Writing – original draft, All authors reviewed the results and approved the final version of the manuscript. **Neema Langa:** Data curation, Formal analysis, and, interpretation of results, Writing – original draft, All authors reviewed the results and approved the final version of the manuscript, and. **Norris Novat:** Writing – original draft, All authors reviewed the results and approved the final version of the manuscript, and. **Sia Mwende:** Data curation, Formal analysis, and, interpretation of results, All authors reviewed the results and approved the final version of the manuscript.

Data availability

Data will be made available on request.

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