BMJ Open

Effects of new dock-less bicycle-sharing programs on cycling: a retrospective study in Shanghai

Yingnan Jia,[1,2] Ding Ding,[3,4] Klaus Gebel,[3,5,6] Lili Chen,[1,2] Sen Zhang,[1,2] Zhicong Ma,[1,2] Hua Fu[1,2]

To cite: Jia Y, Ding D, Gebel K, *et al*. Effects of new dock-less bicycle-sharing programs on cycling: a retrospective study in Shanghai. *BMJ Open* 2019;**9**:e024280. doi:10.1136/bmjopen-2018-024280

► Prepublication history and additional material for this paper are available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2018-024280).

DD and HF contributed equally.

Received 23 May 2018
Revised 13 October 2018
Accepted 29 October 2018

Check for updates

For numbered affiliations see end of article.

Correspondence to
Professor Hua Fu; hfu@fudan.edu.cn and Dr Ding Ding; melody.ding@sydney.edu.au

ABSTRACT

Objectives To examine (1) the effect of new dock-less bicycle-sharing programmes on change in travel mode and (2) the correlates of change in travel mode.

Design A retrospective natural experimental study.

Setting 12 neighbourhoods in Shanghai.

Participants 1265 respondents were recruited for a retrospective study in May 2017.

Main outcome measures Prevalence of cycling before and after launch of dock-less bicycle-sharing programme.

Results The proportion of participants cycling for transport increased from 33.3% prior to the launch of the bicycle-sharing programmes to 48.3% 1 year after the launch (p<0.001). Being in the age group of 30–49 years (OR 2.28; 95% CI 1.30 to 4.00), living within the inner ring of the city (OR 2.27; 95% CI 1.22 to 4.26), having dedicated bicycle lanes (OR 1.37, 95% CI 1.12 to 1.68) and perceiving riding shared bicycles as fashionable (OR 1.46, 95% CI 1.21 to 1.76) were positively associated with adopting cycling for transport. Access to a public transportation stop/station (OR 0.82, 95% CI 0.67 to 0.99) was inversely correlated with adopting cycling for transport.

Conclusions Dock-less bicycle sharing may promote bicycle use in a metropolitan setting. Findings from this study also highlight the importance of cycling-friendly built environments and cultural norms as facilitators of adopting cycling.

Strengths and limitations of this study

- An ecological framework can guide inquiry into a more comprehensive understanding of the factors that influence cycling behaviours.
- This study is the first to quantitatively evaluate whether the introduction of dock-less bicycle-sharing programmes leads to more cycling.
- All measures were based on self-reports.
- This study applied a retrospective design, due to practical reasons outlined earlier. This limits causal inference from the current study.
- It could not verify whether the significant change from inactive transport modes to cycling has increased physical activity at the population level.

INTRODUCTION

Regular physical activity (PA) reduces the risk of major chronic diseases and premature mortality.[1] However, around the world, large proportions of the population are not sufficiently active or completely inactive which has significant health and economic consequences.[2–5] Active transportation by cycling has the potential to contribute considerably to overall activity levels of adults and is associated with significant health benefits.[6–11] Moreover, greater use of bicycles for day-to-day travel provides wider benefits, including reductions in carbon emissions, air pollution and traffic congestion.[10 12] In Chinese cities, cycling used to be a conventional mode of travel for most people, to the point that the country was once referred to as the 'Kingdom of Bicycles'.[12] However, since the turn of the century, Chinese cities have become increasingly cycling-unfriendly due to increasing car ownership and car-oriented urban planning policies such as the conversion of non-motorised to motorised lanes and banning non-motorised vehicles from arterial roads in some cities.[13] With the economic development and booming car industry, between 2002 and 2010–2012, the proportion of people using motorised transport as the main mode of transportation increased from 33.5% to 61.9%, while the proportion travelling by bicycle and walking decreased from 35.8% and 30.7% to 15.6% and 22.5%, respectively.[14]

As a strategy for promoting cycling and sustainable transportation overall, public bicycle-sharing programmes (PBSPs) have been introduced in many cities around the world to provide bicycles as a mode of transportation for relatively short trips and to bridge 'the last mile' of public transport services.[15 16] These PBSPs usually have docking stations where users obtain and return the rental bicycles.[17] Although some studies have shown that cycling has increased in some cities since the introduction of PBSPs, such as Washington, DC, Dublin, Beijing and Hangzhou, China, there are still some common problems and challenges for conventional PBSPs, which may have limited their reach and usage at a population level, such as reliance on docking stations, inconvenience in payment and insufficient supply of shared bicycles.[15 18–20]

With the increasing popularity of smart phone payments, global positioning system (GPS) tracking and other technology, dock-less bicycle sharing provides new opportunities for promoting active travel and PA.[21] Dock-less PBSPs use mobile-controlled wheel lock and GPS tracking, so that users can locate the nearest bicycle, unlock and lock the bicycle, and pay (usually, around ¥1–US$0.15 per half hour) through a mobile app. Moreover, some of the shared bicycles (eg, Mobike) have solid tires, which are durable and low maintenance. Dock-less PBSPs are currently deployed in many cities in China such as Shanghai, Beijing and Guangzhou.[22] As of May 2017, a total of 10 million dock-less shared bicycles had been deployed in China, 1.5 million of which in Shanghai, which even led the government to ban additional shared bicycles.[23 24] Despite the rapid growth in dock-less PBSPs, there is very limited evidence on whether dock-less PBSPs can change travel modes at the population level.[25]

Furthermore, the introduction of bicycle-sharing schemes alone may not lead to population-level uptake, as various other factors may need to be present to facilitate population-level cycling. In line with socioecological models, previous research suggests that population-level cycling behaviour is associated with a range of individual-level and environmental-level characteristics.[26–29] However, these socioecological correlates have rarely been examined in evaluations of PBSPs and remain important research gaps.

Therefore, this study aims to (1) evaluate whether the introduction of dock-less PBSPs leads to more cycling and (2) to examine correlates of initiation of cycling, including sociodemographic characteristics and aspects of the built and social environment.

MATERIALS AND METHODS

Patient and public involvement

A retrospective study was conducted in May 2017. An intercept convenience sample survey was conducted among residents from 12 neighbourhoods. On approaching potential participants, information about the study was provided and written informed consent was obtained before participating in the study. Participants have the right to find out the results of the study by contacting the member of the project.

Intervention

Dock-less bicycle-sharing systems can be considered as a city-level intervention for travel mode. The system was officially launched in Shanghai in April 2016. By July 2017, there were more than 13 million registered users and more than 1 million dock-less shared bicycles in Shanghai.[30] The development of dock-less shared bicycles was so rapid in China that it limited opportunities for prospective data collection or inclusion of a control city that is comparable to Shanghai, but without a bicycle-sharing system. Therefore, a retrospective study design was used.

Study areas and recruitment of participants

To explore the correlates of travel mode, a two-stage sampling method was employed. First, based on the Shanghai Transportation Map, the city was divided into four areas: within the inner ring, between the inner and middle rings, between the middle and outer rings, and beyond the outer ring. Then, three neighbourhoods were selected in each of the four areas of Shanghai by purposive sampling. The selection criteria for neighbourhoods were as follows: (1) within 1–2 km distance from the nearest subway station; (2) the number of residents within the neighbourhood was more than 1000. Within each selected neighbourhood, trained interviewers conducted at least 100 self-administered intercept surveys in May 2017. The inclusion criteria for participants were (1) being 18–70 years old; (2) having lived in the selected neighbourhood for more than 3 months and (3) being physically capable of riding a bicycle. Altogether, 1265 respondents were sampled from 12 neighbourhoods. After excluding 100 respondents with more than 20% missing data, 1165 respondents (92.1%) remained in the analysis.

Measurements

Travel mode

Travel mode before and after the advent of the dock-less PBSPs was assessed by asking respondents two questions: (1) How did you travel most of the time before the advent of dock-less PBSPs? (2) How have you been travelling most of the time after the advent of dock-less PBSPs? Respondents selected one of the following options, including walking, cycling, by car, public transport (subway, bus, ferry and shuttle bus), motorcycles/electric motorcycles, combined public transport with walking (>500 m), combined public transport with cycling, do not travel (staying at home) and other. According to respondents' travel mode before and after the advent of dock-less PBSPs, they were classified into cyclists and non-cyclists at both time points. Cyclists were defined as participants who travelled by bicycle or those who combined cycling and public transport most of the time.

Perceived bikeability

To date, only few instruments have been developed to measure perceived bicycle-friendliness of neighbourhood environments and most of these were developed for the physical environments of Western countries.[31] A new scale for measuring Chinese neighbourhood bikeability was developed based on existing instruments, literature reviews, field visits and expert consultation. Specifically, we adopted five questions (ie, distance to a public transportation stop/station, access to destinations, physical condition of bicycle lanes, maintenance of lanes and vegetation/shade along the bicycle lanes) from the Chinese Walkable Environment Scale for urban community residents.[32] Based on consultation with several Chinese local PA experts to discuss potential correlates and determinants of cycling, we added four questions to the survey, including the presence of dedicated bicycle lanes, and the degree to which traffic violations, traffic volume and motorbikes/electric scooters impede cycling. Finally, this instrument was pilot tested and adjusted prior to the survey. All bikeability variables were on a 5-point scale and the composite score was analysed as a continuous variable. More details about the questions are provided in online supplementary appendix 1.

Social norms

Two survey items assessed social norms: 'Riding dock-less shared bicycles is fashionable' and 'Riding dock-less shared bicycles represents low socioeconomic status'. Each item was rated on a 5-point scale, from 1 (strongly disagree) to 5 (strongly agree).

Demographic variables and other covariates

Self-reported sociodemographic variables included gender, age, education, personal monthly income and marital status. Age was categorised as <30, 30–49 and ≥50 years. Educational attainment was categorised as ≦junior high school, high school/technical secondary school, junior college, and university and higher. Monthly income was categorised as <¥2000, ¥2000–¥4999, ¥5000–¥9999 and ≧¥10 000 (¥1=US$0.15 in May 2017). In addition, questions about motor vehicle and bicycle ownership and characteristics of the commute were asked, including the following: (1) what is the distance between your home and work/college/university and (2) how long does it take you to go to work/college/university every day, both of which were converted to categorical variables.

Statistical analysis

McNemar's test was used to examine the change in travel mode after the introduction of the dock-less PBSPs. To explore the potential correlates of change in travel mode, we focused on the participants who did not cycle before the bicycle sharing became available and classified them as those who (1) changed from not cycling to cycling and (2) remained not cycling as their travel mode. More details can be found in figure 1. Because the data were hierarchical in nature (individuals clustered within neighbourhoods), we explored multilevel modelling. However, on examination of the outcome variable, we decided against multilevel modelling because the intraclass correlation coefficient was 0.0645 and we only found a significant random effect in 1 out of 12 neighbourhoods. Therefore, logistic regression was conducted to examine the association of sociodemographic variables, perceived bikeability and social norms with change in cycling behaviour. Sequential modelling was used with model 1 including only sociodemographic variables, model 2 including sociodemographic and bikeability variables and model 3 additionally including social norms. Statistical analysis was performed using the SPSS V.20.0 (SPSS) and the significance level was set at 0.05.

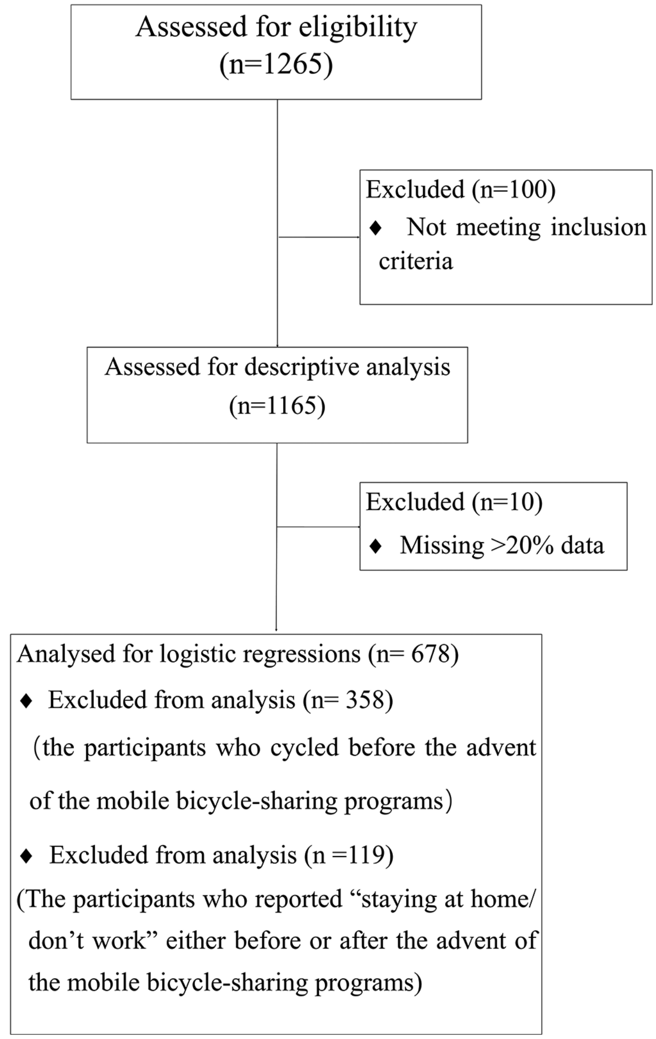

Figure 1 Participants flow.

RESULTS

The demographic characteristics of the study sample are reported in table 1. The final sample consisted of 1165 participants from 12 neighbourhoods. Nearly 40% of the participants were 30–49 years old, and over 75% were married. More than 40% reported an income level between ¥2000 and ¥4999/month. Over 75% of the participants owned bicycles, while nearly half of the participants had motor vehicles. The average distance from work/college/university was 5.6 km, while the average commuting time was 26.6 min.

Change in travel mode

Before the launch of the dock-less PBSPs, 33.3% of the participants cycled for transport which increased

Table 1 Participant characteristics

Variable	n (%)
Gender	
Male	587 (50.5)
Female	575 (49.5)
Age, years	
18–29	297 (25.5)
30–49	460 (39.5)
≥50	408 (35.0)
Education	
Junior high school	289 (25.2)
High school/technical secondary school	339 (29.5)
Junior college	210 (18.3)
University and above	310 (27.0)
Personal monthly income (¥)	
<2000	203 (17.5)
2000–4999	504 (43.4)
5000–9999	329 (28.3)
>10 000	125 (10.8)
Marital status	
Married	891 (76.5)
Unmarried/divorced/widowed	274 (23.5)
Area of residence	
Within the inner ring	284 (24.4)
Between the inner and middle rings	265 (22.7)
Between the middle and outer rings	316 (27.1)
Beyond the outer ring	300 (25.8)
Ownership of bicycle	
Yes	879 (75.5)
No	286 (24.5)
Ownership of motor vehicle	
Yes	550 (47.2)
No	615 (52.8)
Distance from work/college/university	
<1.5 km	282 (25.0)
1.5–5 km	432 (38.2)
>5 km	319 (28.2)
Staying at home/not working	97 (8.6)
Commuting time (one way)	
<15 min	359 (31.8)
15–30 min	416 (36.8)
>30 min	257 (22.8)
Staying at home/not working	97 (8.6)

significantly to 48.3% after the launch (p<0.001). Among the participants who usually travelled by car/motorcycles/electric motorcycles, walking/walking combined with public transport and public transport before the launch of the dock-less PBSPs, there were 115 (28.4%), 50 (28.2%) and 28 (29.2%) participants who adopted cycling as their primary travel mode after the launch, respectively.

Correlates of initiating commuting cycling

As shown in table 2, in model 1, among 645 participants who did not report cycling commuting cycling at baseline, those who were <30 and 30–49 years old had more than twice the odds of adopting commuting cycling than participants who were 50 and older. Participants who lived within the inner ring had more than twice the odds to adopt cycling compared with those who lived in the area between the inner and middle rings. Participants living >5 km from work/college/university had more than twice the odds of initiating cycling compared with those living within 1.5 km from work/college/university. In model 2, presence of dedicated bicycle lanes was positively associated with adopting cycling. Model 3 showed that participants who owned motor vehicles were more likely to adopt cycling than those without motor vehicles. In model 3, access to a public transportation stop/station was inversely associated with adopting cycling, and perceiving riding dock-less shared bicycles as fashionable was positively correlated with adopting cycling. The perception that riding dock-less shared bicycles represents low socioeconomic status was inversely correlated with adopting cycling.

DISCUSSION

This is the first community-based study to evaluate the effect of new dock-less PBSPs on cycling for transport. Over the last 30 years, China has witnessed rapid economic development and a booming car industry and consequentially, a dramatic decrease in cycling.[12–14] With the introduction of dock-less PBSPs, we found that the proportion of participants that cycled for transport increased significantly from 33.3% to 48.3%.

Nearly 30% of the participants who usually travelled by car/motorcycles/electric motorcycles adopted cycling after the launch of dock-less PBSPs. In comparison, a study that evaluated conventional PBSPs with docking stations showed that in Beijing, Shanghai and Hangzhou, 5.2%, 0.46% and 4% of car trips were replaced by bicycle.[33] Another study on members of bike-sharing programmes revealed that in Montreal, Toronto, Washington, DC, Minneapolis-Saint Paul, 40% of members reduced their number of car trips while only 0.4% of members increased their car trips.[34 35] Studies about PBSPs with docking stations in Barcelona, London, Montreal and Washington, DC have all reported low transfer rates from car journeys to shared bicycles.[18 36] It appears that dock-less PBSPs might have the potential to be more effective and to have a wider reach in promoting cycling than conventional PBSPs.[20 37] However, it is important to take into account that the effect sizes are not comparable because our study used individual-level data and previous

Table 2 Predictors of adopting cycling

	Model 1 (n=645)†	Model 2 (n=641)‡	Model 3 (n=641)§
Demographic characteristics	OR (95% CI)	OR (95% CI)	OR (95% CI)
Gender			
Female (ref)	1.00	1.00	1.00
Male	0.81 (0.56 to 1.16)	0.73 (0.50 to 1.06)	0.75 (0.51 to 1.11)
Age (years)			
≥50 (ref)	1.00	1.00	1.00
30–49	2.26 (1.32 to 3.87)**	2.31 (1.33 to 4.00)**	2.28 (1.30 to 4.00)**
<30	2.23 (1.18 to 4.21)*	2.11 (1.10 to 4.07)*	1.92 (0.99 to 3.74)
Education			
University and above (ref)	1.00	1.00	1.00
Junior college	0.95 (0.57 to 1.59)	0.91 (0.53 to 1.54)	0.86 (0.50 to 1.48)
High school/technical secondary school	1.31 (0.79 to 2.17)	1.30 (0.77 to 2.18)	1.26 (0.74 to 2.13)
Junior high school	0.88 (0.45 to 1.72)	0.83 (0.42 to 1.66)	0.75 (0.38 to 1.52)
Marital status			
Unmarried/divorced/widowed (ref)	1.00	1.00	1.00
Married	0.85 (0.53 to 1.37)	0.85 (0.52 to 1.39)	0.83 (0.50 to 1.37)
Personal monthly income (¥)			
≥10 000 (ref)	1.00	1.00	1.00
5000–9999	1.26 (0.70 to 2.27)	1.25 (0.68 to 2.30)	1.29 (0.70 to 2.41)
2000–4999	1.45 (0.78 to 2.69)	1.39 (0.74 to 2.64)	1.43 (0.75 to 2.74)
<2000	0.94 (0.41 to 2.15)	0.86 (0.37 to 2.02)	1.01 (0.42 to 2.41)
Area			
Within the inner ring (ref)	1.00	1.00	1.00
Between the inner and middle ring	0.52 (0.29 to 0.93)*	0.45 (0.25 to 0.84)*	0.44 (0.24 to 0.82)**
Between the middle and outer ring	0.92 (0.56 to 1.51)	0.78 (0.46 to 1.31)	0.72 (0.43 to 1.23)
Beyond the outer ring	0.69 (0.42 to 1.15)	0.59 (0.33 to 1.05)	0.56 (0.31 to 1.01)
Ownership of motor vehicle			
No (ref)	1.00	1.00	1.00
Yes	1.37 (0.95 to 1.98)	1.45 (0.99 to 2.12)	1.53 (1.04 to 2.25)*
Ownership of bicycle			
No (ref)	1.00	1.00	1.00
Yes	0.85 (0.54 to 1.33)	0.84 (0.53 to 1.35)	0.92 (0.57 to 1.48)
Distance from work/college/university			
≤1.5 km (ref)	1.00	1.00	1.00
1.5–5 km	1.28 (0.73 to 2.24)	1.27 (0.71 to 2.27)	1.33 (0.73 to 2.39)
>5 km	2.04 (1.07 to 3.90)*	2.22 (1.13 to 4.33)*	2.58 (1.30 to 5.12)**
Commuting time (one way)			
≤15 min (ref)	1.00	1.00	1.00
15–30 min	0.96 (0.57 to 1.61)	0.97 (0.57 to 1.65)	0.93 (0.54 to 1.60)
>30 min	0.84 (0.45 to 1.58)	0.91 (0.48 to 1.73)	0.83 (0.43 to 1.62)
Perceived bikeability			
Presence of dedicated bicycle lane		1.38 (1.12 to 1.68)**	1.37 (1.12 to 1.68)**
Access to a public transportation stop/station		0.83 (0.68 to 1.01)	0.82 (0.67 to 0.99)*
Access to destinations		0.85 (0.66 to 1.10)	0.81 (0.63 to 1.06)

Continued

Table 2 Continued

Demographic characteristics	Model 1 (n=645)† OR (95% CI)	Model 2 (n=641)‡ OR (95% CI)	Model 3 (n=641)§ OR (95% CI)
Physical condition of bicycle lanes		1.19 (0.89 to 1.59)	1.15 (0.85 to 1.54)
Maintenance of lanes		0.81 (0.60 to 1.08)	0.82 (0.61 to 1.11)
Vegetation/shades along the bicycle lanes		1.29 (0.97 to 1.71)	1.23 (0.91 to 1.65)
Traffic violation as a barrier		1.01 (0.79 to 1.29)	1.01 (0.79 to 1.29)
Traffic volume as a barrier		1.14 (0.87 to 1.49)	1.18 (0.90 to 1.56)
Motor bikes/electronic scooters as barriers		0.99 (0.76 to 1.29)	0.96 (0.74 to 1.26)
Social norms			
Riding dock-less shared bicycles perceived as fashionable			1.46 (1.21 to 1.76)**
Riding dock-less shared bicycles represents low socioeconomic status			0.91 (0.76 to 1.08)

All analyses are restricted to those who did not report cycling as the main mode of transport at baseline.
*P<0.05, **P<0.01.
†Model 1 adjusted for demographic variables, including gender, age, education, marital status, personal monthly income, area, ownership of motor vehicle, ownership of bicycle, distance from work/college/university and commuting time (one way).
‡Model 2 adjusted for all variables in model 1+ perceived environmental variables, including presence of dedicated bicycle lane, access to a public transportation stop/station, physical condition of bicycle lanes, maintenance of lanes, vegetation/shades along the bicycle lanes, traffic violation as a barrier, traffic volume as a barrier and motor bikes/electronic scooters as barriers.
§Model 3 adjusted for all variables in model 2+ social norms variables.

evaluations used trip-level data. We offer several potential explanations for the potentially more effective dock-less PBSPs based on previous studies as follows. First, enough bicycles per resident (more than 50 bicycles per 1000 resident in Shanghai) and the GPS positioning function allow for better access to bicycles.[38–40] Second, conventional PBSPs in China require local 'HuKou' (a permanent residency system unique to China) and are therefore not available to visitors and temporary residents. Instead, dock-less PBSPs are available to all who have registered an account online.[38] Third, a fully dock-less system makes it convenient for users to pick up and drop off bicycles wherever they want. Fourth, the provided bicycles are durable, attractive and practical.[38 40] Lastly, mobile payment is instantaneous and convenient. However, it is important to note that a prerequisite for successful dockless PBSPs is the ubiquity of mobile payment, as is the case in China.[41]

Based on our preliminary evidence, one may conclude that dock-less PBSPs have great potential for cycling promotion in China. Perhaps a key ingredient for the success of dock-less PBSPs in Shanghai is China's history of cycling as a social norm.[42] Another reason for the success of dock-less PBSPs is that they have been created and promoted by the private sector which has vested interest in the wide adoption of shared bicycles. Business competition stimulates continuous development and improvement of bicycle-sharing technology and promotion of cycling at the population level.[43]

However, dock-less PBSPs are not guaranteed to be more effective than conventional PBSPs in all settings. A report on bike share in the USA in 2017 showed that station-based systems produced an average of 1.7 rides per bike per day, while dock-less bike-share systems nationally had an average of about 0.3 rides per bike per day.[44] Several factors might explain these differences. First, it is difficult to control the distribution of dock-less shared bicycles, resulting in insufficient bicycles in some areas and overcrowding in others.[45] Second, nearly one-third of station-based bicycle share systems have income-based discount programmes, making renting station-based bicycles cheaper and potentially more appealing for low-income groups.[44] Third, station-based and dock-less BSPSs may appeal to different types of riders. Some evidence from USA suggests that station-based bicycle share trips are mainly for commuting, while dock-less bicycle-share trips suggested more recreational use.[44]

To date, few studies have examined correlates of adopting cycling in the context of newly introduced PBSPs. With the rapid development and popularity of dock-less PBSPs, it is necessary to examine potential correlates of adopting commuting cycling. We found that younger participants were more likely to adopt cycling, which is consistent with previous studies.[46–48] Gender and education were not related to adopting cycling, which is consistent with a study conducted in Beijing, but different to results from other studies from the USA, Spain and the UK which found that males and those with higher education were more likely to cycle.[28 47–49] Previous evidence on the associations between income and cycling was mixed, and our findings suggest no association between income and change in travel mode.[27 28 47 50] It is noteworthy that we found positive associations of commuting distance and car ownership with adopting cycling, which is counterintuitive and different from previous findings.[47–49 51] A potential explanation is that those who lived within walking distance (<1.5 km) to work/college/university may not own a car or have considered cycling, so bicycle sharing was most likely to affect those who lived relatively far away from work/college/university and previously travelled by car because they could not easily access public transportation stops/stations without shared bicycles.

Among the perceived bikeability of the environment, presence of dedicated bicycle lanes were positively associated with change in travel mode which is in line with several other studies, including some from Beijing.[27 47 51–55] Among them, a study in India suggested that dedicated bicycle lanes were the most important attribute of bicycle infrastructure.[53] A study from Beijing found that the perception that bicycle lanes being taken over by motorised vehicles is a key deterrent for people to switch to cycling.[47] On the other hand, consistent with other studies, we found an inverse association between access to a public transportation stop/station and adopting cycling.[29 48 55] Unlike some previous studies, we did not find an association between other aspects of the bikeability of the environment, such as traffic safety and aesthetics, with adopting cycling.[27 46 49 51 52]

Another finding from our study relates to social norms. Although previous studies have found effects of attitudes towards cycling and other modes of transportation on mode choice, our study examined effects of both positive and negative attitudes towards cycling.[56–59] Our data showed that the perception that riding dock-less shared bicycles is fashionable was positively correlated with adopting cycling while considering riding dock-less shared bicycles representing low income was inversely correlated with switching to cycling. This finding highlights that promoting positive social norms may be critical to increasing cycling at the population level.

Dock-less PBSPs provide new opportunities for active travel, but also pose challenges for their management[21] Several related issues have been raised: such as road and pedestrian safety concerns, bicycle dumping, crowding footpath and vandalism.[21 60] We discuss a few suggestions for better management of PBSP planning and management, as follows. First, public bike-sharing operators and local governments should consider what types of systems are the most effective for linking bike sharing with public transit and vehicle-sharing systems according to population density and land use.[35 39 61] Second, local governments should assess the social and environmental impacts of new bike-sharing programmes.[61] Besides quantitative assessment, some in-depth qualitative evaluations should be encouraged.[62 63] Third, companies that run dock-less bike-sharing programmes should be open to sharing more data about bike usage with local governments to facilitate evaluations, so that the local governments can better support the development of bike-sharing programmes to help achieve goals of safety, equity and sustainable mobility.[44 64]

Strengths and limitations

There are some limitations to this study. First, all measures were based on self-report, however, the measures have been validated.[32] Second, this study applied a retrospective design due to practical reasons outlined earlier. This limits causal inference from the current study. Third, because we did not collect total PA levels at two time points, we could not determine whether those who have adopted cycling have become more physically active overall.

CONCLUSION

We found that dock-less bicycle sharing can be effective in increasing bicycle use and might have the potential to be scaled up internationally. To maximise the impact of dock-less PBSPs at the population level, improving attributes of the built environment, such as dedicated bicycle lanes, and promoting positive social norms about cycling should be considered. The rapid development and popularity of dock-less PBSPs provides new opportunities for active travel, but also poses challenges for their management. Operators of dock-less PBSPs and local governments should work together to create better built environment and social norms for promoting active travel and PA.

Author affiliations

[1]School of Public Health, Key Lab of Public Health Safety of the Ministry of Education, Fudan University, Shanghai, China

[2]Health Communication Institute, Fudan University, Shanghai, China

[3]Prevention Research Collaboration, Sydney School of Public Health, The University of Sydney, Camperdown, New South Wales, Australia

[4]The Charles Perkins Centre, University of Sydney, Camperdown, New South Wales, Australia

[5]School of Allied Health, Australian Catholic University, Sydney, New South Wales, Australia

[6]Centre for Chronic Disease Prevention, School of Public Health, Tropical Medicine and Rehabilitation Sciences, James Cook University, Smithfield, Queensland, Australia

Acknowledgements We would like to express our sincere thanks all participants for their time and the community organisers from 12 neighborhoods who provided assistance during the field investigation.

Contributors YJ and HF conceived the idea, analysed the data and drafted the paper. DD, KG, LC, SZ and ZM contributed to the writing and assisted with the analysis and interpretation. YJ, LC, SZ and ZM contributed to collecting the data. All authors have read and approved the final manuscript.

Funding The work was supported by the Shanghai Municipal Commission of Health and Family Planning (Grant No. 15GWZK1001 and 2013SY006).

Disclaimer The funders had no role in study design, data collection and analysis, decision to publish or preparation of the manuscript.

Competing interests None declared.

Patient consent for publication Not required.

Ethics approval This study received approval from the ethics committee of the School of Public Health of Fudan University, China (IRB00002408 and FWA0002399).

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement Please contact authors for data requests.

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