UNIVERSITY OF LEEDS

Article:
Heinen, E orcid.org/0000-0001-8428-5709 and Buehler, R (2019) Bicycle parking: a systematic review of scientific literature on parking behaviour, parking preferences, and their influence on cycling and travel behaviour. Transport Reviews, 39 (5). pp. 630-656. ISSN 0144-1647

https://doi.org/10.1080/01441647.2019.1590477

Bicycle parking: a systematic review of scientific literature on parking behaviour, parking preferences, and their influence on cycling and travel behaviour

Abstract

Cycling is experiencing a revival in many cities. Research has focused on the determinants of cycling—in particular the role of the built environment and road infrastructure. Bicycle parking has received little attention—even though bicycles are parked most of the time.

This article reviews the scientific literature on bicycle parking and identifies existing gaps in research and knowledge. The review analyses 94 peer-reviewed papers identified through a search in Scopus and Web of Science, in December 2017.

The annual number of papers increased 15-fold between 1995 and 2017. Overall, the level of evidence on the importance of bicycle parking is limited. The majority of studies are based on cross-sectional data with the presence of parking as a binary independent variable. Most studies focus on bicycle parking at public transport stops and at work places. Few studies report on bicycle parking throughout cities, and hardly any on parking at residential locations. Bicycle parking supply and quality appears to be a determinant of cycling for current and potential cyclists.

Our findings can serve as input for an evidence-based debate on the role of bicycle parking. For practitioners, our research supports investment in bicycle parking, but acknowledges that a proper evaluation of such initiatives needs to be conducted to increase the level of evidence.

Keywords:
bicycle, parking, cycling, work-place, residence, stations

1. Introduction

Cycling has many individual and societal benefits. Riding a bicycle requires less space than driving a car, it does not produce air pollution, and it can help increase levels of physical activity and thereby improve individual and population health (Chief Medical, 2011). During the past few decades, governments have increasingly encouraged cycling through various initiatives including investments in bicycle infrastructure. At the same time, the number of bicycling-related peer-reviewed publications has soared (Pucher & Buehler, 2017).

The majority of studies focus on the infrastructure necessary for the movement of bicycles—such as the impacts of bike lanes or bike paths on cycling levels. Infrastructure for bicycle parking has received limited attention—even though bicycles are parked the majority of the time. For example, German and US national household travel surveys from 2017/2018 suggest that bicycles are parked at least 23 hours per day. This is likely an underestimate of bicycle parking/standing time, because this estimate assumes that cyclists only own one bicycle and excludes all bicycles owned by individuals who did not ride the day of the survey.

It seems intuitive that parking is important infrastructure for cycling. Bicycle parking can protect bicycles from theft, damage, and weather. The presence of bicycle parking, the convenience and security of the location, its quality, and potential cost facilitate or hinder cycling. Easily accessible, safe, secure, and inexpensive bicycle parking may increase the likelihood to ride a bicycle. In contrast, the absence of easily accessible, safe, and inexpensive bicycle parking may deter cycling. Next to theft, longer travel times, or more demanding journeys due to inconveniently located and remote bicycle parking or increased effort to park safely could reduce cycling.

Desirable features of bicycle parking facilities may depend on the characteristics of the parking behaviour itself (e.g. duration and frequency of parking), trip characteristics (e.g. purpose and distance), the bicycle (e.g. value, type), the location (e.g. at home, work, public transport stop), and the user. Moreover, these factors may interrelate. For example, longer distance trips may require higher quality and more expensive bicycles with increased financial damage in case of theft. Alternatively, individuals may ride cheaper and lower quality bicycles if the perceived chance of theft is high.

Typically, bicycles are parked at the residential location for the majority of time. The residential location is the origin of most trips—including utilitarian (e.g. the work commute) and recreational trips. Compared to other locations, parking at home involves parking for a long duration (often multiple days or even weeks and months), with the potential of parking multiple bicycles per household. A second frequent location to park is at work. Parking at work is concentrated during an 8 hour work day and must accommodate multiple employees commuting by bicycle. Bicycles are also often used in combination with public transport. Parking at bus stops and train stations ranges from short-term parking to parking for multiple days. Parking at public transport stations may potentially be very crowded, with continuous movement of bicycles being parked and collected throughout a day. Finally, parking may take place at any other urban or rural location. This parking can be highly variable in duration and could be either spatially concentrated or dispersed.

A dedicated (systematic) review of bicycle parking is lacking thus far and we consequently have a limited understanding of bicycle parking demand, how people park their bicycles, and the effect of bicycle parking on (travel) behaviour. Consequently, transport professionals and urban planners have limited guidance on where parking is best placed, how much parking is needed, and which characteristics this parking should have in terms of quality, proximity, and price. To provide bicycle parking of sufficient quality, an evidence-based debate on the impact of bicycle parking facilities (and their absence) on cycling informs future policies that promote cycling and can help estimate the demand of bicycle

parking and the required quality at different locations. For this, a better understanding of the current evidence on bicycle parking and the development of a research agenda is essential.

This paper aims (1) to review the scientific knowledge in published peer-reviewed papers on the impact of the presence, the amount and the quality of bicycle parking on bicycle ownership, (travel) behaviour, bicycle parking behaviour (practices), and preferences as well as (2) to identify empirical and methodological gaps in existing literature. These aims are guided by the following questions:

(a) How do the quality, amount, cost, and safety of parking facilities influence bicycle parking behaviour and demand?
(b) What is known about cyclists' and non-cyclists' preferences for bicycle parking facilities?
(c) How are cycling and other (travel) behaviour influenced by the availability of bicycle parking?
(d) Which methods are used to investigate bicycle parking and what is the current level of evidence?

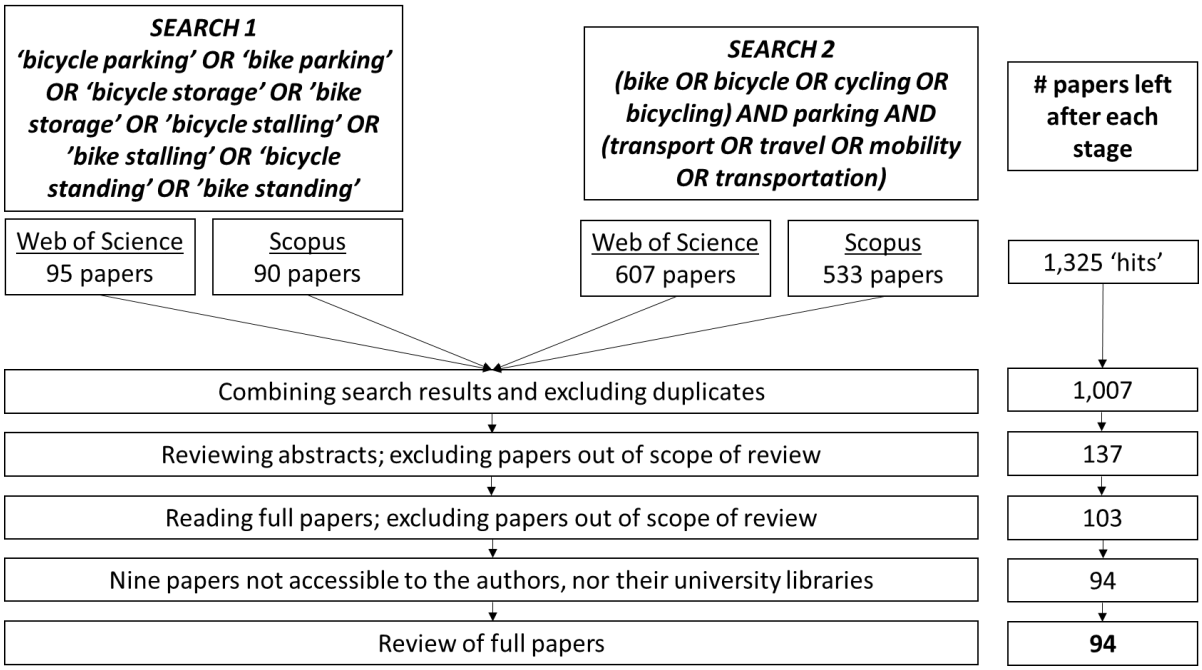
This paper is limited to reviewing the scientific literature on parking of private bicycles. It excludes studies that focus on bicycle sharing, e.g. calculating where best to position docking stations. Moreover, it does not comprise bicycles transported on-board or outside of public transport vehicles.

2. Method

We searched two electronic databases, Scopus and Web of Science (WoS), because Scopus covers a greater number of journals in the social sciences and WoS has better historical coverage (Mongeon & Paul-Hus, 2016). In December 2017, we conducted two searches for peer-reviewed academic publications and reviews on bicycle parking. The first search focused narrowly on search terms related directly to bicycle parking. The second was wider to capture papers that investigated bicycle parking, but did not mention the exact combination of search terms in search 1 (see Figure 1). All searches were based on the content of the title, abstract, and keywords. The first search yielded 95 papers in WOS and 90 in Scopus, with an overlap of 60. The second search yielded 607 papers in WOS and 533 in Scopus, with an overlap of only 174. In total, we had 1,325 hits and 1,007 unique papers. There was an overlap of 328 in total: 174 in the wider search, 60 in the narrow search, and 94 between wider and narrow search results.

We read all abstracts and examined 137 papers in detail. We excluded papers that did not focus on bicycle parking. The majority of those focussed on the positioning of parking docks for bicycle-sharing schemes or on the effect of car parking on cycling or cyclist safety. We excluded nine papers that could not be accessed—even after contacting the authors directly and attempts by our university libraries to find the papers. Our final list comprised 94 papers for the literature review—including four review papers on cycling that contained parking as a sub-topic (Figure 1). Sixteen of these papers focused exclusively on bicycle parking. The other papers analysed bicycle parking as one factor among others—for example as one of several variables in a regression model. We extracted information regarding (1) study design, (2) dimension of bicycle parking studied, (3) country, (4) sample size, (5) location where bicycle parking was provided, and (6) the findings of the study (see Tables 1-4).

Figure 1: Review flow chart



3 Results

3.1 Trends and origin of research

Comparable to the strong growth in research on bicycling overall (Pucher & Buehler, 2017), the number of peer-reviewed papers about bicycle parking increased sharply during the last two decades. There was an average of only 0.8 papers in peer-reviewed journal publications that included bicycle parking between 1995 and 2005. This rate almost tripled to 2.8 publications per year between 2006 and 2010. The years 2011-2015 saw another tripling of this rate to 10.2. Finally, in both 2016 and 2017, around 15 bicycle-parking-related papers were published. Thus, the number of peer-reviewed-bicycle parking papers per year increased 15-fold between 1995 and 2017. For comparison research on car parking has not seen such a sharp increase. The largest number of papers (n=30) originated from the USA, followed by China (n=8), the UK (n=7), and the Netherlands (n=7) (see Tables 1-4).

3.2 Methods Used in Bicycle Parking Studies

Most studies were conducted on the individual level, but the unit of analysis included train stations, libraries, hospitals, schools, zip-code areas, cities, counties, and countries. Sample sizes ranged from several thousand survey participants to interviews with a few respondents (Table 1-4).

Only 17 of the studies reviewed used qualitative research methods, such as focus groups or interviews. About a quarter (26) used descriptive statistics to analyse bicycle parking. One in seven papers relied on stated preference data collected from survey respondents. About one third of studies (33) featured cross-sectional data based on surveys, observations, and counts of cyclists or bicycles. We found only seven before-and-after studies evaluating the impact of bicycle parking provision. Methods of analysis followed the type of data collected, and varied from describing the observations to determining causal relations in before and after studies. The most common form of analyses was the inclusion of the

presence of parking as one of the independent variables in a multivariable statistical analysis based on cross-sectional data.

3.3 Empirical findings

We identified four relatively distinct categories of studies based on the location of bicycle parking at: public transport stations and stops (n=26); work, universities (both employment and education), and schools (n=40); in the city and at other locations (n=27), and at home (n=7). Although there is some overlap in findings, the emphasis of the topics addressed differed. Possible explanations are that some locations are more likely to serve as an origin (e.g. residence) and other locations (e.g. work, the city) as destinations, that trip purposes differ by location, and that the duration of parking differs by location. We discuss the empirical findings for each location by first providing a general overview of the body of research, followed by a discussion of the research questions outlined above focusing on (1) supply, demand and parking behaviour, (2) preferences, and (3) effect on (travel) behaviour.

3.3.1 Parking at public transport exchanges

Bicycle parking at public transport (PT) stops and stations has received much attention in the scientific literature. The successful coordination of PT and bicycle parking can enlarge the PT catchment area, reduce the need of operating feeder (bus) services, and increase demand for bicycling and PT (Krizek & Stonebraker, 2011). Bicycle parking is typically analysed as an element of bicycle–PT integration, and the literature has addressed issues of proximity, quality, and price on stated preferences and potential effect on travel behaviour.

Supply, demand, parking behaviour, and preferences

The type of bicycle parking available at PT stops ranges from simple bicycle racks without weather protection to full-service bicycle parking garages with video surveillance, repair services, and bicycle rentals (Pucher & Buehler, 2006, 2008a). Reported bicycle trip shares are higher for PT access than egress. Reported bicycle shares of PT access trips ranged from 0.8% (California) and 9% (Singapore) to 25% (Netherlands and Denmark). Bicycle trip shares for egress trips ranged from 5% in the UK, 6% in Denmark, 7% in the Netherlands to 9% in Singapore (Calimente, 2012; Cervero, Caldwell, & Cuellar, 2013; Chen et al., 2012; Halldórsdóttir et al., 2017; Martens, 2007; Sherwin, et al., 2011). The bicycle is more often used for accessing rail, than other forms of PT (Martens, 2007). These variations in use may affect the demand for parking, or the quality and quantity of parking may explain the differences in use.

Cyclists park preferably close to PT. Four of five bicycles at rail stations in New South Wales, Australia were parked within very close distance to the rail-station entrance (30 m). Cyclists were willing to walk farther to access higher quality parking, such as bicycle lockers, but occupancy rates dropped by 20% for lockers farther than 100 m from the entrance (Arbis et al., 2016). Martens (2007) reported that the inconvenient location of bicycle parking at some bus stops in the Netherlands resulted in bicycles parked closer to the bus stop, but not in designated bicycle-parking facilities. Highly visible areas are also preferred (Molin & Maat, 2015) and more bicycles are parked in areas with video or public surveillance (Arbis et al., 2016).

Several studies showed that bicycle-parking duration at PT stations and stops varies. Some report an average of about 4-8h at Nanjing Metro stations (Chen et al., 2012), others found that many bicycles were hardly used at all: a quarter of available parking spaces were occupied by abandoned bicycles in New Jersey USA (Harvey et al., 2016) and 7% of bicycles parked overnight at the Bristol, UK train station were used only once a week (Sherwin et al.,

2011). The presence of abandoned or vandalised bicycles is a deterrent to parking (Rojas López & Wong, 2017).

Effect on travel behaviour

The vast majority of papers found a positive relationship between bicycle parking supply and cycling levels or the stated likelihood to cycle to access PT (e.g. Appleyard, 2012; Arbis et al., 2016). For example, Appleyard & Ferrell (2017) found that commuters in California are more likely to cycle to stations with a greater bicycle parking supply. In Denmark, the availability of bicycle parking increased the likelihood of cycling to a station by a factor of 2.5 (Halldórsdóttir et al., 2017).

Few quantitative studies consider the quantity or quality differences of bicycle parking. Those studies predominantly conclude that a larger number of parking spaces and higher quality parking increases cycling (e.g. Geurs, La Paix, & Van Weperen, 2016). For example, in Denmark, 100 additional bicycle parking places were related to a 2.5% greater likelihood of making a bicycle egress trip from a station (Halldórsdóttir et al., 2017). The presence of covered bicycle racks made cycling from the station 2.9 times more likely (Halldórsdóttir et al., 2017), and bicycle lockers were approximately 2.5 times more of an incentive for bike-and-ride use than simple covered bicycle racks (Taylor & Mahmassani, 1996). Puello & Geurs (2015) found that improvements in unguarded bicycle parking facilities may increase the number of people who cycle to the train station more than improvements in guarded bicycle parking facilities—although the lack of safe bicycle parking is a key barrier to cycling to bus, train, and metro stations (de Souza et al., 2017). Proximity of parking may also increase cycling. If bicycle parking was closer to the entrance, there was a greater likelihood to cycle to Metro stops (Chen et al., 2012) and for main train stations 2 minutes was found to be the critical factor (Geurs et al. 2016). Most studies focus on rail–bicycle integration, and the one study on bus–bicycle integration suggest that high quality parking at bus stops may not have similar effects: bicycle lockers at bus stops are rarely used, possibly given the high cost of locker parking compared to the inexpensive bicycles typically used for such trips in the Netherlands (Martens, 2007).

Paying for parking decreases the likelihood of cycling (Molin & Maat, 2015). Geurs et al. (2016) found that free bicycle parking would result in an 11% greater likelihood of cycling to the train station (vs. having to pay for parking).

Table 1: Overview of topics and methods of papers on parking at transport exchanges

Paper	Method								Country	Sample size
Author(s) and year	**Monologue**	**Case study**	**Qualitative**	**Quantitative - Descriptive analyses**	**Quantitative - Stated preference experiment**	**Quantitative Revealed preference cross-sectional**	**Quantitative-intervention**	**Other**		
Appleyard & Ferrell, 2017						x			USA	crime data
Appleyard, 2012						x			USA	5,694
Arbis et al., 2016		x	x(observational)	x					Australia	146 outside parking and 102 lockers
Bachand-Marleau et al., 2011				x		x			Canada	1,432
Bopp, Sims, Matthews, et al., 2016				x					USA	999 employees and staff
Calimente, 2012		x		x					Japan	
Cervero et al., 2013		x							USA	396 stations

Chen et al., 2012				x		x			China	1,784
de Souza et al., 2017			x(focus group)			x			Brazil	505 (survey respondents)
Debrezion et al., 2009						x			Netherlands	1,440 postcode areas
Fukuda & Morichi, 2007						x			Japan	1,616
Geurs et al., 2016		x			x				Netherlands	1,524 train station users
Halldorsdottir, 2017						x			Denmark	2,921 trips originating from home, 3658 from activity
Harvey et al., 2016		x	x(focus group)	x					USA	35 stations, 8 in focus group
Ji et al., 2017						x			China	709
Krizek & Stonebraker, 2011		x	x(focus group)		x				USA	6 case studies
Martens, 2007		x	x						Netherlands	
Martinez & Cornejo, 2003					x				Peru	2,500
Molin & Maat, 2015					x				Netherlands	1,109
Pucher & Buehler, 2008b		x	x	x					Netherlands, Denmark, Germany	
Pucher & Buehler, 2008a	x	x							Netherland, Denmark, Germany	
Puello & Geurs, 2015						x			Netherlands	12,000 observations of journeys
Rojas López & Wong, 2017			x						Singapore	3 focus groups, 26 interviews
Sherwin et al., 2011		x						x(observational)	UK	2 stations
Taylor & Mahmassani, 1997					x				USA	814
Yang et al., 2015						x			China	825

In bold papers that are (largely) focussed on parking

3.3.2 Parking at work, universities, and schools

Commuting as a trip purpose has received substantial attention in transport research and perhaps consequently, the number of studies on bicycle parking at work and educational facilities school is large. The majority of studies focussed on employment sites, including universities, but several studies concentrated on university students or children. We combined the discussion of work and school, given that several papers combine students and staff at universities. Moreover, parking at these locations shares similarities in terms of duration and concentration in time. Most studies are cross-sectional quantitative studies analyzing the effect of parking on (travel) behaviour.

Supply, demand and parking behaviour

Two studies address whether employers may consider facilities for cyclists as important and whether they are offered and conclude that provision is far from standard. In the US, 12 out of 16 companies listed in the League of American Bicycle-Friendly Businesses Framework described parking as important for cyclists. In another study, only four out of 13 hospitals self-reported providing parking specifically for staff (Owen, Day, & Scullion, 1999). This indicates that parking is not necessarily considered as important as it may be.

Although, one would expect relatively long-duration parking at employment and educational sites, at a university about a third of the bicycles were parked for less than 2 h (Moskovitz & Wheeler, 2011). Illegal parking may also be a problem at educational/employment sites, and Fujii (2005) conducted an experiment to reduce illegal parking behaviour. Those that received a leaflet describing illegal parking as a problem as

well as those receiving a leaflet on how to park correctly reduced their incidence of inappropriate bicycle parking after two weeks.

Preferences

Several papers point towards a preference of safer parking facilities at work. At Peking University, students preferred caged sheds, and these were also occupied to a higher level than other facilities (Yuan et al., 2017). Similarly, Noland & Kunreuther (1995) found that employees with safe bicycle parking rated the convenience of cycling higher than those without safe parking. Overall, parking at work does not seem to align with cyclist preferences. In Montreal, 60% of the respondents were satisfied with their parking at work and school, and 55% were satisfied with the level of parking availability, although 20% were not satisfied with the facilities (Van Lierop, Grimsrud, & El-Geneidy, 2015).

Effect on travel behaviour

Most papers found a positive relationship between parking and bicycle mode choice. Only one study reported a negative effect on cycling: Caulfield, Brick, & McCarthy (2012) found, based on a stated preference survey, that increasing the number of bicycle parking would be unlikely to encourage cycling to work. Most other studies showed that the presence of (safe) bicycle parking increases the likelihood of commuting by bicycle (e.g. Bopp et al., 2016; Yang & Zacharias, 2016). For example, Bueno et al. (2017) found that individuals with either bicycle parking, workplace showers and lockers, or shared-use paths were 50% more likely to cycle to work. On a zoning level, Chriqui et al. (2016a, 2017) found that zoning provisions including bicycle parking were associated with higher levels of active travel to work. The extent to which bicycle parking is important for mode choice is perhaps best shown by Hunt & Abraham (2007). They found that secure parking results in the same effect on utility as a decrease of 26.5 min spent cycling in mixed traffic. Parking may be more important to younger people, as they valued secure parking much more highly, possibly as the bicycle is a relatively more expensive possession (Hunt & Abraham, 2007).

At schools, the availability of parking spaces was mostly found to have a positive effect on cycling to school, but evidence is mixed. The lack of bicycle parking is often mentioned as a reason for not cycling to school (Mackie, 2010). In other studies, a large share of respondents indicate that safer parking would encourage them to cycle to school more (Mandic et al., 2017). The presence of bicycle parking (yes/no) also positively affects the choice to ride the bicycle to school (e.g. Kamargianni & Polydoropoulou, 2013). However, two studies found less clear results. In a stated preference experiment in Greece and Cyprus (n=10,194), bicycle parking was only statistically significant at some locations and not others (Kamargianni, 2015). In an intervention study in Ireland, which included parking, no effect on active travel was found (Lambe, Murphy, & Bauman, 2017).

There are relatively few studies on the quality of parking. Nevertheless, available research indicates that improved parking facilities may increase ridership. One intervention study monitored parking behaviour before and after the installation of more higher-quality parking spaces (Mrkajic, Vukelic, & Mihajlov, 2015) and occupancy rose from 30%-40% to 68%. Another study found that a bicycle station with repairs and more convenient parking would encourage cycling (Akar & Clifton, 2009). Heinen, Maat, & van Wee (2013) showed that having a bicycle facility inside (which 45% of the sample had) instead of outside (which almost all respondents had) increased the likelihood of cycling to work and the frequency of cycling to work. McDonald et al. (2013) showed that providing covered bicycle parking was associated with increases in cycling (11% points).

Some studies concluded that the combination of facilities is important. Bicycle parking and cyclist showers were found to be associated with higher levels of bicycle

commuting, but the likelihood of cycling was higher for employees with access to both compared to those with just bicycle parking (Buehler, 2012). The need to pay for parking and its price, however, reduces the likelihood of bicycle commuting (Murillo Acosta & Romero-Conrado, 2017).

Theft has received some attention and fear of theft reduces cycling. In addition to the studies mentioned above on quality, Piatkowski & Marshall (2015) showed that increased concern regarding security and comfort, which includes bicycle parking, storage, and fear of theft, was associated with 0.37 lower odds of bicycle commuting (Piatkowski & Marshall, 2015) and Titze et al. (2007) showed that students who were not concerned about bicycle theft were more than twice as likely to regularly cycle to university.

Table 2: Overview of topics and methods of papers on parking at work, universities, and schools

Paper	Method									Country	Sample size
Author(s) and year	**Monologue**	**Case study**	**Qualitative**	**Quantitative - Descriptive analyses**	**Quantitative - Stated preference experiment**	**Quantitative Revealed preference cross-sectional**	**Quantitative-intervention**	**Other**			
Akar & Clifton, 2009				X						USA	1,500
Bopp, Sims, Colgan, et al., 2016						x				USA	551
Bopp, Sims, Matthews, et al., 2016				x						USA	999 employees and staff
Braun et al., 2016						x				Spain	765
Buehler, 2012						x				USA	5,091
Bueno et al., 2017						x				USA	21,761
Caulfield et al., 2012					x					Ireland	1,904
Chriqui et al., 2017						x				USA	zoning data 3914 jurisdictions
Chriqui, et al., 2016a						x				USA	3,914 municipal-level jurisdictions located in 471 counties
Curto et al., 2016						x				Spain	814
Fujii, 2005							x			Japan	99
Hamre & Buehler, 2014						x				USA	4,630
Heinen et al., 2013						x				Netherlands	2,929
Hipp et al., 2017						x		x(accelerometer)		USA	2,013
Hunt & Abraham, 2007					x					Canada	1,128
Kaczynski et al., 2010						x				USA	375
Kamargianni & Polydoropoulou, 2013					x					Cyprus	4,147
Kamargianni, 2015					x					Greece and Cyprus	10,194
Lambe et al., 2017						x	x			Ireland	1,038
Mackie, 2010			x	x						New Zealand	6 schools
Maldonado-Hinarejos et al., 2014					x					UK	1,985
Mandic et al., 2017				x		x				New Zealand	774
McDonald et al., 2013							x			USA	14 schools
Moskovitz & Wheeler, 2011								photographic; observational		USA	35 areas with 368 places

Mrkajic et al., 2010					x	x(observational)	Serbia	
Mrkajic et al., 2015					x		Serbia	
Murillo Acosta & Romero-Conrado, 2017			x	x			Colombia	Students and staff
Nkurunziza et al., 2012				x			Tanzania	600
Noland & Kunreuther, 1995			x				USA	1,500
Owen et al., 1999		x					Australia	13 hospitals
Piatkowski & Marshall, 2015				x			USA	1,633
Rojas López & Wong, 2017	x						Singapore	3 focus groups, 26 interviews
Stinson & Bhat, 2004			x				USA and Canada	2,822
Titze et al., 2007			x				Austria	538
Vairo et al., 2017	x(interview with company)						USA	16 businesses
Van Lierop et al., 2015		x	x				Canada	2,039 (1,922 valid)
Wang et al., 2015		x					USA	2,000
Yang & Zacharias, 2016				x			China	852
Yuan et al., 2017		x					China	425 students

In bold papers that are (largely) focussed on parking

3.3.3 Parking in the city and other locations

Despite the fact that bicycle parking in cities can be a challenge from a transport and urban planning perspective, this topic has received less attention than parking at stations and employment sites. Some research argues that programmes may have focussed too much on bicycle sharing and limited attention has been given to private bicycle use and storage (Yang et al., 2015). Others argue that bicycle-related investments, including parking, are more common in privileged/wealthier areas (Flanagan, Lachapelle, & El-Geneidy, 2016). Studies vary widely in approach and topic.

Supply, demand and parking behaviour

Different locations have different levels and quality of bicycle parking infrastructure. Dutch, Danish, and German cities have large supplies of high-quality bicycle parking (Pucher & Buehler, 2008b). Nevertheless, parking levels in the US are also increasing (Hirsch et al., 2016), and some city zoning rules require bicycle parking (Pucher et al., 2011). In national parks, parking can help prevent visitors from parking in unsafe locations or in a manner that is detrimental to natural or historically sensitive surroundings (Villwock-Witte, Gleason, & Shapiro, 2012). A limited number of studies investigated parking at specific locations and often reveal the lack of (high-standard) parking. For example, Thompson (2006) showed that only half of the libraries in Pennsylvania had bicycle parking, of which 50% had their own bicycle racks.

Bicycle parking behaviour in cities showed variation between location and revealed that parking takes place at unintended locations or street furniture (e.g. Aldred & Jungnickel, 2013). Larsen (2017) observed that whereas in some cities such as New York, bicycles were always attached to something when parked, 'unmoored' bicycles, i.e. parked unattached to a fixed object, were common in Copenhagen and Amsterdam. Two studies noticed that many elements of the built environment were used for parking, counter to their primary purpose, sometimes referred to 'fly-parking' (Gamman, Thorpe, & Willcocks, 2004; Larsen, 2017). Fly-parking may be an indicator that current cycle parking provision is mismatched to user requirements and a result of higher user demand (Nakamura & Abe, 2014). An alternative

explanation is that when illegal parking is prevalent, it becomes the norm (Abou-Zeid et al., 2013; Brock & Durlauf, 2002; Fukuda & Morichi, 2007). In countries with high cycling rates, fly parking is often more prevalent, and shop keepers and authorities are enraged by fly parking and abandoned bicycles (Van der Spek & Scheltema, 2015).

Not all locations are equally prone to theft and to prevent theft, communication may encourage individuals to lock their bicycles more securely. The presence of bicycle stands, pawn shops, universities, train stations, and vacant houses increased the likelihood of a bicycle being stolen in London (Mburu & Helbich, 2016). Communication through stickers could reduction 'bad' parking and improve the level of 'OK' parking (Sidebottom, Thorpe, & Johnson, 2009). Also making people directly aware that they are a victim was positively associated with an increase in the use of the lock immediately after the message (Shimada & Arai, 2017). These studies demonstrate that individual strategies could reduce bicycle theft.

Preferences

Few scientific studies focus on preferences for parking in cities, possibly as a result of the large variety of facilities available and large differences between countries. One study showed little happiness with the current provisions (30%), and a third indicated that they would pay for improved facilities (Van Lierop et al., 2015). The popularity of paid parking dropped if the price was over two Canadian dollars, and individuals with a bicycle of a value over $500 were more likely to be willing to pay. Research shows that better quality parking is valued, but that cost matters: if parking is free and guarded, users in the Netherlands rate it 8.2 on a ten-point scale, but only 6.9 if it is paid and guarded, and 6.3 if it is paid and automated (Van der Spek & Scheltema, 2015).

Effect on travel behaviour

Although a lack of parking is found to be an important barrier to cycling (Simons et al., 2014), few studies provide estimates of the effect of parking in a city on cycling. Having a bicycle rack was positively associated with outdoor physical activity frequency (Schipperijn et al., 2013). On a county aggregated zoning level, the presence of bicycle parking was significantly associated with biking (OR 1.83) (Chriqui et al., 2016b).

The question whether the quality of the parking facilities affects cycling has only been addressed to a limited extent. Burke (2011) found that a newly opened cycle centre at a central square in Brisbane, Australia in 2008 saw immediate use, but the opening did not result in many people switching from car to bicycle. The importance of safe parking and theft is discussed in several studies. The main obstacles to buying and using a private bicycle are fear of theft (46%) and the lack of proper parking (57%) (Castillo-Manzano, Castro-Nuño, & López-Valpuesta, 2015). The latter is particularly important to women. In contrast, theft and parking were not very important variables for mode choice in India (Majumdar & Mitra, 2015).

Table 3: Overview of topics and methods of papers on parking in the city and other locations

Paper	Method								Country	Sample size
Author(s) and year	Monologue	Case study	Qualitative	Quantitative - Descriptive analyses	Quantitative - Stated preference experiment	Quantitative Revealed preference cross-sectional	Quantitative-intervention	Other		
Aldred & Jungnickel, 2013		x	x						UK	4 cities

Burke, 2011				x			(x)		Australia	44
Castillo-Manzano et al., 2015						x			Spain	505
Chriqui, et al., 2016b						x			USA	1,617 county and municipal jurisdictions
Flanagan et al., 2015		x				x			USA	2 cases
Gaffga & Hagemeister, 2015				x					Germany	410 tricycles, 479 trailers
Gamman et al., 2004		x						observational	UK and Europe	
Hirsch et al., 2016		x						x(longitudinal BE changes)	USA	4 cities
Larsen, 2017		x	x(ethnographic)						Denmark, Netherlands, USA	3 case studies
Lee & March, 2010		x		x					Australia	1,023
Majumdar & Mitra, 2015				x				x(expert judgement)	India	survey 575; 12 experts
Mburu & Helbich, 2016						x			UK	1,029 crimes
Nakamura & Abe, 2014									Japan	
Owen et al., 1999				x					Australia	13 hospitals
Pucher & Buehler, 2008b		x	x	x					Netherlands, Denmark, Germany	
Pucher et al., 2011		x		x					USA, Canada	9 cases
Schipperijn et al., 2013						x			Denmark	1,305
Shimada & Arai, 2017							x		Japan	256
Sidebottom et al., 2009							x		UK	5 sites twice
Simons et al., 2014			x(focus groups)						Belgium	36
Susilo et al., 2012						x			UK	659
Thompson, 2006		x		x					USA	225 libraries
Van der Spek & Scheltema, 2015	x								Netherlands	
Van Lierop et al., 2015				x	x				Canada	2,039 (1,922 valid)
Villwock-Witte et al., 2012				x					USA	28 sites/plans
Yang et al., 2015	x								China	

In bold papers that are (largely) focussed on parking

3.3.4 Parking at home

Few papers have focussed on bicycle parking at the residential location: our search only yielded seven papers on parking in and around residences. This is surprising, as bicycles are likely most commonly and for the longest duration parked at the residential location. Six of the seven papers focussed on current bicycle parking behaviour and satisfaction with the parking situation and one on bicycle theft in relation to travel behaviour.

Supply, demand, parking behaviour, and preferences

Cyclists prefer safe bicycle parking at home, but there is variability by country and city. In China, parking sheds were most commonly used (~40%), and the most preferred option to park the bicycle (~60%) (Lusk, Wen, & Zhou, 2014). Cyclists were less likely to park their bicycle in a shed (~40%) compared to non-(frequent)-cyclists (~63%), which corresponded with their differences in preferences. In Singapore, cyclists also often prefer to park their bicycle inside, perhaps as a result of insufficient infrastructure outside (Meng et al., , 2016), which was also found by Lusk et al. (2014) indicating that 17% of the respondents agreed with the statement that ‘it is always difficult to find parking for my bicycle’. Parking is an

even greater issue for 'specialty bicycles' and was mentioned as an obstacle by 10% of tricycle and 25% of trailer users (Gaffga & Hagemeister, 2016).

Parking locations at home differ between cities and suburbs. Comparing bicycle parking in the city of Vienna to the suburbs showed that Vienna cyclists more likely parked in staircases (10% vs. 4%), living rooms (8% vs. 3%), and the street (6% vs. 3%), but less likely in a garage (4% vs. 15%) (Pfaffenbichler & Brezina, 2016). Those that parked in bicycle storage rooms with easy access or in gardens were more satisfied with their storage facilities. These differences may be due as well to variations in crime levels. In the USA, fear of crime was mentioned as a reason why blacks and Hispanics preferred to park their bicycle inside (52% and 47%) compared to whites (28%) (Lusk et al., 2017). However, Van Lierop et al. (2015) showed that individuals tend to underestimate the risk of theft at their own residential location.

Effect on travel behaviour

One study showed a relationship between the presence of parking and the likelihood of cycling (Nkurunziza et al., 2012). The lack of safe parking at home reduced the likelihood of being in the maintenance group instead of the action group and to be in the relapse group instead of the maintenance group, i.e. it reduced the likelihood of being more advanced on 'stages of change model' towards more cycling.

Table 4: Overview of topics and methods of papers on parking at home

Paper	Method									Country	Sample size
Author(s) and year	Monologue	Case study	Qualitative	Quantitative - Descriptive analyses	Quantitative - Stated preference experiment	Quantitative Revealed preference cross-sectional	Quantitative-intervention	Other			
Gaffga & Hagemeister, 2015				x						Germany	410 tricycles, 479 trailers
Lusk et al., 2014				x						China	1,150
Lusk et al., 2017				x						USA	252 surveys, 120 intercept surveys, 709 observations
Meng et al., 2016				x						Singapore	553
Nkurunziza et al., 2012						x				Tanzania	600
Pfaffenbichler & Brezina, 2015								x(spatial demand modelling)		Austria	324
Shaheen et al., 2011				x						China	806
Van Lierop et al., 2015				x	x					Canada	2,039 (1,922 valid)

In bold papers that are (largely) focussed on parking

4. Discussion & Conclusion

This paper aims to (1) understand how the quality, the amount, the costs, and safety of parking facilities influence bicycle parking behaviour and demand, (2) identify individual preferences for bicycle parking facilities and (3) highlight how cycling and other (travel) behaviour are influenced by the availability of bicycle parking. Several general patterns emerged from the review pertaining to parking at various locations.

First, greater bicycle parking supply is correlated with more bike parking. Cyclists also tend to park their bicycles predominantly at higher quality (e.g. sheltered and secure) bicycle parking over parking of lower quality, and at convenient locations, such as close to entrances of public transport stations. Compared to free bicycle parking, charging for parking reduces the likelihood of using a facility. Many cyclists lock their bicycles to urban street-furniture not intended for bicycle parking (Gamman et al., 2004; Larsen, 2017), which may indicate a local imbalance between supply and demand. At home, bicycles are parked at various locations in and around the residence depending on the country, urban or rural residential location, and individual characteristics.

Second, cyclists and potential cyclists prefer higher quality bicycle parking facilities (such as covered parking) over lower quality facilities or no bicycle parking. However, preferences, quality and convenience vary by user group. Current and potential cyclists prefer bicycle parking facilities that increase personal security and safety from bicycle theft and vandalism (e.g. Appleyard & Ferrell, 2017; Lusk et al., 2017; Yuan et al., 2017). Greater awareness of 'good' parking/locking behaviour seems to increase improved parking and may contribute to reducing bicycle theft. Cyclists seem willing to pay for better parking facilities (Van Lierop et al., 2015).

Third, bicycle parking supply appears to be a determinant of cycling for current and potential cyclists. Conversely, a lack of bicycle parking and/or inadequate bicycle parking discourages cycling. Higher quality bicycle parking facilities are associated with more bicycle use (e.g. Halldórsdóttir et al., 2017; Heinen et al., 2013; Taylor & Mahmassani, 1996). More convenient bicycle parking is also associated with more cycling. Convenience includes easy access to bicycles, e.g. short distances between bicycle parking and actual trip origins or destinations. However, the need to pay for parking reduces bicycling (Geurs et al., 2016 Molin & Maat, 2015; Murillo Acosta & Romero-Conrado, 2017).

Moreover, this paper tried to answer the question on which methods are used to investigate bicycle parking. Although a large variety of methods are used, including interviews, focus groups, observations, revealed preference surveys, stated preference surveys and intervention studies, the most common research design is cross-sectional, commonly using either a revealed or stated preference survey. Most of these studies do not focus on parking exclusively, but only consider parking as one of several correlates of bicycling or public transport usage. It is noticeable that the methodology applied seems to vary between locations. The abovementioned methods are dominant for studies that focus at public transport stations and at employment and educational sites. However, in urban centres in-depth qualitative, observational and ethnographic studies on bicycle parking behaviour (practices) are also common, which are hardly existing at other locations. Longitudinal studies, such as studies on panel data or intervention studies hardly exist.

Empirical gaps

This review revealed that few studies have focussed on bicycle parking at residential locations. This is noteworthy given that bicycles in a typical day are parked for a longer time than they are ridden, and it is conceivable that the main bicycle parking location is its users' residence or residential area. The available research revealed that cyclists have strong preferences for certain facilities, although they may park in/at different facilities in the absence of the preferred facility. The dearth of studies on the effect of parking at residential locations and its behavioural consequences result in a limited understanding of the potential effects of parking in residential areas on behaviours such as mode choice. Consequently, attention from planners to address parking at home may be limited given the lack of evidence.

This review also found few quantitative studies on bicycle parking in cities in general and even fewer about the effect on travel behaviour. Most studies focussed on supply, bicycle

parking behaviour and preferences. We also did not find many studies that evaluated bicycle parking strategies at the city level—such as the appropriateness of zoning requirements for bicycle parking in certain buildings or imbalances in bicycle parking supply between stations, neighbourhoods, and central business districts.

The level of evidence on the importance and effect of good quality parking is limited. Most studies have focussed on whether there is parking, or on the amount of parking available. Although some studies have focussed on the quality of parking, and these tend to draw similar conclusions, the number of high-quality studies that determine the influence of better parking facilities on cycling behaviour, and parking demand is limited. This is remarkable given the reported differences in preferences of cyclists for various parking facilities and the effects found for higher quality parking compared to simple parking in the few studies available (e.g. Geurs et al., 2016; Heinen et al., 2013; McDonald et al., 2013). These few studies tend to focus on train stations and sites of education and employment, but it is conceivable that the effect is similar at other locations. This lack of evidence may result in insufficient evidence to support an argument for improving bicycle parking at a local level.

Cycling is known to vary by country and city (e.g. Heinen et al., 2009). Cycling practices differ, and the studies that focus on parking practices/bicycle parking behaviour (e.g. Larsen, 2017) show that where people park, and how they lock their bicycles differs between countries/cities. This could be either explained by differences in supply, preferences, or different behavioural responses. Given the limited number of studies that focus solely on bicycle parking, and the variation in measurement and modelling (see below) it is hard to draw firm conclusions on whether the reported findings are similar around the world or whether some may be location specific.

Finally, the focus on bicycle parking seems very restricted to specific locations. Most current studies focus on key destinations, especially PT-stations and work and educational locations. More generic locations in cities, or the main origin of trips (i.e. residences) have received limited attention. It remains uncertain whether the preferences, and consequent effects on travel behaviour are similar at the origin or destination, or whether they mostly differ by trip purpose.

Methodological gaps

This review showed that there are key gaps in research methods, data availability, and measurement to study bicycle parking. First, studies on bicycle parking are predominantly cross-sectional. The dominance of one type of study results in a limited understanding of the topic. Moreover, the focus on cross-sectional studies prohibits causal conclusions on the reported relationships.

Second, most studies, especially if they are quantitative cross-sectional studies, consider parking as only one of the correlates of bicycling or public transport usage. As a result the effect size, statistical significance, and possibly even the direction of the reported effect, are affected by the inclusion or absence of other covariates.

Third, a complexity accompanying interpretations of the existing literature is the variation in the measurement of bicycle parking. Not only is bicycle parking not well defined in many of the reviewed studies, but even when it is defined, differences in measurement between studies and/or combining parking with other characteristics in one variable complicate comparisons. Many studies included parking as a dummy variable, representing whether bicycle parking was available or not. Other studies used measures such as the number of parking spaces. Few studies considered a measure of parking quality. There is also no agreed-upon term for parking a bicycle outside of designated spots, which is labelled as ‘illegal’, ‘fly’, or ‘wild’ bicycle parking.

Fourth, bicycle parking behaviour (practices) and the variety within those seem to have received attention in urban centres (e.g. Aldred & Jungnickel, 2013; Larsen, 2017), but have received little attention at other locations. In-depth qualitative or observational studies are noticeably absent which limits the understanding of the variety how and why bicycles are parked and the options for improvement.

Finally, intervention studies are limited. Existing intervention studies focus on changing individual bicycle parking behaviour (Fujii, 2005; Shimada & Arai, 2017; Sidebottom et al., 2009), such as parking bicycles differently to prevent theft. Intervention studies on the effect of parking on cycling behaviour are absent. The lack of intervention studies on parking hampers the implied causality on the effect of bicycle parking on cycling. We therefore recommend that intervention studies on parking be conducted. They could be relatively easily implemented for parking compared to assessments of other bicycle infrastructure.

Implications for future research on bicycle parking

It remains speculative on why parking has not received more and focussed attention. One potential reason for the limited attention for the quality of parking and the dominance of cross-sectional studies in which parking is only included as a dummy variable may be that bicycle parking is often seen as part of a mix of policies designed to increase cycling. Improving parking rarely occurs in isolation as a single measure to encourage cycling. This may explain why parking, if considered at all in the scientific literature, is only one of many covariates in cross-sectional studies. Although this corresponds with current practice, it complicates the interpretation of results even further due to differences between studies in the correlates considered. Improved measurement of parking and its effects are essential for evidence-based planning and to select the most cost-effective policies to encourage cycling.

Existing studies hardly discuss the relationship between bicycle parking demand and supply. This is in sharp contrast to car parking, where both supply and demand have received attention (Marsden, 2006). Some examples have shown that after the opening of new high-quality bicycle parking facilities, the demand exceeded expectations. This demonstrates that we have only a limited understanding of (latent) demand and the feedback loops that exist between levels of cycling and the presence of bicycle parking.

The current urban transport system is facing many changes. Important for the topic of this paper is especially the rise of bicycle sharing. Issues related to parking have been addressed in studies on the best placement for docking station (please note this excludes the scope of this review). More recently, dockless bicycle sharing systems have gained popularity. Parking issues for those systems could be more comparable to parking for personal bicycles as they do not have designated parking places (i.e. docking stations), but can be parked anywhere within designated areas. Research on this topic is still limited, but may enhance our understanding of parking on an urban level, although issues such as theft and consequent bicycle parking behaviour and demand may be very different. In the long turn it also has the potential to contribute to discussions on parking management and changing individual parking behaviour to reduce annoyance, as we already see in some countries with a high bicycle modal split.

In conclusion, this review showed that while there is some clear empirical evidence that bicycle parking may be an essential criterion to stimulate cycling, the results are limited due to empirical and methodological limitations in existing research. Consequently, we still have a narrowed understanding of the effects of bicycle parking policies and provisions. Despite these shortcomings, for research, our findings can serve as input for an evidence-based debate on the role of bicycle parking. For practice, our research supports investment in

bicycle parking, but acknowledges that a proper evaluation of such initiatives needs to be conducted to increase the level of evidence of the effects of bicycle parking on cycling.

References

Abou-Zeid, M., Schmoecker, J.-D., Belgiawan, P. F., & Fujii, S. (2013). Mass effects and mobility decisions. Transportation Letters, 5(3), 115–130.

Akar, G., & Clifton, K. J. (2009). Influence of Individual Perceptions and Bicycle Infrastructure on Decision to Bike. Transportation Research Record, (2140), 165–172.

Aldred, R., & Jungnickel, K. (2013). Matter in or out of place? Bicycle parking strategies and their effects on people, practices and places. Social and Cultural Geography, 14(6), 604–624.

Appleyard, B. (2012). Sustainable and healthy travel choices and the built environment. Transportation Research Record, (2303), 38–45.

Appleyard, B., & Ferrell, C. (2017). The Influence of crime on active & sustainable travel: New geo-statistical methods and theories for understanding crime and mode choice. Journal of Transport & Health, 6, 516–529.

Arbis, D., Rashidi, T. H., Dixit, V. V, & Vandebona, U. (2016). Analysis and planning of bicycle parking for public transport stations. International Journal of Sustainable Transportation, 10(6), 495–504.

Bachand-Marleau, J., Larsen, J., & El-Geneidy, A. M. (2011). Much-anticipated marriage of cycling and transit: How will it work? Transportation Research Record, 2247, 109–117.

Bopp, M., Sims, D., Colgan, J., Rovniak, L., Matthews, S. A., & Poole, E. (2016). An examination of workplace influences on active commuting in a sample of university employees. Journal of Public Health Management and Practice, 22(4), 387–391.

Bopp, M., Sims, D., Matthews, S. A., Rovniak, L. S., Poole, E., & Colgan, J. (2016). There′s an app for that: development of a smartphone app to promote active travel to a college campus. Journal of Transport and Health, 3(3), 305–314.

Braun, L. M., Rodriguez, D. A., Cole-Hunter, T., Ambros, A., Donaire-Gonzalez, D., Jerrett, M., … de Nazelle, A. (2016). Short-term planning and policy interventions to promote cycling in urban centers: Findings from a commute mode choice analysis in Barcelona, Spain. Transportation Research Part A: Policy and Practice, 89, 164–183.

Brock, W. A., & Durlauf, S. N. (2002). A Multinomial-Choice Model of Neighborhood Effects. American Economic Review, 92(2), 298–303.

Buehler, R. (2012). Determinants of bicycle commuting in the Washington, DC region: The role of bicycle parking, cyclist showers, and free car parking at work. Transportation Research Part D, 17(7), 525–531.

Bueno, P. C., Gomez, J., Peters, J. R., & Vassallo, J. M. (2017). Understanding the effects of transit benefits on employees' travel behavior: Evidence from the New York-New Jersey region. Transportation Research Part A, 99, 1–13.

Burke, M. I. (2011). Are cycle centers effective transport interventions? Evaluating King George Square cycle center in Brisbane, Australia. Transportation Research Record, 2247(1), 118–125.

Calimente, J. (2012). Rail integrated communities in Tokyo. Journal of Transport and Land Use, 5(1), 19–32.

Castillo-Manzano, J. I., Castro-Nuño, M., & López-Valpuesta, L. (2015). Analyzing the transition from a public bicycle system to bicycle ownership: A complex relationship. Transportation Research Part D, 38, 15–26.

Caulfield, B., Brick, E., & McCarthy, O. T. (2012). Determining bicycle infrastructure preferences - A case study of Dublin. Transportation Research Part D, 17(5), 413–417.

Cervero, R., Caldwell, B., & Cuellar, J. (2013). Bike-and-ride: Build it and they will come. Journal of Public Transportation, 16(4), 83–105.

Chen, L., Pel, A., Chen, X., Sparing, D., & Hansen, I. (2012). Determinants of bicycle transfer demand at metro stations. Transportation Research Record, 2276, 131–137.
Chief Medical, O. (2011). Start active, stay active: a report on physical activity from the four home countries'. Chief medical officers. London: Department of Health.
Chriqui, J. F., Leider, J., Thrun, E., Nicholson, L. M., & Slater, S. (2016a). Communities on the Move: Pedestrain-Oriented Zoning as a Facilitator of Adult Active Travel to Work in the United States. Frontiers in Public Health, 4.
Chriqui, J. F., Leider, J., Thrun, E., Nicholson, L. M., & Slater, S. J. (2017). Pedestrian-oriented zoning is associated with reduced income and poverty disparities in adult active travel to work, United States. Preventive Medicine, 95, S126–S133.
Chriqui, J. F., Nicholson, L. M., Thrun, E., Leider, J., & Slater, S. J. (2016b). More Active Living–Oriented County and Municipal Zoning Is Associated With Increased Adult Leisure Time Physical Activity—United States, 2011. Environment and Behavior, 48(1), 111–130.
Curto, A., De Nazelle, A., Donaire-Gonzalez, D., Cole-Hunter, T., Garcia-Aymerich, J., Martínez, D., … Nieuwenhuijsen, M. J. (2016). Private and public modes of bicycle commuting: A perspective on attitude and perception. European Journal of Public Health, 26(4), 717–723.
De Souza, F., La Paix Puello, L., Brussel, M., Orrico, R., & van Maarseveen, M. (2017). Modelling the potential for cycling in access trips to bus, train and metro in Rio de Janeiro. Transportation Research Part D, 56, 55–67.
Debrezion, G., Pels, E., & Rietveld, P. (2009). Modelling the joint access mode and railway station choice. Transportation Research Part E, 45(1), 270–283.
Flanagan, E., Lachapelle, U., & El-Geneidy, A. (2016). Riding tandem: Does cycling infrastructure investment mirror gentrification and privilege in Portland, OR and Chicago, IL? Research in Transportation Economics, 60, 14–24.
Fujii, S. (2005). Reducing inappropriate bicycle parking through persuasive communication. Journal of Applied Social Psychology, 35(6), 1171–1196.
Fukuda, D., & Morichi, S. (2007). Incorporating aggregate behavior in an individual's discrete choice: An application to analyzing illegal bicycle parking behavior. Transportation Research Part A, 41(4), 313–325.
Gaffga, G., & Hagemeister, C. (2016). Space for tricycles and bike trailers: Necessary provisions. Proceedings of the institution of Civil Engineers, 169(2), 67–75.
Gamman, L., Thorpe, A., & Willcocks, M. (2004). Bike Off! tracking the design terrains of cycle parking: Reviewing use, misuse and abuse. Crime Prevention and Community Safety, 6(4), 19–36.
Geurs, K. T., La Paix, L., & Van Weperen, S. (2016). A multi-modal network approach to model public transport accessibility impacts of bicycle-train integration policies. European Transport Research Review, 8(4).
Halldórsdóttir, K., Nielsen, O. A., Prato, C. G., Halldorsdottir, K., Nielsen, O. A., & Prato, C. G. (2017). Home-end and activity-end preferences for access to and egress from train stations in the Copenhagen region. International Journal of Sustainable Transportation, 11(10), 776–786.
Hamre, A., & Buehler, R. (2014). Commuter mode choice and free car parking, public transportation benefits, showers/lockers, and bike parking at work: Evidence from the Washington, DC region. Journal of Public Transportation, 17(2), 67–91.
Harvey, E., Brown, C. T., DiPetrillo, S., & Kay, A. (2016). Bicycling to Rail Stations in New Jersey. Transportation Research Record: Journal of the Transportation Research Board, 2587, 50–60.

Heinen, E., Maat, K., & van Wee, B. (2013). The effect of work-related factors on the bicycle commute mode choice in the Netherlands. Transportation, 40(1), 23–43.
Heinen, E., van Wee, B., & Maat, K. (2009). Commuting by bicycle: an overview of the literature. Transport Reviews, 30(1), 59–96.
Hipp, J. A., Dodson, E. A., Lee, J. A., Marx, C. M., Yang, L., Tabak, R. G., … Brownson, R. C. (2017). Mixed methods analysis of eighteen worksite policies, programs, and environments for physical activity. International Journal of Behavioral Nutrition and Physical Activity, 14(1), 79.
Hirsch, J. A., Meyer, K. A., Peterson, M., Rodriguez, D. A., Song, Y., Peng, K., … Gordon-Larsen, P. (2016). Obtaining Longitudinal Built Environment Data Retrospectively across 25 years in Four US Cities. Frontiers in Public Health, 4.
Hunt, J. D., & Abraham, J. E. (2007). Influences on bicycle use. Transportation, 34(4), 453–470.
Ji, Y., Fan, Y., Ermagun, A., Cao, X., Wang, W., & Das, K. (2017). Public bicycle as a feeder mode to rail transit in China: The role of gender, age, income, trip purpose, and bicycle theft experience. International Journal of Sustainable Transportation, 11(4), 308–317.
Kaczynski, A. T., Bopp, M. J., & Wittman, P. (2010). Association of workplace supports with active commuting. Preventing Chronic Disease, 7(6).
Kamargianni, M. (2015). Investigating next generation's cycling ridership to promote sustainable mobility in different types of cities. Research in Transportation Economics, 53, 45–55.
Kamargianni, M., & Polydoropoulou, A. (2013). Hybrid choice model to investigate effects of teenagers' attitudes toward walking and cycling on mode choice behavior. Transportation Research Record, 2382, 151–161.
Krizek, K. J., & Stonebraker, E. W. (2011). Assessing options to enhance bicycle and transit integration. Transportation Research Record.
Lambe, B., Murphy, N., & Bauman, A. (2017). Active travel to primary schools in Ireland: An opportunistic evaluation of a natural experiment. Journal of Physical Activity and Health, 14(6), 448–454.
Larsen, J. (2017). The making of a pro-cycling city: Social practices and bicycle mobilities. Environment and Planning A, 49(4), 876–892.
Lee, A., & March, A. (2010). Recognising the economic role of bikes: Sharing parking in Lygon Street, Carlton. Australian Planner, 47(2), 85–93.
Lusk, A. C., Anastasio, A., Shaffer, N., Wu, J., & Li, Y. (2017). Biking practices and preferences in a lower income, primarily minority neighborhood: Learning what residents want. Preventive Medicine Reports, 7, 232–238.
Lusk, A. C., Wen, X., & Zhou, L. (2014). Gender and used/preferred differences of bicycle routes, parking, intersection signals, and bicycle type: Professional middle class preferences in Hangzhou, China. Journal of Transport and Health, 1(2), 124–133.
Mackie, H. (2010). Overcoming barriers to cycling to school: A key to improving transport system performance. Road and Transport Research, 19(2).
Majumdar, B. B., & Mitra, S. (2015). Identification of factors influencing bicycling in small sized cities: A case study of Kharagpur, India. Case Studies on Transport Policy, 3(3), 331–346.
Maldonado-Hinarejos, R., Sivakumar, A., & Polak, J. W. (2014). Exploring the role of individual attitudes and perceptions in predicting the demand for cycling: a hybrid choice modelling approach. Transportation, 41(6), 1287–1304.
Mandic, S., Hopkins, D., García Bengoechea, E., Flaherty, C., Williams, J., Sloane, L., … Spence, J. C. (2017). Adolescents' perceptions of cycling versus walking to school:

Understanding the New Zealand context. Journal of Transport and Health, 4, 294–304.
Marsden, G. (2006). The evidence base for parking policies-a review. Transport Policy, 13(6), 447–457.
Martens, K. (2007). Promoting bike-and-ride: The Dutch experience. Transportation Research Part A, 41(4), 326–338.
Martinez, M. J., & Cornejo, J. (2003). Value of Facilities and Attributes of New Heavy Rail and Bus Rapid Transit Projects in a Developing City . The Case of Lima , Peru Value of Facilities and Attributes of New Heavy Rail and Bus Rapid Transit Projects in a Developing City . The Case of Lima, 3, 1–17.
Mburu, L. W., & Helbich, M. (2016). Environmental risk factors influencing bicycle theft: A spatial analysis in London, UK. PLoS ONE, 11(9), 1–19.
McDonald, N. C., Yang, Y., Abbott, S. M., & Bullock, A. N. (2013). Impact of the Safe Routes to School program on walking and biking: Eugene, Oregon study. Transport Policy, 29, 243–248.
Meng, M., Zhang, J., Wong, Y. D., & Au, P. H. (2016). Effect of weather conditions and weather forecast on cycling travel behavior in Singapore. International Journal of Sustainable Transportation, 10(9), 773–780.
Molin, E., & Maat, K. (2015). Bicycle parking demand at railway stations: Capturing price-walking trade offs. Research in Transportation Economics, 53, 3–12.
Mongeon, P., & Paul-Hus, A. (2016). The journal coverage of Web of Science and Scopus: a comparative analysis. Scientometrics, 106(1), 213–228.
Moskovitz, D., & Wheeler, N. (2011). Bicycle parking analysis with time series photography. Transportation Research Record, 2247, 64-71.
Mrkajic, V., Stamenkovic, M., Males, M., Vukelic, D., & Hodolic, J. (2010). Proposal for reducing problems of the air pollution and noise in the urban environment. Carpathian Journal of Earth and Environmental Sciences, 5(1), 49–56.
Mrkajic, V., Vukelic, D., & Mihajlov, A. (2015). Reduction of CO2 emission and non-environmental co-benefits of bicycle infrastructure provision: The case of the University of Novi Sad, Serbia. Renewable and Sustainable Energy Reviews, 49, 232–242.
Murillo Acosta, M., & Romero-Conrado, A. (2017). The influences of perceptions in bicycle demand for users with the same socioeconomic characteristics. Espacios, 38(16).
Nakamura, H., & Abe, N. (2014). Evaluation of the hybrid model of public bicycle-sharing operation and private bicycle parking management. Transport Policy, 35, 31–41.
Nkurunziza, A., Zuidgeest, M., Brussel, M., & Van Maarseveen, M. (2012). Examining the potential for modal change: Motivators and barriers for bicycle commuting in Dar-es-salaam. Transport Policy, 24, 249–259.
Noland, R. B., & Kunreuther, H. (1995). Short-run and long-run policies for increasing bicycle transportation for daily commuter trips. Transport Policy, 2(1), 67.
Owen, H., Day, R. H., & Scullion, P. (1999). Cycling and walking: Why don't hospitals provide facilities for healthy transport? Australian Journal of Primary Health - Interchange, 5(2), 105–113.
Pfaffenbichler, P. C., & Brezina, T. (2016). Estimating bicycle parking demand with limited data availability. Proceedings of the institution of civil engineers.
Piatkowski, D. P., & Marshall, W. E. (2015). Not all prospective bicyclists are created equal: The role of attitudes, socio-demographics, and the built environment in bicycle commuting. Travel Behaviour and Society, 2(3), 166–173.
Pucher, J., & Buehler, R. (2006). Why Canadians cycle more than Americans: A comparative analysis of bicycling trends and policies. Transport Policy, 13(3), 265–279.

Pucher, J., & Buehler, R. (2008a). Cycling for everyone: Lessons from Europe. Transportation Research Record, 2074, 58–65.
Pucher, J., & Buehler, R. (2008b). Making Cycling Irresistible: Lessons from The Netherlands, Denmark and Germany. Transport Reviews, 28(4), 495–528.
Pucher, J., & Buehler, R. (2017). Cycling towards a more sustainable transport future. Transport Reviews, 1–6.
Pucher, J., Buehler, R., & Seinen, M. (2011). Bicycling renaissance in North America? An update and re-appraisal of cycling trends and policies. Transportation Research Part A, 45(6), 451–475.
Puello, L. L. P., & Geurs, K. (2015). Modelling observed and unobserved factors in cycling to railway stations: Application to transit-oriented-developments in the Netherlands. European Journal of Transport and Infrastructure Research, 15(1), 27–50.
Rojas López, M. C., & Wong, Y. D. (2017). Attitudes towards active mobility in Singapore: A qualitative study. Case Studies on Transport Policy, 5(4), 662–670.
Schipperijn, J., Bentsen, P., Troelsen, J., Toftager, M., & Stigsdotter, U. K. (2013). Associations between physical activity and characteristics of urban green space. Urban Forestry Urban Greening, 12 (1), 109–116.
Shaheen, S., Zhang, H., Martin, E., & Guzman, S. (2011). China's Hangzhou Public Bicycle: Understanding early adoption and behavioral response to bikesharing. Transportation Research Record, 2247, 33–41.
Sherwin, H., Parkhurst, G., Robbins, D., & Walker, I. (2011). Practices and motivations of travellers making rail-cycle trips. Proceedings of the Institution of Civil Engineers: Transport, 164(3), 189–197.
Shimada, T., & Arai, T. (2017). The effect of victim description and receiver vulnerability in threat appeal on crime prevention behavior. Shinrigaku Kenkyu, 88(3), 230–240.
Sidebottom, A., Thorpe, A., & Johnson, S. D. (2009). Using targeted publicity to reduce opportunities for bicycle theft: A demonstration and replication. European Journal of Criminology, 6(3), 267–286.
Simons, D., Clarys, P., De Bourdeaudhuij, I., de Geus, B., Vandelanotte, C., & Deforche, B. (2014). Why do young adults choose different transport modes? A focus group study. Transport Policy, 36, 151–159.
Stinson, M. A., & Bhat, C. R. (2004). Frequency of Bicycle Commuting: Internet-Based Survey Analysis. Transportation Research Record, 1878, 122–130.
Susilo, Y. O., Williams, K., Lindsay, M., & Dair, C. (2012). The influence of individuals' environmental attitudes and urban design features on their travel patterns in sustainable neighborhoods in the UK. Transportation Research Part D: Transport and Environment, 17(3), 190–200.
Taylor, D., & Mahmassani, H. (1996). Analysis of stated preferences for intermodal bicycle-transit interfaces. Transportation Research Record, 1556, 86–95.
Thompson, S. T. C. (2006). Bicycle access to public libraries: A survey of Pennsylvania public libraries and their accessibility to patrons arriving via bicycle. Library Philosophy and Practice, 9(1).
Titze, S., Stronegger, W. J., Janschitz, S., & Oja, P. (2007). Environmental, social, and personal correlates of cycling for transportation in a student population. Journal of Physical Activity & Health, 4(1), 66–79.
Vairo, N., Bopp, M., & Sims, D. (2017). Best practices for businesses promoting bicycling. International Journal of Health Promotion and Education, 55(5–6), 298–310.
Van der Spek, S. C., & Scheltema, N. (2015). The importance of bicycle parking management. Research in Transportation Business and Management, 15, 39–49.

Van Lierop, D., Grimsrud, M., & El-Geneidy, A. (2015). Breaking into bicycle theft: Insights from Montreal, Canada. International Journal of Sustainable Transportation, 9(7), 490–501.

Villwock-Witte, N., Gleason, R., & Shapiro, P. (2012). Good practices to encourage bicycling and pedestrians on federal lands 11 components. Transportation Research Record, 2307, 80–89.

Wang, C.-H., Akar, G., & Guldmann, J.-M. (2015). Do your neighbors affect your bicycling choice? A spatial probit model for bicycling to The Ohio State University. Journal of Transport Geography, 42, 122–130.

Yang, J., Chen, J., Zhou, M., & Wang, Z. (2015). Major issues for biking revival in urban China. Habitat International, 47, 176–182.

Yang, M., & Zacharias, J. (2016). Potential for revival of the bicycle in Beijing. International Journal of Sustainable Transportation, 10(6), 517–527.

Yuan, C., Sun, Y., Lv, J., & Lusk, A. C. (2017). Cycle tracks and parking environments in China: Learning from college students at Peking university. International Journal of Environmental Research and Public Health, 14(8), 930.