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The strengths and weaknesses of bike sharing as an alternative mode during disruptive public health crisis: A qualitative analysis on the users’ motivations during COVID-19

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ABSTRACT

The coronavirus pandemic may provoke an increase on our overreliance on private car usage due to a permanent loss of confidence on public transport (PT), threatening current decarbonization efforts of the transport sector. Thus, alternative modes like bike sharing systems (BSS) must be considered.

In this study, through conducting 16 semi-structured interviews and by employing thematic analysis, we explore the users’ perceptions of using Lisbon’s BSS during this pandemic. Our findings show that the observed decrease on BSS usage during the COVID-19 lockdowns was mostly due to mandatory teleworking than to a perceived infection risk. Even during the height of the pandemic, users still turned to BSS to fulfill their essential trip needs. Users considered bike sharing to have a lower infection risk comparatively to PT, with some users joining BSS during the pandemic to specifically avoid using PT. Furthermore, users associate riding a shared bicycle with a pleasant activity that reduces their travel times and costs, while also providing health and environmental benefits. Consequently, bike sharing contributes to the resilience of transport systems by providing its users with a transport alternative perceived to have a low infection risk, ensuring their mobility needs during disruptive events.

Findings from this research provide evidence that support policies, such as, expanding BSS coverage areas, optimizing rebalancing operations, introducing shared e-bikes, and implementing segregated cycling lanes alongside BSS. These policies may be particularly effective at increasing the competitiveness of BSS as an alternative mode during disruptive public health crises and beyond.

1. Introduction

The coronavirus pandemic presents serious challenges for the transport sector. Public transport (PT) systems have been especially affected by COVID-19 due to the infection fear of having large numbers of passengers in confined spaces for long periods of time, leading to massive ridership drops (Gkiotsalitis and Cats, 2020; Teixeira and Lopes, 2020). Even during the periods where COVID-19 seemed under control and no travel restrictions were in effect, PT ridership remained well below pre-pandemic levels, showing disturbing signs that users may have lost confidence on PT systems (Medlock et al., 2021). For example, in New York City during the summer of 2021 when COVID-19 infection rates were low (NYC Health, 2021), subway and bus ridership were still 50% and 60%, respectively, of the pre-pandemic levels (MTA, 2021).

As epidemiologists start to consider the possibility that the coronavirus will become endemic (Phillips, 2021), the question may not be how long it will take to PT ridership to recover to pre-pandemic levels, but rather if it will recover at all. Such a permanent PT ridership loss would have severe consequences particularly regarding current decarbonizing efforts. The transport sector is a major source of CO₂ emissions, with private car usage being by far the main culprit (Graham-Rowe et al., 2011; Brand and Dons, 2021). Indeed, car usage has been much less affected than PT during this pandemic, registering lower ridership drops and being perceived as having a lower risk of infection (de Haas et al., 2020; Shamshiripour et al., 2020). Consequently, this pandemic could further exacerbate our current overreliance on car travel.

Cycling has been positioning itself as an alternative, with cycling levels increasing in several countries during COVID-19 (Buehler and...
Pucher, 2021; Kraus and Koch, 2021). In this study we look at one of the most popular measures promoting cycling: bike sharing systems (BSS). Characterized by providing bicycles either at stations or within operational areas, BSS are known for their convenience and affordability, being associated with increasing both the number and the diversity of cyclists (Teixeira and Moura e Sá, 2021a). BSS have already been shown to be able to reduce private car usage (Teixeira and Moura e Sá, 2021a), and to be a transport alternative during disruptive events such as PT strikes (Saber et al., 2018).

As such, it is paramount not only to investigate how coronavirus is impacting bike sharing, but also what can be the potential role of BSS during this pandemic and similar disruptive public health crises. In that sense, the use of qualitative methods could deliver important insights on the disruptive impacts that COVID-19 has provoked on travel behaviour, providing rich, in-depth data on BSS users’ motivations and attitudes which is not easily captured by quantitative approaches (Clifton and Handy, 2003; Beirao and Sarsfield Cabral, 2007). Consequently, the objectives of this research were twofold. Firstly, we aimed at analysing the major COVID-19 impacts on the travel behaviour as well as the motivations and safety perceptions of BSS users, better understanding why they have chosen to use bike sharing during the pandemic instead of other available modes of transport. Secondly, we assessed the strengths and weaknesses of bike sharing to identify the features that could increase the competitiveness of BSS as an alternative mode during disruptive public health crisis like COVID-19 and beyond. Through conducting semi-structured interviews to the users of Lisbon’s BSS (entitled GIRA) and by employing thematic analysis, we present, to the best of our knowledge, the first qualitative study focused on examining the effects of COVID-19 on BSS users.

The rest of the paper is structured as follows. Section 2 provides a literature overview of the potential benefits of bike sharing (2.1.) and the main reasons for (not) using BSS (2.2.), with a special emphasis on the contribution of qualitative studies (2.3.), as well as on the existing research exploring the COVID-19 impacts on BSS (2.4.). Section 3 briefly describes the case-study (3.1.) and the employed methodology (3.2.). Section 4 presents the results of the thematic analysis, which are then discussed in section 5. Lastly, section 6 explores the main conclusions, ending with policy recommendations aimed at improving BSS.

2. Literature review

2.1. The (potential) benefits of bike sharing

Embodying the modernistic “ideals of freedom, privacy, movement, progress and autonomy” (Böhm et al., 2006), the car has throughout the last century dominated our transport systems and reshaped our urban areas (Urry, 2004; Bart, 2010). Fostered by planning processes and transport models focused on the paradigm of predict and provide (Owens, 1995), automobility has marginalized other modes of transport such as PT, walking and cycling (Cox, 2008; Koglin and Rye, 2014). However, such overreliance on private car travel has led to several negative consequences, including regarding climate change (Douglas et al., 2011; Gossling, 2020).

Consequently, there is a growing pressure to promote a more sustainable mobility through challenging the current automobility regime (Ogilvie et al., 2004; Urry, 2004; Graham-Rowe et al., 2011). In that regard, cycling is amongst the most promising solutions to tackle this car dependency, especially in urban areas (Pucher and Buehler, 2008), being amongst the most efficient decarbonization policies (Brand and Dons, 2021; Brand and Gotschi, 2021). For instance, a recent study estimated that if countries cycled as much as the Netherlands, it could lead to a reduction of 686 million metric tons of CO₂ emissions and prevent 0.62 million deaths per year (Chen et al., 2022). Moreover the bicycle also shares most of the same modernistic ideals of the car such as the freedom of movement and autonomy (Cox, 2008), with bicycles capable of being even faster than cars in urban areas (Jensen et al., 2010).

However, the pervasive nature of automobility that dominates not only our current transport systems but also our planning practices and culture (Urry, 2004; Cox, 2008; Koglin and Rye, 2014; Haustein et al., 2020), hinders any transition to alternative mobility cultures (Koglin, 2015). Indeed, even in cities where cycling usage is widespread such as Copenhagen, the car continues to dominate (Freudental-Pedersen, 2015a; 2015b; Haustein et al., 2020). Taking inspiration from the concept of biodiversity, Cox (2008) argues that we are currently facing a mobility monoculture, where the car is the default transport alternative for most citizens, suggesting that a possible way to challenge this automobility dominance is by introducing alternative modes of transport. In that sense, the meteoric rise of bike sharing in the last two decades, with BSS currently deployed in more than 1000 cities and providing more than 10 million shared bikes (Meddin Bike-sharing World Map, 2021), could offer such alternative.

Several benefits have been attributed to bike sharing, namely its ability to reduce CO₂ emissions and other air pollutants, increase physical activity levels, induce travel time savings and decrease congestion levels (Teixeira and Moura e Sá, 2021a), provided that BSS are replacing car trips which is not always the case (Medard de Chardon, 2019). Amongst the most promising benefits of BSS is their potential ability to increase cycling levels and normalize cycling usage in low-cycling contexts (Goodman et al., 2014; Teixeira, Silva and Moura e Sá, 2021a). For example, New York City’s BSS is responsible for around 10% of the city’s cycling trips, even though the system is still mostly confined to the city core (Department of Transportation NYC, 2018). Bike sharing has also been associated with reversing the decline of cycling usage in China (Mobike, 2017) with, for instance, Beijing’s dockless BSS accounting for over 1.5 million trips per day and having more than 11 million users (which corresponds to half the city’s population) (Chai et al., 2021).

Importantly, bike sharing has been associated with increasing the diversity of cyclists (Goodman et al., 2014) and to enhance the public legitimacy of cycling (Fishman et al., 2012). For example, through observing the clothing of BSS users comparatively to cyclists using their own bike in London, Goodman, Green and Woodcock (2014) found that BSS users were much less likely to use any type of specialist cycling clothing (such as helmets and sports clothes). Seeing other people cycling (Fishman et al., 2012), particularly “people like yourself”, could help to attract potential cyclists that avoid cycling due to it being perceived as an activity for “sporty” people and not for them (Aldred, 2013; Goodman et al., 2014).

2.2. Overview of the main reasons for joining bike sharing

Mostly through conducting travel behaviour surveys, researchers enquired BSS users regarding their motivations for using bike sharing, with a smaller number of studies also investigating the reasons of non-users for not joining BSS. We present in Table 1 an overview on the main literature findings regarding the reasons for (not) using bike sharing.

Users cite several reasons for joining bike sharing. Convenience is often referred to as the major motivation for using BSS (Riccì, 2015; Fishman, 2016). For example, a survey targeting users and non-users of bike sharing in two Australian cities (Brisbane and Melbourne) found that the convenience of using bike sharing was the most important motivation, while for non-users their main justification for not joining BSS was that other modes of transport (such as the car) were more convenient to use (Fishman et al., 2014). Convenience is in addition closely related to the suitable location of BSS stations near users’ homes and destinations (Bachand-Marleau et al., 2012; Fishman et al., 2015; Raux et al., 2017; Hosford et al., 2018) as well as the easiness of using the system itself (Fishman et al., 2012; Chen and Lu, 2016; Wu et al., 2019).

Furthermore, users associate bike sharing with reductions on their
Table 1
Summary of the current literature on the main motivations and barriers for using bike sharing.

| Reasons for (not) using BSS | Main Findings | References |
|-----------------------------|---------------|------------|
| Convenience (related to availability, usefulness, spontaneity, easiness of use) | Major reason for BSS usage for all users Car convenience is a barrier Perceived ease of use positively influences positive attitudes towards BSS | Fishman et al. (2012) (F); Fishman et al. (2014) (S); Ricci (2015) (R); Chen and Lu (2016) (S); Fishman et al. (2014); Ricci (2015); Fishman (2016) (S); Wu et al. (2019) (S) |
| BSS stations close to O/D | Motivation for BSS use (related to convenience) | Bachand-Marleau et al. (2012) (S); Fishman et al. (2015) (S); Raux et al. (2017) (S); Hosford et al. (2018) (S) |
| Reductions on travel times | Motivation for BSS use | TfL (2011) (S); Fishman et al. (2014) (S); Reilly et al. (2020) (S) |
| Financial savings | Among the motivations for BSS use for some users | TfL (2011) (S); Ma et al. (2020) (S); Reilly et al. (2020) (S) |
| Enjoyment/pleasure of cycling | Major motivation for BSS use Perceived fun to use is positively associated with users’ continuing to use BSS | Fishman et al. (2014) (S); Chen (2016) (S); Wu et al. (2019) (S) |
| Environmental benefits | Among the motivations for BSS use Associated with intention to use and to continue to use | TfL (2011) (S); Fishman et al. (2014) (S); Chen and Lu (2016) (S); Kim et al. (2017) (S); Hosford et al. (2018) (S); Wang et al. (2018) (S); Cerutti et al. (2019) (S) |
| Health benefits | Health/exercising among the motivations for BSS use Perceived health gains (physical and mental) influence positive attitudes towards BSS | TfL (2011) (S); Fishman et al. (2014) (S); Kim et al. (2017) (S); Hosford et al. (2018) (S); Cerutti et al. (2019) (S) |
| Safety | Lack of cycling infrastructure and dangerous driving behaviour are reasons for not using BSS | Fishman et al. (2012) (F); Bateman et al. (2021) (F) |
| Helmet use | Barrier for BSS use in countries where helmet is mandatory | Ricci (2015) (R); Fishman (2016) (R) |
| Social influence | The attractive design of the bikes as well as seeing people using them positively influence BSS usage | Bachand-Marleau et al. (2012) (S); Fishman et al. (2012) (F); Wang et al. (2018) (S); Chen et al. (2020) (S) |

(F) – Focus group; (I) – Interview; (R) – Literature review; (S) – Survey.

decision to use or not bike sharing. Arguably the most influential qualitative study on bike sharing was developed by Fishman et al. (2012) with the aim of identifying motivations and barriers for using BSS in Brisbane (Australia). Employing thematic analysis and focus groups, which were categorized according to the type of cyclists (non and infrequent cyclists; regular cyclists; BSS users), Fishman et al. (2012) found that the reasons for (not) using Brisbane’s BSS revolved around three major themes: accessibility and spontaneity; safety; weather and topography. Also through thematic analysis, Lyu et al. (2021) conducted semi-structured interviews to the BSS users of Shanghai (China), providing an unique view from a city that was amongst the first to experience the rise (and fall) of the dockless systems. Among others, the study revealed the major problems of Shanghai’s BSS to be related to the poor quality of the bicycles due to vandalism and inadequate maintenance; rebalancing issues; as well as the fact that several dockless systems abruptly closed due to bankruptcy, leading users to lose confidence on the systems (Lyu et al., 2021). Similarly to the previous two studies, Bateman et al. (2021) assessed the motivators and barriers for BSS usage in Alabama (USA), classifying the barriers and motivators as intrapersonal, interpersonal and as structural factors. Bateman et al. (2021) found that the most important motivations influencing BSS usage where not so much connected to intrapersonal or interpersonal factors (like the pleasure of cycling or the support from friends and family) but to structural ones such as the coverage of the system and features of the built environment (like the existence of dedicated cycling lanes).

2.4. The coronavirus pandemic and BSS usage

A growing body of literature is revealing BSS to be more resilient than other modes of transport, particularly PT, to the current coronavirus pandemic, suffering lower ridership drops (Bacsoky, 2020; Teixeira and Lopes, 2020; Hu et al., 2021) and registering faster recovery rates (Hu et al., 2021; Wang and Noland, 2021), with ridership recovering and even surpassing pre-pandemic levels (Wang and Noland, 2021). Moreover, several BSS registered an increase in their average trip durations during the pandemic (Teixeira and Lopes, 2020; Hu et al., 2021; Padmanabhan et al., 2021; Shang et al., 2021), with preliminary research pointing to some PT users shifting to bike sharing (Teixeira and Lopes,
In order to better understand the reasons for the BSS relative resilience to the pandemic, a smaller number of studies has started to analyse the effects of COVID-19 on the travel behaviour of BSS users through surveys (Nikiforiadis et al., 2020; Shamshiripour et al., 2020; Teixeira, Silva and Moura e Sã, 2021b, 2022). The emerging trend from such studies seems to point that bike sharing is considered to have a lower infection risk comparatively to public transport, but is perceived as less safe than using personal modes such as the private car (Nikiforiadis et al., 2020; Shamshiripour et al., 2020; Teixeira, Silva and Moura e Sã, 2022). For instance, through using a travel survey aimed at the BSS users of Lisbon, Teixeira, Silva and Moura e Sã (2021b, 2022) found that users now value much more using BSS to avoid PT and to maintain a social distance during their trips, leading the authors to hypothesize that BSS could provide an alternative to PT during COVID-19.

Building on this previous research, in this study we conducted semi-structured interviews with BSS users from Lisbon to explore in more depth the individual behavioural changes provoked by coronavirus, particularly regarding their motivations and attitudes. Furthermore, this research aims to use the detailed data provided by qualitative methods to better understand the reasons that lead users to choose bike sharing instead of other available modes of transport. For instance, inconveniences associated with specific modes of transport previously used can be a major motivation for shifting to BSS, however that concept varies according to the mode of transport being replaced. For former car users, perhaps, the difficulty in finding car parking or enduring traffic jams could explain their decision to shift to bike sharing, while for former PT users overcrowding could be a major motivation. Accordingly, the setting of a semi-structured interview will provide the opportunity to discuss in depth more specific types of motivations, not easily captured by the close-ended responses that characterize travel surveys, and which have been so far insufficiently addressed in the literature.

3. Study design

3.1. Case-study

As case-study we used the bike sharing system of Lisbon, named GIRA. Lisbon is the capital of Portugal and, like the rest of the country, is heavily reliant on car use with 45% of all commuting trips being conducted by car, while cycling represents less than 1% of the modal share (INE, 2018). As such, Lisbon can be classified as a starter cycling city, e., a city with a residual cycling shares characterized by having poor cycling conditions and no cycling tradition (Rupprecht et al., 2016; Silva et al., 2019).

To reduce car usage in the city, since 2016 Lisbon has started to promote cycling as a mode of transport, mainly through developing a 200 km dedicated cycling network (mostly constituted by cycling lanes and paths segregated from motorized traffic) and by implementing a public-owned docked BSS (Câmara Municipal de Lisboa, 2020). Nevertheless, most of the city’s transport infrastructure (and public space) continues to be allocated to the car. Fig. 1 presents the location of the GIRA stations and the existing cycling network. GIRA currently has around 700 shared bikes (most being e-bikes) distributed among 83 stations, which are mainly concentrated in the city centre and riverside.

Regarding the impact of COVID-19 on GIRA’s operation, the system was initially closed during the first COVID-19 lockdown on March 18th, 2020 (EMEL, 2020c). However, GIRA was reopened just three days later to support essential workers such as healthcare professionals, security personal as well as food-delivery couriers (EMEL, 2020a, 2020b). Since then, GIRA remained open, including during the second full lockdown in 2021, operating normally with enhanced cleaning protocols.

Fig. 2 presents the percentage difference between GIRA’s monthly ridership in 2020 versus in 2019, comparing it with the reported number of new COVID-19 daily cases throughout 2020 (monthly average) in Portugal. The figure shows an overall trend in which GIRA ridership tends to decrease when COVID-19 daily cases increase. The system registered the largest ridership drops during the height of the first lockdown, culminating in an historic 65% ridership drop in April 2020 comparatively to the same period in 2019. However, with the end of the first lockdown, in May 2020, GIRA’s ridership quickly bounced back even surpassing pre-pandemic levels during the summer months. As the number of daily COVID-19 cases started again to rapidly increase in the beginning of autumn 2020, GIRA ridership levels declined again but at a lower rate when compared to the first wave (April 2020).

3.2. Data collection and analysis

In this study, semi-structured interviews were conducted following the implementation of a travel survey to the users of GIRA (Teixeira et al., 2021b, 2022) to explore in more depth the COVID-19 impacts on their travel behaviour, preferences and motivations. As such, the interviewees were recruited through the previously mentioned survey, which had an option at the end for respondents interested in participating in a second research phase to leave their contact details. Invitations for study participation were sent to the respondents who provided valid emails (63 in total), with 16° individuals agreeing to be interviewed.

The interviews were conducted between 4 and 19 of November 2021, through videocall with an average duration of 15 min. The interviews were recorded and transcribed verbatim. A series of questions (mostly open-ended) were asked to the participants focused on the reasons for their decision to use GIRA, the impacts of COVID-19 on that usage as well as GIRA’s relationship with other modes of transport (the list of the interview questions can be found as appendix).

The profile of the interviewees is provided in Table 2. Most participants were already GIRA users before COVID-19 and continue to currently use the system, while two interviewees reported to have joined GIRA during the pandemic. Regarding the sociodemographic profile of interviewees, more than half were male, with their ages ranging from 25 to 64 years old (the majority between 25 and 44 years old), and with only one interviewee not currently working.

We employed thematic analysis to interpret and structure the data obtained from the interviews, following Braun and Clarke (2006) 6-step approach. Thematic analysis is one of the most commonly used qualitative methods aimed at identifying patterns in the data (themes) (Braun and Clarke, 2006; Bryman, 2012). First, we became familiarized with the data through reading the transcripts multiple times and taking notes of initial ideas. Secondly, the entire dataset was analysed in a systematic way, grouping pertinent characteristics of the data into codes. Next, the generated codes were clustered into potential themes. Afterwards, the initial generated themes were reviewed considering their consistency and representativeness across the dataset as well as their relevance for our research goals. The last steps involved defining and naming the themes, followed by selecting illustrative interview excerpts for each theme.

1 To date, Portugal has experienced two full lockdowns as a response to the COVID-19 pandemic, which included in both cases stay-at-home orders, where only essential trips were allowed. The first lockdown was implemented between March 18th and May 2nd, 2020, while the second lockdown between January 15th and March 15th, 2021. In both cases the lockdown easing was gradual with several reopening phases.

2 A sample size of 12 interviews in considered as sufficient to reach data saturation in a relatively homogeneous population (Guest et al., 2006).

3 The interview excerpts presented throughout this study were translated from Portuguese to English by the first author.
Thematic analysis

Four major themes were developed. The first theme discusses the major impacts of COVID-19 on GIRA users, namely the perceived infection risk as well as the impact of government restrictions, particularly mandatory home/teleworking, on their travel behaviour. The following two themes explore the factors that influence bike sharing adoption, specifically the perceived benefits of using the system as well.

Fig. 1. Distribution of GIRA’s stations across Lisbon (background: Bing Maps).

Fig. 2. Percentage difference on GIRA’s monthly ridership between 2020 and 2019 versus the number of COVID-19 new daily cases (monthly average) throughout 2020 in Portugal (DGS, 2021).

4. Thematic analysis

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as the main factors behind its success or failure. The last theme delves on the relationship of bike sharing with other modes, particularly with the personal bicycle and the private car. Table 3 provides an overview of the themes and subthemes generated as well as their prevalence.

### 4.1. COVID-19 effects

The first theme discusses the major perceived impacts of COVID-19 on the usage of GIRA, being divided into four subthemes. Fig. 3 presents the associated subthemes as well as the interviewees that addressed each one of the subthemes.

#### 4.1.1. Teleworking

The restrictions on travelling implemented to try to curve the spread of the pandemic, limiting mobility especially during the lockdown periods, led to massive reductions on travel demand and, subsequently, also affected GIRA usage. As such, most interviewees reported a decrease on GIRA usage (as well as on virtually all other modes), particularly during the lockdown phases when teleworking was mandatory as bike sharing was often their mode of transport for commuting:

“The pandemic what it did was that part of my work became remote. So that made me decrease the use of GIRA substantially simply because I didn’t have to commute to my work which was the main use of the bicycles. So, I used it less. This was mainly in the first wave …” (Interviewee 5)

With the gradual lifting of the travel restrictions, users returned to the system. Furthermore, even during the lockdown periods, where GIRA ridership generally declined, five interviewees report that they still used the system in the trips that they had to do:

“Anyway, I remember that during the lockdown I had to travel a few times to work and from work. I had some visits and meetings outside and I remember to renew it especially, so I have the annual [GIRA] pass, and I remember at the height of the pandemic of needing to renew [the pass], because it had expired, for using.” (Interviewee 3)

#### 4.1.2. Infection risk

The prevalent opinion among the interviewees was that GIRA was a safe mode of transport to be used during the pandemic regarding infection risks, particularly when comparing to PT. Interviewees emphasized GIRA’s ability of allowing to maintain a social distance during their trips and to be an outdoor activity, in contrast with PT characterized by having a large number of people together in a closed and poorly ventilated environment. The only precaution mentioned by the interviewees when using GIRA was to wash or disinfect their hands before and after use, with some also disinfecting the shared bicycle before using it or wearing a mask during the trip:

“… because we maintain a social distance much more easily, we are in a ventilated area [outdoor]. The only caution is that we are sharing some equipment. If we have this precaution, and we wash or disinfect our hands after using it, I think it is much safer than actually being on a bus or on the subway where social distancing is sometimes not easy, and the fact that it is a very enclosed place.” (Interviewee 3)

“So, if the bicycle was available and if I could use it, I didn’t feel that it represented a risk. I mean, before using it I disinfected my hands, after using it I disinfected my hands, so no. Even while cycling I used a mask, even because at the time it was mandatory to wear a mask on the street, so I didn’t honestly feel that this represented a risk.” (Interviewee 14)

#### 4.1.3. Using GIRA to avoid PT

As a consequence of perceiving a lower infection risk while using GIRA comparatively to public transport, eight interviewees stated that they prefer to use GIRA instead of PT during this pandemic, replacing trips that they had previously done with PT:

“But I really feel that while before it was automatic for me to think about the route I had to take by metro and bus, now I have a previous step which is: ‘where am I going?’ the first thing I do is to open GIRA [the pass] and I remember that during the lockdown I had to travel a few times to work and from work. I had some visits and meetings outside and I remember to renew it especially, so I have the annual [GIRA] pass, and I remember at the height of the pandemic of needing to renew [the pass], because it had expired, for using.” (Interviewee 3)

Table 3

| Theme              | Subtheme                           | Frequency |
|--------------------|------------------------------------|-----------|
| COVID-19 effect    | Teleworking                        | 20        |
|                    | Infection risk                     | 31        |
|                    | Using GIRA to avoid PT             | 13        |
|                    | Food delivery couriers             | 4         |
| Perceived benefits | Reductions in travel times         | 25        |
|                    | Reductions in travel costs         | 12        |
|                    | Pleasure of cycling                | 11        |
|                    | Health benefits                    | 10        |
|                    | Environmental benefits             | 9         |
| Success determinants | System coverage                  | 29        |
|                    | Reliability                        | 37        |
|                    | E-bikes                            | 26        |
|                    | Safety                             | 42        |
| Relationship with other modes | Bike sharing & the personal bicycle | 23        |
|                    | Bike sharing & the private car     | 55        |
4.1.4. Food delivery couriers

An interesting topic that emerged during the interviews was the fact of GIRA being used by food-delivery couriers, such as Uber Eats, during the pandemic and how that impacted the availability of shared bicycles for the users. Two interviewees were extremely against this usage by what they consider an abuse of the system by private companies:

“But GIRA was intensely used by food-delivery couriers, intensely ... Indeed, there are all those images of GIRA bicycles always with those backpacks from Bolt and Uber Eats and so on. Meanwhile this has already decreased a little but it’s still the same thing, in a place like Bairro de Alvalade [a major Lisbon neighbourhood] where I live, at lunchtime or at dinnertime it’s unthinkable to be able to find a GIRA because they’re all taken by couriers and, therefore, one of the negative elements is that we are subsidizing something for an absolutely private use in a profit logic.” (Interviewee 4)

“At lunchtime, for example, the use of GIRA by Uber Eats and the like, which I know is prohibited but, greatly harms people who want to use GIRA during lunchtime and there is no supervision. They use it a lot at that hour and end up harming those who want to travel at lunchtime.” (Interviewee 12)

In fact, during the first lockdown after a short period where GIRA was closed, on March 21st 2020 the system was reopened to support, amongst others, food-delivery couriers as during the lockdowns restaurants and other food services were only allowed to operate through takeaway. However, with the end of the first lockdown in May 2020 and following major backlash from GIRA users, including an opinion piece published by a prominent newspaper columnist (Tavares, 2020), the operator decided to end this exceptional measure, but GIRA users still complain that this misuse continues to occur.

4.2. Perceived benefits

The second theme delves on the perceived benefits of using GIRA, aimed at better understanding why interviewees chose to use bike sharing. Users reported several personal benefits with five topics...
standing out (Fig. 4).

4.2.2. Reductions in travel times

Reductions in travel times was the most frequently mentioned benefit, with nine interviewees reporting GIRA to be the fastest mode of transport available to them in Lisbon:

“I even had the example that I could get from home to the workplace in 7 minutes [by bicycle]. If it was by walking it would be 20 min, if it was by subway it would also be 20 min, if it was by car it would be half an hour. That’s it, that’s the difference, isn’t it? It turned out to be the most functional mean.” (Interviewee 4)

Using GIRA allows its users to avoid traffic jams as well as PT strikes and other disruptions that affect those modes:

“… we are not conditioned by car traffic issues, by public transport strikes that are frequent, by any issue that happens to the bus or metro that makes them stop. So, the next one that only comes after half an hour and a half an hour of transport delay means, maybe, we arrive an hour late to work, and riding a GIRA or a bike in general we are usually not so exposed to these issues.” (Interviewee 11)

The existence of segregated cycling lanes is also often associated with decreasing travel times by allowing GIRA users to avoid traffic:

“… then with the fact that we have cycling lanes which end up making travelling faster, avoiding road traffic. So, we already have cycling lanes and they are dedicated cycling paths, so it ends up being faster to move to certain places.” (Interviewee 15)

4.2.3. Pleasure of cycling

The enjoyment of cycling was also highly regarded by GIRA users, with riding a bicycle being considered a much more pleasant activity than driving or using PT:

“… at the end of a working day, it’s much more pleasant to take a bike and go somewhere than to get on a bus, taking the subway it’s even worse, …” (Interviewee 10)

4.2.4. Health benefits

GIRA users also valued the opportunity of exercising while travelling as well as the health benefits of cycling, including regarding their mental health. Interviewee 11 perfectly explains this view:

“In terms of health, it has an excellent effect, it is preferable to cycle, whether with GIRA or not, than to take public transport. We have the issue of physical health; we also have the issue of mental health. I notice that those who cycle, those who ride a bicycle usually have a greater decompression in relation to work stress, etc., I think this is also a very important factor nowadays. There is a different contact between, I think, us and the city and the environment that surrounds us, than, for example, travelling in a closed tunnel using the subway, I don’t know. I think it’s healthier in every way.” (Interviewee 11)

4.2.5. Environmental benefits

The environmental benefits of using GIRA were also mentioned several times by the interviewees as a reason for joining the system:

“First of all, the environmental theme. I am generally in favour of public transport as a method to reduce CO2 emissions and unnecessary energy wastes.” (Interviewee 5)

In particular, interviewees consider bike sharing as a much more environmentally friendly mode of transport than the car:

“Then it’s a matter of the concept of a city in which cars must naturally be replaced by means of transport that are less polluting, less invasive, less noisy, …” (Interviewee 7)

4.3. Success determinants

Although the previous discussed benefits are important motivations for joining and using GIRA, they are not enough by themselves to ensure the success of a BSS. Consequently, this theme addresses the structural factors that influence the competitiveness of GIRA as a mode of transport. These factors were often characterized by the interviewees as both motivators as well as major barriers affecting their BSS usage. Four factors were identified (Fig. 5).

4.3.1. System coverage

In order to be considered as a viable transport alternative, a BSS needs to sufficiently cover the major destinations of its users. Furthermore, the suitable location of GIRA stations directly influences travel times and, consequently, the competitiveness of GIRA against other modes of transport:

“Most of my trips are relatively short, I live and work in the city centre, I have … [GIRA] stations near my home and my workplace, literally 50 m, 100 m from the front door. The place where I do sports, my children’s schools, all have [GIRA] stations, all are in the city centre and, therefore, everything has a GIRA nearby …” (Interviewee 6)

Therefore, when GIRA stations are not sufficiently near their destinations, GIRA stops being a transport option. Accordingly, one of the major barriers of GIRA mentioned by 15 of the 16 interviewees is that it still doesn’t cover enough of Lisbon to always fulfil their travel needs. A better system coverage would allow GIRA users to rely more on the system and to replace additional trips currently conducted by other modes of transport, including the car:

“But it’s because the GIRA network is not completed, I think that if they completed it […], it would allow me to make 80% of my trips with GIRA, maybe 80% is too much, but 60%, 70% of the trips.” (Interviewee 13)

This was particularly felt by some interviewees who moved to a new residence still inside Lisbon, but that found themselves now living in areas not served by GIRA, forcing them to use other transport alternatives that they wanted to avoid. This is illustrated by interviewee 10 which had avoided using PT during the pandemic due to infection fears but having moved to a new home and confronted with the need to get back to the workplace, had no other option but to use PT:

“… from the moment I got back to the office, I had to use PT again because, there it is, I don’t have any [GIRA station] near my home or near the office. Because if not, I even live quite close to my work, I would like to use GIRA for this trip as well.” (Interviewee 10)

4.3.2. Reliability

The reliability of the system itself is another major factor that will determine BSS success as a mode of transport. A lack of sufficient available bikes, and to a lesser extend a lack of free docks at the end of the trip, particularly during the rush hours greatly affects the image of the system. Not knowing if a shared bicycle will be available when needed, particularly in their commuting trips which tend to be very time sensitive, leads the users to not trust GIRA for their daily travel needs. Eight interviewees reported heavily decreasing their GIRA usage due to...
this fact, leading GIRA to become their secondary mode of transport:

“… it is not a predictability scenario. In other words, I can’t think: ‘I’m going to leave here at a certain time and I’ll find a bike available at the station and I’ll be able to get to the station where there is a slot available for me to dock the bike’. So, this availability of GIRA ended, preventing me from being able to use it in my daily life…” (Interviewee 4)

Interestingly, two interviewees reported to increase their usage of GIRA during the height of the pandemic because it was easier to find shared bicycles available, but with the easing of the travel restrictions, the shortage of bikes returned:

“During the pandemic I was normally working at home, a lot of remote working, and the few times I had to travel, I was able to use GIRA regularly, so I avoided using mine [personal bicycle], and during that period I could use GIRA more easily. With the pandemic over, we are back at the same problem.” (Interviewee 9)

In addition to the lack of bicycles, although in a much smaller scale, interviewees also reported problems with the app especially during the process of unlocking the shared bicycle, which made it more difficult to use the system:

“Lately I notice some difficulties in the app. It has happened to me quite recently in two days in a row to unlock the bike, it doesn’t unlock, then it won’t let me unlock because it says I’ve unlocked it, I have to call customer support, …” (Interviewee 11)

4.3.3. E-bikes
A success feature of GIRA is the availability of shared e-bikes which are highly appreciated by the users as it helps them overcome the hilliness of the city and, consequently, the physical effort as well as the worry of arriving sweaty to the workplace:

“… and of course, the electric bikes are also a big motivation because Lisbon is the city of the 7 hills and I’m a smoker and I don’t have the lungs to climb hills with a manual bike, especially a GIRA that must weight 20 kg or something.” (Interviewee 7)

Therefore, the shared e-bikes are intensely sought after leading to shortages on availability, which is identified as a problem by users:

“… the few bikes that were there were rarely electric, and I have some more complicated areas on my route and I don’t like to arrive at work sweaty, tired, and, therefore, I started to not trust GIRA…” (Interviewee 9)

4.3.4. Safety
Safety concerns were also mentioned by 14 of the 16 interviewees as an issue, with a general view that Lisbon is still not a safe place to cycle, particularly for inexperienced cyclists. For instance, Interviewee 6 justify still driving his children to school because he still doesn’t feel safe in letting them cycle in the city:

“But then again, there is another factor that I don’t weigh a lot for myself, but I do for my children, which is the safety of cycling in the city. In other words, I would say that what would mainly make me [replace his car trips with GIRA] is the safety, because I feel that it’s still unsafe to cycle in the city, especially for those who don’t have much experience.” (Interviewee 6)

During the pandemic, Interviewee 4 describes that cycling in Lisbon has become more unsafe, not because of the risk of infection, but due to an increase on risky behaviour from car drivers:

“Safe in terms of infection [using GIRA]. In terms of traffic [safety] no, because I think that one of the bad things the pandemic brought was an increase in car speeds. […] and one of the things that the pandemic provoked was also an epidemic of disregarding red lights. As there were fewer cars in circulation, the few cars that circulated behaved as if they were travelling on a deserted road without any care for anything or anyone, disrespecting signs.” (Interviewee 4)

In that sense, the existence of segregated cycling lanes was highly regarded by users as increasing safety, including the new pop-up cycling lanes constructed during COVID-19, as they separate cyclists from the motorized traffic. An extension of the cycling network to other parts of the city would also potentially increase cycling usage, as GIRA users would feel safer in cycling to additional destinations:

“The other advantage for me is the cycling network that in my route mostly has a cycling lane that is separated from the road. […] there is a border between the bike path and the road and that for the route that I take is an advantage. Eventually I could use GIRA for other trips if there were cycling lanes available in those routes or if, in some cases, they already exist but I don’t consider them safe.” (Interviewee 14)

Lastly, another issue related to safety is the conditions of the GIRA bicycles themselves, with five interviewees reporting that it was common to find shared bicycles in poor conditions, including with faulty brakes, which posed a threat for the user and is blamed on vandalism, bad behaviour of some users, as well as a lack of maintenance and oversight from the operator:
“... the GIRA bikes are very badly, very poorly preserved, because there are abusive behaviours from the users, [...] and, therefore, this even makes me often not feeling safe in a GIRA because the brakes fail, the lights are broken, the basket was used by someone who was sitting there and therefore you can’t store things ... I see GIRA users in my front and I notice that the wheels are completely bent.” (Interviewee 4)

4.4. Relationship with other modes

In addition to the relationship between GIRA and PT during the pandemic, which was previously explored in subsection 4.1.3., BSS was found to have a complex relationship with two other modes: personal bicycles as well as the private car (Fig. 6).

4.4.1. Bike sharing & the personal bicycle

GIRA users reported an interesting relationship with personal bicycles. Firstly, interviewees mentioned various advantages that shared bicycles provide comparatively to using a personal bicycle. Specifically, the freedom of not having to worry about where to park or store the bicycle as well as avoiding the maintenance associated with a personal bicycle were highly regarded by four interviewees:

“... we don’t need to worry about storing, parking, leaving the bike in a safe place, putting a padlock. So, all these worries associated with using your own bike don’t apply because, there, it’s a safe shared system, a person leaves it at the dock and goes about their business and doesn’t have to worry about where they left their bike, whether it’s in a safe place or not, ...” (Interviewee 2)

Interestingly, four interviewees reported to have their own bicycles but to still prefer to use GIRA in certain trips. Firstly, one of the reasons was theft concerns, particularly among those who own e-bikes which they were extra careful where to park them. Secondly, some users prefer GIRA because their bicycle is not electric and a shared e-bike decreases the physical effort of their trips. Lastly, users value the flexibility that a shared bicycle provides comparatively to using a personal bicycle. Specifically, GIRA were highly regarded by four interviewees:

“Interestingly, four interviewees reported to have their own bicycles but to still prefer to use GIRA in certain trips. Firstly, one of the reasons was theft concerns, particularly among those who own e-bikes which they were extra careful where to park them. Secondly, some users prefer GIRA because their bicycle is not electric and a shared e-bike decreases the physical effort of their trips. Lastly, users value the flexibility that a shared bicycle provides comparatively to using a personal bicycle. Specifically, GIRA were highly regarded by four interviewees:

“... the permeability of the [GIRA] network in the urban fabric is important and I think it’s important also for starting to change the mentality and habits of the people of Lisbon. I mean, if we have GIRA bikes all over the city, anywhere, going from one place to another, the taxi drivers themselves, who are the worst, and the others too, will start to accept that it is part of the norms to have bicycles on the streets like it was back in the 60s or 70s.” (Interviewee 13)
relates to the fact that GIRA is rarely an option when the users need to transport people or cargo. For example, some interviewees reported using their car to transport their family, including more elderly family members, during the pandemic:

“... when I used the car during the pandemic [...] it was more to help other people and to ensure that their transport was safer than if they had to take the bus or the subway, which is the case with my grandmother who uses public transport a lot, so, we tried to avoid that as much as possible [...] Because if it’s just for me, GIRA is an excellent option, but sometimes, when it’s necessary to guarantee the transport of someone else, GIRA is no longer an option.” (Interviewee 7)

Users particularly complained about GIRA’s inability to be an option for transporting children, with even the inclusion of the newest bicycles’ models that can support a child’s seat not being a convenient option:

“Even those new GIRA bikes which have that rack for a children’s seat, that’s not practical, isn’t it? [...] first, I have to pick up one of the new GIRA bikes, then I have to have a children’s seat that fits on that rack and then I have to carry the children’s seat with me when I get to my destination, right? So, I don’t think it’s practical.” (Interviewee 12)

Interviewees also recounted conflicts with car drivers, including aggressive driving behaviours from car users towards GIRA users and cyclists:

“The main disadvantage, which is changing, it’s a matter of culture and habits, which is that the people from Lisbon were very aggressive towards cyclists in the beginning, especially the drivers. [...] I had altercations several times, several times I had car drivers suddenly braking to see if I would crash. Anyway, I had all of these confrontations.” (Interviewee 13)

This issue is part of a bigger challenge regarding the sharing of public space, where car drivers feel threatened by the loss of road space to other users to avoid the risk of theft as well as the inconveniences of main transport, the coronavirus has provoked a decrease on GIRA usage during the lockdowns due to a reduction on travel demand resulting from mobility restrictions such as mandatory teleworking. However, with the lockdown easing, users returned to the system as they perceived bike sharing to have a low infection risk. In fact, interviewees considered bike sharing to have a lower infection risk comparatively to PT, being an outdoor activity where social distancing was easily maintained in contrast with the overcrowded and closed environment associated with PT. Consequently, participants preferred to use bike sharing instead of PT during the COVID-19 pandemic, with some users joining GIRA specifically to avoid using PT. Furthermore, even during the lockdown periods, with stay-at-home policies in full effect, interviewees still used GIRA to conduct their essential trips. As such, BSS have a valuable contribution to the resilience of transport systems by providing its users with a transport alternative perceived to have a low infection risk, ensuring their mobility needs during a disruptive event. This is especially important to the more vulnerable groups, as bike sharing provides an affordable transport alternative. For example, in Lisbon GIRA was intensely used by food-delivery couriers particularly during the COVID-19 lockdowns, providing a transport option to a group characterized by their precarious working conditions (Jhaun et al., 2020) but whose services were in high demand during the pandemic.

At the same time, this study provides evidence on the benefits perceived by BSS users. These include not only tangible benefits such as reductions in travel times and costs, but more intangible ones like the pleasure of cycling or its perceived positive effect on mental health, contrasting with the stressful experiences of using other transport options such as PT or the private car. The positive effects on mental health and subjective well-being associated to cycling are of particular importance during the present pandemic as they can help ameliorate some of the COVID-19 negative effects on mental health such as increases in social isolation and boredom (De Vos, 2020; Brodeur et al., 2021).

Moreover, the analysis uncovered four major factors that influence the competitiveness of BSS. Ensuring that the BSS covers a sufficient portion of the city and that there is a good distribution of shared bicycles across the stations is paramount for its users to be able to rely on the system for their travel needs and will have direct influence on the travel time competitiveness of bike sharing. Likewise, shared e-bikes were highly regarded by users, with this study providing further support for the deployment of e-bike sharing systems, particularly in hilly (or perceived as hilly) cities. Lastly, we found perceived dangerous traffic conditions to be a major barrier for BSS use, particularly for more inexperienced cyclists, with some evidence that this feeling of unsafety has increased during the pandemic due to a surge on risky driving behaviour. In that sense, the provision of segregated cycling lanes was found to be an important motivation for BSS users improving not only their perceive safety but also potentially reducing travel times by allowing users to avoid motorized traffic. The existence of segregated cycling lanes to foster BSS usage is supported by the bicycle counts conducted by Félix et al. (2020) in Lisbon, which found that areas where BSS stations were available but segregated cycling lanes were not cycling levels did not changed (conversely, when both infrastructures were available a significant increase in cycling usage was registered).

Additionally, this research provides evidence on the relationship between bike sharing and the personal bicycle. BSS is considered to be more convenient and more flexible than a personal bicycle, allowing its users to avoid the risk of theft as well as the inconveniences of maintaining, storing and parking a bicycle. Concurrently, BSS also plays an important role in increasing and normalizing cycling by introducing new users to cycling who otherwise wouldn’t cycle if the BSS did not exist. In that sense, bike sharing seems to act as a gateway drug for cycling, introducing new people to urban cycling, which in turn will later buy and use their own bicycles. Bike counts support the role of GIRA in increasing cycling numbers in Lisbon, with counts conducted between 2016 and 2018 showing an 817% increase in cycling levels, with 34% of all trips being conducted with shared bicycles (Félix et al., 2020).

Lastly, the study also found evidence on the BSS ability of ameliorating car use. Even though most users reported to have a car available to them, they still prefer to use GIRA in several of their trips. Using BSS is associated with a pleasant experience that has environmental benefits and allows travel time and cost savings, while using the car in Lisbon is associated with a stressful and expensive activity due to traffic jams and difficulties in parking. GIRA users still drive in Lisbon mostly because GIRA does not cover all of the city and because bike sharing is an inadequate option for transporting goods (such as groceries) and other people (particularly children).

6. Conclusions and policy recommendations

With PT facing the risk of a permanent ridership decrease under the scenario where COVID-19 continues to impact mobility, our research provides evidence on the BSS potential of acting as a possible alternative. In this study, we looked at the performance of Lisbon’s BSS during the present pandemic using a qualitative approach to shed light on the attitudes of its users. Our research uncovered that bike sharing is not only considered as having a low infection risk, especially comparatively to PT, but also as a travel time and cost competitive mode of transport that provides environmental and health benefits.

Consequently, policymakers should take advantage of bike sharing as an alternative mode, particularly to PT, during disruptive public health emergencies such as the present coronavirus pandemic. In that
sense, BSS should not only be allowed to operate during COVID-19 (although with new safety measures implemented such as enhanced cleaning protocols) but used to reinforce transport systems namely through deploying additional stations and bicycles near PT stations and hospitals. Likewise, policymakers could turn to bike sharing as a possible transport option for essential workers during COVID-19 namely through subsidizing programmes providing waivers and free trips.

Moreover, our study provides further evidence on the potential role of bike sharing on normalizing cycling usage in low-cycling settings. Our participants stated not only to start cycling due to bike sharing but also to buy their own personal bicycles as a result. Consequently, by increasing both the number and diversity of cyclists, bike sharing can help to create the political conditions necessary for further investments in cycling as argued by Koglin and Mukiirat-Landgren (2021). Such pressure could induce a reallocation of car space to cycling infrastructure (e.g., converting car lanes into cycling lanes and car parking spaces into BSS stations), challenging the dominant car-dependent environments that characterize most of our cities and, thus, helping to foster a transition from automobiles to velocimobility.

Our findings about the structural factors affecting the performance of bike sharing as well as regarding its relationship with other modes of transport provide guidance for the formulation of policies for improving the competitiveness of BSS. Based on the results of the interviews, we developed the following set of recommendations for operators and policymakers aimed at maximizing the effectiveness of bike sharing as an alternative mode of transport during COVID-19 and beyond:

- Operators must ensure that BSS covers enough of the city (with special attention to the major trip generators) to allow users to rely on the system for most of their trips.
- The inclusion of shared e-bikes may increase the attractiveness of BSS as they solve some of the main barriers of cycling namely physical effort and transpiration.
- The deployment of BSS should be complemented by the implementation of segregated cycling lanes as it would improve the perceived safety of cycling, which in turn might increase BSS usage rates, fostering the creation of bicycle friendly territories.
- More attention should be given to BSS rebalancing problems. The promotion of mixed land-uses within the catchment areas of BSS could be particularly effective at solving rebalancing issues as it would minimize direction commuting peak flows.
- The concept of seamless travel should always be present when designing bike sharing systems, namely ensuring that the app usage is the smoothest experience possible. In that sense, operators could also consider other ways of accessing BSS, namely through integrating the service with PT smartcards.
- Pilot-projects introducing cargo bikes as well as bikes with child seats (respectively, at the BSS stations near supermarkets and schools) should be tested as such bikes may increase the ability of BSS to carry cargo and children.
- Instead of completely banning food delivery couriers from using bike sharing, BSS operators may consider establishing partnerships, namely through sponsorship deals, with food delivery companies. This would not only provide BSS with additional funding for further expansions but would also increase the sustainability of food delivery services and help to normalize cycling in the city.

Even though the above recommendations were developed based on the feedback from Lisbon’s BSS users, the issues faced by GIARA are common to several other BSS in the world, particularly docked systems. Future research should continue to analyse the potential of BSS (and other types of micro-mobility such as e-scooter sharing) in increasing the resilience of transport systems, particularly under the scenario where COVID-19 remains a threat and PT systems continue to experience lower ridership levels due to infection fears. Additional studies on how to increase the competitiveness of bike sharing against the car are specially needed as BSS can help to ameliorate a surge in car use during COVID-19 due to a loss of confidence on PT.

**CRediT authorship contribution statement**

João Filipe Teixeira: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. Cecilia Silva: Supervision, Writing – review & editing. Frederico Moura e Sá: Supervision, Writing - review & editing.

**Declaration of competing interest**

The authors have no conflicts of interest to declare.

**Data availability**

Data will be made available on request.

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**Appendix A. Supplementary data**

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