Women-friendly bike infrastructures in Turin:

assessing requirements and strategies for a gender-inclusive bike system and its potential influence on air quality

ANDREA ROSSO

MSC THESIS IN ENVIRONMENTAL SCIENCES: ENVIRONMENTAL SYSTEM ANALYSIS

SUPERVISED BY DR.IR. KAREN FORTUIN

COURSE CODE: ESA-80436

WAGENINGEN
UNIVERSITY & RESEARCH

Women-friendly bike infrastructures in Turin:

assessing requirements and strategies for a gender-inclusive bike system and its potential influence on air quality

Andrea Rosso

MSc Thesis in Environmental Sciences: Environmental System Analysis

February 2021

Supervisor:

Dr. ir. Karen Fortuin

Environmental System Analysis Group

Email: karen.fortuin@wur.nl

Examiner:

Prof. dr. Rik Leemans

Environmental System Analysis Group

Email: rik.leemans@wur.nl

Preface

This Thesis was developed as part of my Master at Wageningen University in Environmental System Analysis. I performed this research from June 2020 to February 2021.

The idea of this topic stemmed from my passion in Environmental Justice. In particular, I wanted to find a bridge between environmental problems and human rights. Currently, the world is facing with economic, social and environmental instabilities due to the spread of COVID-19. This crisis is also seen as a turning point of new paradigms of growth and a rise of intellectual beginnings. From this acknowledge I developed a study rooted in the present and looking towards the future of mobility. When I chose this topic I was motivated to combine environmental justice with urban mobility by looking at the implications of the transport sector for different social groups.

I would like thanks all the people I involved during these months, from respondents of my questionnaire to experts I interviewed. In truth, I could not have achieved my current knowledge and enthusiasm towards the topic without the strong support of my supervisor Dr. ir. Karen Fortuin. She motivated me during the arsh moments and she provided me useful insights to conduct this investigation. She also helped me to devote opportunities when I felt lost due to COVID-19 implications for my research.

I want also to express my gratitude to Dr. Rik Leemans to help me to improve my final thesis.

I know this report would not been finished without the inspiration of my lovely family who never stopped to believe in my abilities. Lastly, I would like to thank my friends Sara, Flaminia. Sofia, Giulia, Sarah, Ylenia, Margherita, Martina and all my other friends who supported me with encouragement during the most tough moments.

Table of content

Summary

During recent years, cities have witnessed a booming interest in cycling. However, the implementation of cycling networks did rarely follow a strategy to increase accessibility for different social groups, such as women. Such social groups have been explicitly included in few recent studies on cycling networks. They addressed all aspects of cycling and incorporated the women's perspective.

I build upon these studies and aim to examine the social and environmental perspectives of cycling for women (alone or with their children) in Turin, Italy. Hence, I studied how the city could guarantee a woman-friendly cycling system, ensuring women's participation as key-stakeholders stimulating a bike-friendly city.

To fulfill this goal, I will clarify women's perception of cycling in Turin and identify the requirements for more inclusive bike infrastructures. I thus will identify strategies to promote better access to bike lanes for women and investigate the environmental benefits of reduced air pollution by such bike network.

I integrated different outcomes to have a complete overview of the heterogeneous women's needs. Firstly, I launched a questionnaire to understand requirements to make Turin suitable for women cycling. Secondly, I observed local bike lanes and assessed how their structures affected the women's number who cycle. Thirdly, I interviewed experts to better understand which strategies likely promote an inclusive mobility. Finally, I used vehicle-emission factors to assess the consequences of a woman-friendly bike system for air-quality in Turin.

My results show that factors related to women's personal and collective well-being encourage them to cycle. Their motivations to cycle make also the city more livable and less polluted. Unsecure bike lanes strongly disincentivize their cycling. All strategies that promote women's role on several levels, likely contribute to boosting woman-inclusiveness mobility. All these strategies and factors to make women-friendlier bike lanes, lead to more cycling and to decrease the current air pollution emitted from private vehicles.

To conclude, my study demonstrates that women are the driver for a sustainable transition. As such, women's involvement likely brings to a more socially inclusive and environmental-friendly transport system. All these principles lead Turin to be a sustainable city as depicted in Goal 11 of SGDs.

Volunteer at Food not Bombs Turin (Manfredi,2019)

Introduction

1. Introduction

1.1 Background

1.1.1. Cycling to promote social inclusiveness and environmental protection

Nowadays, different institutional entities acknowledge the importance to tackle urban problems by promoting environmental strategies and ensuring social equality. For example, the European Union has over recent years recognized the key-role of sustainable cities as model to enhance social cohesion and a space to promote environmental-friendlier behavior. Goal 11 of sustainable development goals (SDGs), called '*Sustainable cities and communities'*, aspires to sustainable, inclusive and safe cities with special attention for women, kids and older people (United Nations, 2020). In such envisioned city, the transport sector contributes to a sustainable transition within a city, both in environmental and social terms (Haughton, 1999). In particular, cycling as means of transportation increases gender equity with consequences for the environment and the welfare of citizens as shown in Figure 1 (Garrard *et al.*, 2012). These insights raise two questions: whether social groups and especially women are currently incentivized to use bicycles in an urban context and how they can contribute to promote sustainable city.

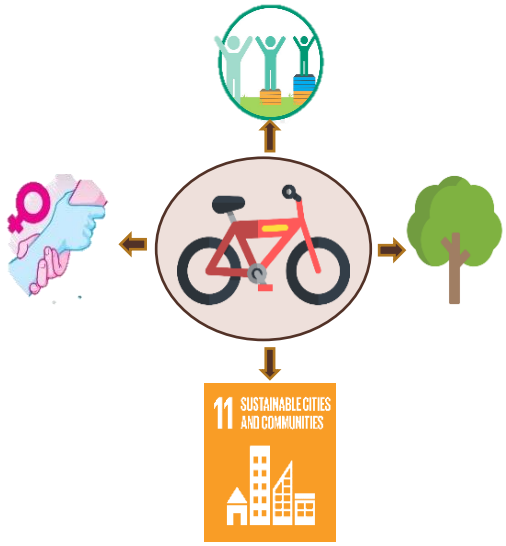

Figure 1. Multiple benefits of a bike-friendly city in countering gender gap, ensuring social equity, achieving a sustainable transition towards a city and promoting the environment protection.

1.1.2. The role of the bike to ensure gender equity

Historically, cycling contributed to achieve empowerment and freedom for many women (Garrard *et al.*, 2012). During the Victorian time, bikes were a tool for social reform since cycling offered women to escape from the physical confines of home and from domestic responsibilities (Strange & Brown, 2002). The woman activist Elizabeth Cady Stanton, saw the bike as a means for dressing reform, that promotes more casual clothes among women (Garrard *et al.*, 2012). Many members of the women's suffrage movement were also riders. Bicycles inspired them to escape from social roles and to promote self-respect and self-reliance. Hence, even nowadays where gender issues are still not properly addressed in different countries, improving cycling could guarantee the continuation of better equity among modern society (Ortiz Escalante & Gutiérrez, 2015).

According to several studies (Ortiz Escalante & Gutiérrez, 2015; Honey-Roses *et al.*, 2020), women could be the driver themselves to promote the social equity and accessibility of cycling for everyone. On the other hand, conditions that exclude women from cycling, are likely to accentuate social inequalities over time. Indeed, intellectuals agree that existing social gaps will exacerbate when inclusive cycling will not be an integral part of mobility planning. Hence, concepts such as feminist planning (Ortiz Escalante & Gutiérrez, 2015) are increasingly adopted among policymakers to propose gender-transformative urban planning that makes visible the women's needs. Besides, participatory processes within urban planning are increasingly used as strategies for better integration and for eliminating gender discrimination.

Including women in the mobility transformation of the cycling system allows also cities to start the transition towards a sustainable city as targeted by the SDGs. Women are an 'indicator species' for safer and livable cities for everyone (Baker, 2009, Camp 2013). Indeed, stimulating the use of bicycles among women is based on the assumption of Camp (2013) that ensuring women-friendly bike lanes makes cities safer and even environmental-friendlier. This assumption is further supported by Jar Garrard et al. (2008) who demonstrate that promoting cyclists who are women, means supporting cycling around the city for every citizen. Additionally, other studies claim that countries where trips are mostly made by cycling, have a greater gender balance and perform a higher score on Gender Equality Index, GEI (Fishman *et al.*, 2015; Aldred *et al.*, 2016; Sustrans, 2018).

To conclude, whereas the SDGs have established the principles for a sustainable city, several studies have shown potential pathways to achieve such a city. Cities thus should achieve a social and environmental transition through the promotion of gender equity from cycling.

1.1.3. Requirements for a woman-friendly bike system

The promotion of a woman-friendly bike system passes by identifying those requirements that positively or negatively affect women's willingness to cycle. Understanding their requirements is essential since mobility is experienced differently between genders. Indeed, roles and behaviors assigned to genders have strongly shaped the women's and men's needs. As such, gendered differences in cycling behavior have been officially recognized.

These differences can be grouped as shown in Figure 2: 1) *structural*; 2) *biological*; 3) *cultural norms*; and 4) *social barriers*.

1) Women have different travel patterns compared to men. For example, women are more likely to make multi-stop travels, travel with child(ren) and have 'short-distance' trips (Hanson, 2010; Aldred *et al.*, 2016; Garrard *et al.*, 2012). These structural divergencies can be explained in the availability of an environment that does not support women to cycle (Garrard *et al.*, 2008). For example Lubitow (2019) claims that being a woman in a lane without proper infrastructures means drawing attention from men on sidewalks or driving the car. Indeed, the sexualization of female body is still a source of risk in bike lanes (Ortiz Escalante & Gutiérrez, 2015). The need for safety likely affects comfortability while cycling, thus the decision among women to use the bike (Garrard *et al.*, 2012).

2) Biological differences between men and women affect the decision to cycle. During pregnancy many women increase their interest in cycling for environmental sensitivity and health reasons (e.g. to lessen excessive weight or reduce anxiety) (Pérez Brandón, 2019; Robledo-Colonia *et al.*, 2012; Costa *et al.*, 2003). Cioffi et al. (2010) came to different results. Indeed, they demonstrated that pregnant women can give up cycling due to safety concerns.

3) According to Emond et al. (2009) and Grudgings et al. (2018) having child(ren) significantly impacts the choice to use bicycles among women. For example, Ravensbergen (2019) demonstrated that cycling with child(ren) in certain contexts performs as being a 'good mother' who cares on the health and the happiness of her child(ren). However, in several cities new-designed bike lanes lack being parenthood-friendly since they are not wide enough for cargo bikes (Pucher *et al.*, 1999). Moreover, they demonstrated that safety and security related risks on the bike lanes affect engagement of mothers to cycle with their child(ren) (Pucher *et al.*, 1999).

4) Finally, social constraints influence women's willingness to use bikes. For example, women are less likely to ride a bike because they are expected to arrive at work more carefully dressed than men (Judge, 2011; Garrard *et al.*, 2012). In different countries, some workplaces have changing rooms

specifically designed for dressing up after having to ride a bicycle. Nevertheless, this assumption implies that being presentable at work is still for many women a necessity rather than a choice. Additionally, McDonald (2012) alleges that parents are less likely to allow girls to bike to and from school than boys of the same age since the former are considered more vulnerable. Also older women are subjected to social prejudices sine they often are put off the image of sporty women (Rissel *et al.*, 2010).

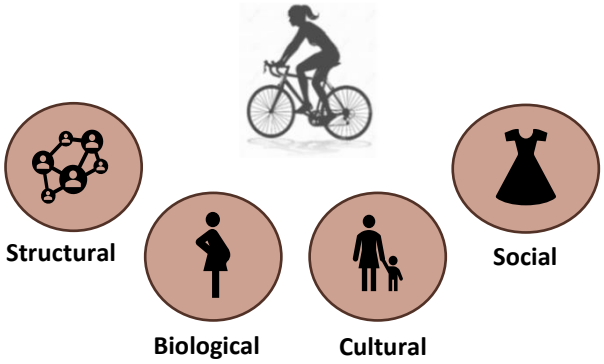

Figure 2. Differences among gender when using the bike. These four spheres lead women to have specific needs and requirements to support them to cycle

1.1.4. Multiple Benefits of a bike-friendly city

The Institute for Transportation and Development Policy estimates that in 2050 carbon dioxide emissions from urban transport are expected to decrease by 11% if people using bicycles will globally increase by one-fifth (Mason *et al.*, 2015). Indeed, bike-friendly cities likely benefit by reducing Carbon Dioxide (CO_2), Nitrogen Dioxide (NO_2), Methane (CH_4) and Particulate matter (PM) emissions coming from private vehicles. As such, bike-oriented policies help to improve locally the air-quality of a city and to tackle climate change globally.

Moreover, several studies (Wang *et al.* 2016; Heinen *et al.* 2010) have proven an increased personal and collective wellbeing in bike-friendly cities. They demonstrated that cycling decreases stress levels and makes cities greener and more livable. The presence of trees and parks alongside the bike lanes, additionally reduces on-site heat of paved bike lanes and produces more oxygen while subtracting carbon dioxide (Wang *et al.* 2016).

All these benefits show how gender and cycling interact in the context of environmental goals required to make cities more livable, less polluted, and greener for every citizen.

1.2. Study area

Turin is a middle size city with over 875,000 inhabitants (Tuttitalia.it, 2019) located in the Piedmont Region. The city is well-known as home to the Italian automotive industry, FCA.

Even though the car industry is in the process of being scaled down, it still retains a prominent role in either the provincial economy and social identity. Indeed, in 2017 the province of Turin was the city with one of the highest rates of motorization in Italy, 664 cars every 1000 inhabitants (Regione Piemonte, 2017). Consequently, Turin is known for its poor air-quality based on a combination of high commuting car's numbers and traffic, favorable topographic and climatic conditions. Indeed, the annual report of Legambiente (2020), declared Turin as one of the most polluted cities in Italy: in 2019, Turin has overcome for 147 days the permissible limits for PM10 and Ozone. According to data collected from the Italian Environmental Protection Agency – ARPA - in 2019, the transport sector accounted for more than four-fifths (85%) of the total PM10 and for almost two-thirds (61%) of the total NO_x emitted into the atmosphere. Only the vehicle trips accounted for almost half of the total NO_x emissions (Sistema Piemonte, n.d.).

Figure 3. 'Controviali' in Turin with bike- priority and 'case avanzate' in front of each traffic light (Parisotto, 2020).

To address problems derived from air pollution, during the last 20 years Turin has undertaken a transformative process of its vocation. Since the Winter Olympic Games 2006 occurred in Turin, the city has undergone a process of changes that has redefined its economy and socio-cultural identity. These efforts have capitalized more effectively in the development of cycling infrastructures.

Besides, during the last years, the urban asset has been built around students' needs who are increasingly attracted by using bicycles. Indeed, more than three-quarters of the 100,000 university students in Turin use public transportations or bikes to reach their destinations (Unito, 2018). To deal with this number, the Municipality of Turin is carrying out green policies that aim at discouraging private vehicles. For example, all the 80 kilometers of the secondary streets alongside the main streets

of Turin, called ‘controviali’ (Figure 3), will prioritize bicycles over cars which should not exceed 20 kilometers per hour.

1.3. Knowledge gaps

An earlier European report carried out by Civitas (2020) has demonstrated that women on a national scale are more inclined to use public and active transportations than men. Nevertheless, national averages usually do not reflect local circumstances. Italian cities, Turin included, are characterized by phenomena such as higher economic and social insecurities, smog and less safety levels that can influence the bicycles’ use among women.

Besides, no data addresses those factors, infrastructures and strategies that affect the women’s willingness to cycle in Italy. For example, several studies in the US and Spain have correlated gender and awareness of environmental issues as stimulus for cycling (Pérez Brandón, 2019; Dill *et al.*, 2014; Judge, 2011; Camp, 2013). Comparable studies are lacking for Turin.

Lastly, the relationship between women’s requirements, mobility strategies and a possible reduction in emissions from the private vehicles in a woman-friendly city has never been investigated before in any country.

1.4. Problem Statement

As presented in the previous chapters, cycling could be an incentive to accelerate more inclusive and environmentally sound mobility system in Turin. Since the understanding of needs and barriers to make Turin accessible to women who want to cycle is poorly investigated, I aimed with my study to focus on women issues related to cycling. As mentioned in the Introduction, different factors, requirements and strategies contribute positively or negatively to stimulating women to use bicycles. These needs, in turn, likely influence the modes of transportation chosen by women in Turin, and thus the amount of pollutants emitted into the atmosphere.

1.5. Research objective and research questions

My research aims to (i) identify requirements and bike infrastructures for a woman-friendly bike system in Turin;(ii) assess which strategies promote women to cycle in Turin; and (iii) evaluate the CO_2, CH_4 and N_2O emissions of a woman-friendly bike system.

These objectives are elaborated through three main research questions (RQs):

RQ1: What are the factors and infrastructures that stimulate women to cycle (more)?

RQ2: What are possible strategies to improve and promote a gender-inclusive bike system?

RQ3: What is the potential impact of a shift from cars to bicycles on the CO_2, CH_4 and N_2O emissions if the bicycle network will be characterized by more women-friendly infrastructures and services?

1.6. Reading guide

In line with mobility's aspects of inclusiveness and environmental protection mentioned in Chapter 1, my research explores cycling among women in Turin. Women are the sample group of my research. In my study, women cycling are meant as a heterogeneous social group of different sociodemographic conditions who cycle independently or with their child(ren).

Accordingly with this definition, five data collection and elaboration methods are presented in Chapter 2. All these methodologies are meant to reach women since I assessed women's mobility, not gender's mobility. Chapter 2 is the ground to define processes and tools that I have used to answer the three RQs.

With respect to Chapter 3, it presents significant findings by answering the three RQs. This chapter is structured in such a way that results from different chapters enrich each other. Therefore, it defines strategies to address mobility under different perspectives and indicates the multi-benefits derived from cycling.

These benefits cover different domains, from social wellbeing to environmental protection. They are addressed in Chapters 4. Specifically, I compare my results with findings from other studies. Moreover, the limitations of my work and strategies are discussed in this chapter.

Chapter 5 is dedicated to the main findings of my study. This chapter is connected with the introduction because it defines my results in the context of a sustainable city. It demonstrates that cycling does not only play a crucial role to promote social cohesion and environmental-behavior. Indeed, it also empowers women. Consequently, women's contribution to mobility is essential to devote Turin as a sustainable city.

As a wrap-up, my thesis includes in Chapter 6, recommendations for Institutions, media, bike volunteering associations and citizens.

Bike Pride event in Turin (Malagnino, 2018)

Methodology

2. Methodology

2.1. Introduction

This chapter presents the techniques and processes carried out during the data collection and analysis. Firstly, the conceptual framework and its parts will give an understanding of the overall methodological structure applied in my study. Secondly, the data collection methods are explained. Each of them contributes to achieving a multifaceted perspective of women's mobility. For each method, I explain the development of the data analysis as it drives the interpretation of the results of Chapter 3. Lastly, Chapter 2.6. will relate the RQ3 with RQ1. This linkage is innovative since no studies have compared women's requirements with the potential emissions' impact. Moreover, in my study women were the target population. As such, the questionnaire was strictly turned to women, interviews addressed only strategies to promote women cycling and observations identified women's percentage out of men.

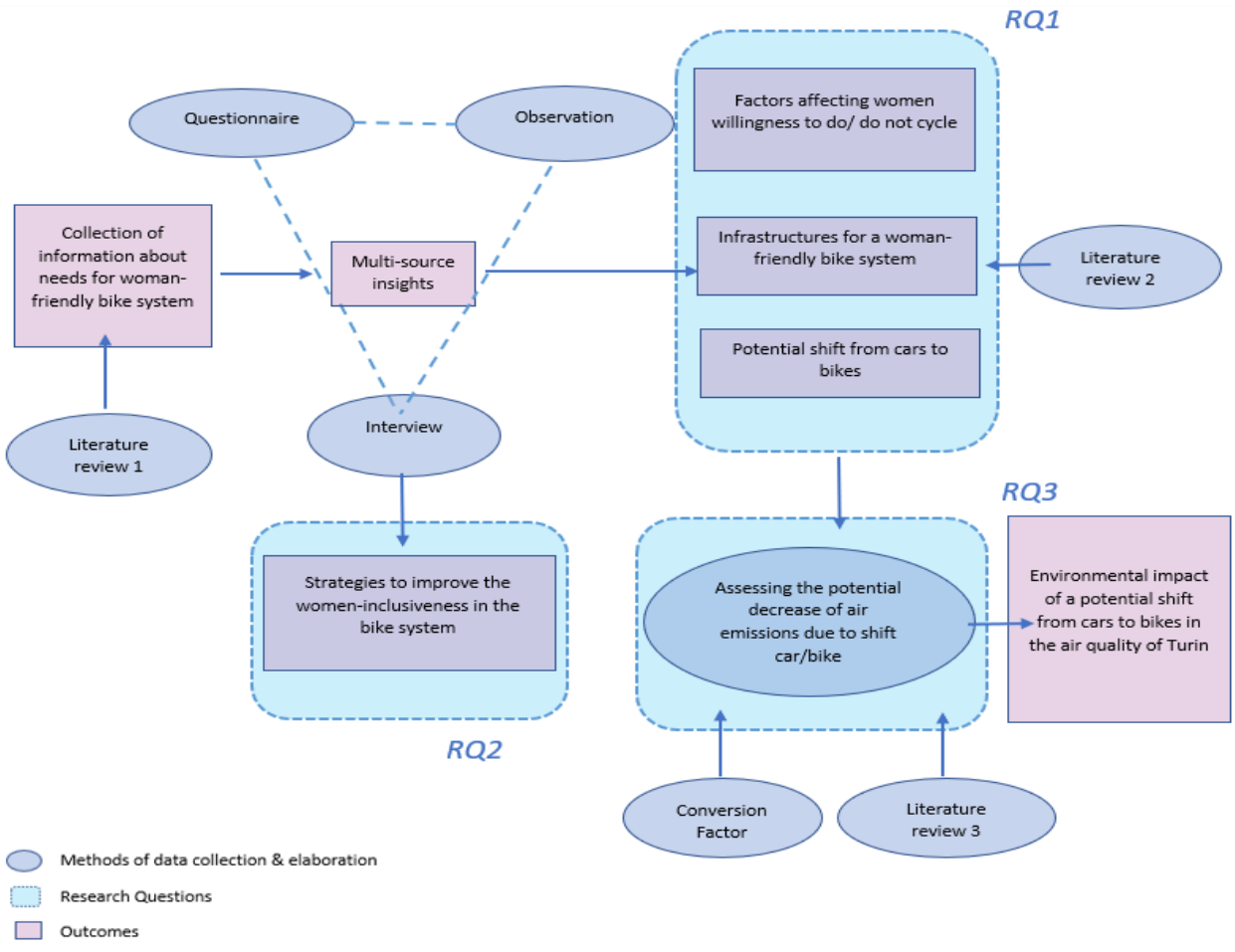

Figure 4. Conceptual framework

Figure 4 visualizes the methods, RQs and outcomes of my study. To answer RQ1, an academic survey off-site – literature review and online questionnaire – was integrated with the collection of on-site data in Turin through by-hand questionnaires and field-observations. Interviews with experts covered the domain of the RQ2. To answer the RQ3, additional literature review was combined with results from the questionnaire and a conversion factor provided by the UK Government.

I started my study with a literature review to define the study's domain, frame the questionnaire and identify a topic list for interviews. Questionnaires, observations and interviews followed the literature review and they addressed RQ1 and RQ2 through triangulation. Its essence was to validate data from questionnaires by cross-verifying them with results from interviews and field-observations. I launched the questionnaire to investigate women's requirements to develop a gender-friendlier bike system. I assessed the influence of bike infrastructures on the number of women cycling through field-observations. Whilst, interviews defined those mobility strategies that likely promote cycling for women. The questionnaire was also meant to determine women's willingness to shift from using cars to riding a bicycle. This information provided the ground for addressing RQ3. I enriched this phase with additional literature review and a conversion factor. This factor was meant to assess the consequences of a potential shift from cars to bicycles on the air-quality in case of a woman-friendly bike system.

The following phase provided for the data elaboration collected during the fieldwork. In my study, the SPSS Software, Excel and the vehicle-emission conversion factor were methods of analysis applied to elaborate data.

2.2. Literature review

I consulted literature review at three different moments: during the beginning of my study, to underpin findings from the questionnaire and subsequently as support for RQ3.

During the first phase, I examined scientific articles, subject-specific books, research reports, documents from municipalities to investigate the research theoretical background.

In a second phase, I consulted the literature review to ensure that behavioral and sociodemographic outcomes from the questionnaire reflected the real situation in Turin.

Official documents from the Municipality of Turin, reports from environmental agencies and statistic data obtained by other institutes were instead conferred during the last phase of my study to verify CO_2, CH_4 and N_2O emissions from the private vehicles. Moreover, online conferences, what O'Leary calls grey literature (O'Leary, 2017), were used to assess the RQ3.

2.3. Questionnaire

Data Collection

Literature reviews provide insights to finalize the structure of the questionnaire as shown in Table 1. In developing my survey, I first conducted a pre-test: fifteen women were asked to fill in the questionnaire and comment on the questions. The final version of the questionnaire was launched through Google Forms on September 1st, 2020. I distributed it anonymously. Respondents were asked to complete it only once, since the survey was cross-sectional.

The online questionnaire (see Appendix I) reached 348 women and it was launched mostly through social media. I kept it available for one month. I tried to reach the most heterogeneous group of people as possible. As such, I shared the questionnaire in twenty-four Facebook pages and in twenty-six private groups that differed for their goals, political beliefs and ideologies. Additionally, I distributed twelve questionnaires by hand on streets with the same questions of the online version. This approach was mostly necessary to reach a random sample of not Italian women since only a few of them answered through the virtual mode. The survey's spread followed the snowball sampling.

Table 1. Questionnaire's structure

N Question	Topic	Description
1,2	Gender & residence	Information about the gender and where the respondent lives to filter those that were men or did not live in Turin
3,4,5,6	Car's and bike's characteristics	Information about the frequency of using a car and bike in Turin and car's characteristics
7,8	Factors that affect women to cycle	Likert Scale with fourteen statements about factors that encourage women to cycle. Another Likert scale with thirteen factors that prevent women going by bike
9	Bike infrastructures	Eleven bike infrastructures that women would like to see implemented in bike lanes
10	Willingness to shift	Willingness to use the bike whether a bike infrastructure according to their choices is implemented
11	Destination	Seven destinations and purposes towards which they would be encouraged to use the bike
12	Amount of shift	Estimating of the amount of kilometers of shift from the use of car to bike
13,14,15,16,17	Demographic information	Information about the respondents' nationality, age, level of education and current occupation

Data Analysis

In my study, the IBN SPSS Statistics27 software was employed to elaborate raw data from the questionnaire. From Google Forms, I transferred the 360 responses to an Excel spreadsheet in which answers from the questionnaire were coded numerically. For example, the willingness among women in shifting from vehicles to bicycles was elaborated by making a five-scale of reference, from 1 = Not at all (no shift) to 5 =Very much (complete shift of kilometers weekly travel by car). Besides, I translated values of two Likert Scales into numerical information, from 1 to 5 where 1 corresponded to Strongly Disagree and 5 to Strongly Agree. The software computed the average mean of the five-point Likert Scale and made a cross-sectional analysis of different variables. I applied crosstabulation analysis to answer to what extent participant's characteristics (e.g. age and nationality) influence the results of the Likert Scale.

2.4. Interviews

Data Collection

Interviews were semi-structured since questions were not either fully fixed or fully free. I collected information according to six/seven questions that differed among respondents. However, a similar structure could be defined as follow: 1) a first question about which strategies likely stimulate women to cycle; 2) questions related to experts' specific knowledge in the field of mobility; and 3) a final question about their personal experiences working in the mobility sector. During my study, interviews were administered through both face-to-face surveys and Zoom meetings since the current circumstances have forced for some virtual meetings.

Seven out of nine experts were women. I chose experts based on their contribution and priorities to my study (see Appendix II). Additionally, I selected interviewees to have a heterogeneous audience in terms of age, profession and knowledge (see Figure 5). Both their personal opinions and professional knowledge were included in my research. Whereas the latter was used to enrich the outcomes from the surveys, personal experiences gave a subjective interpretation of my results. Their professional knowledge covered the social, scientific, linguistic and political domains.

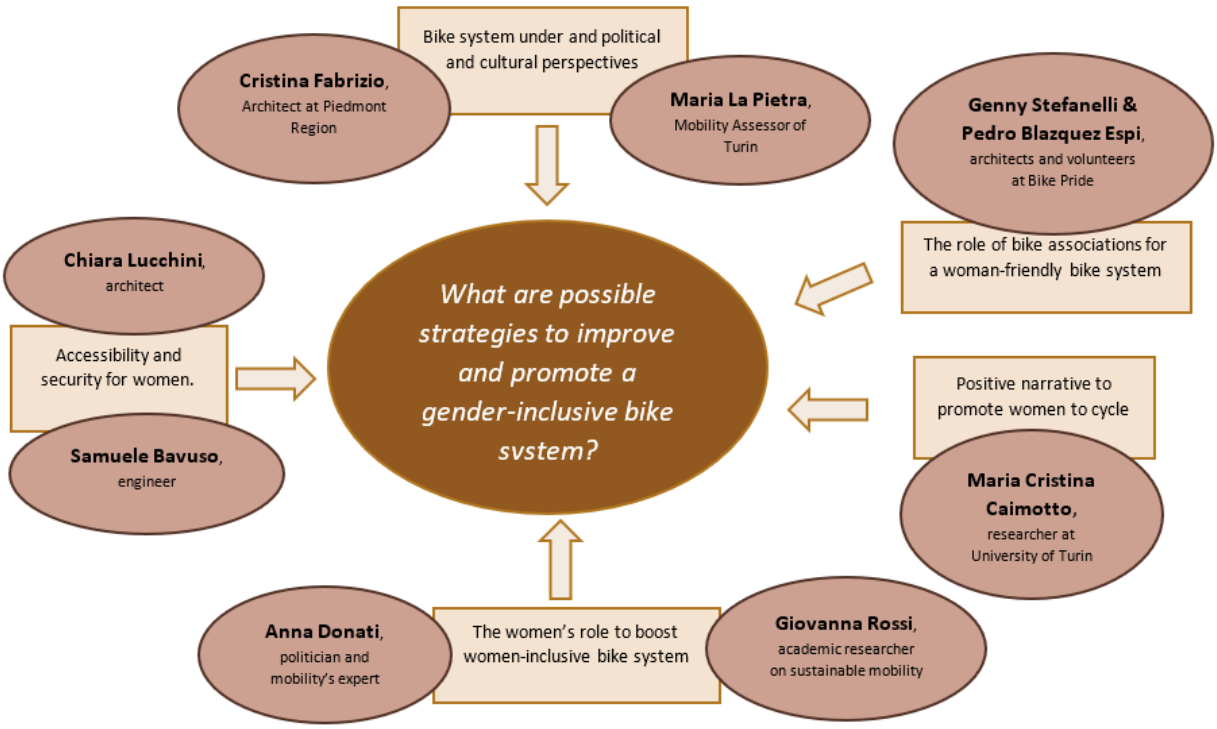

Figure 5. Methodological framework to assess RQ2.

Data Analysis

I recorded all nine interviews. Subsequently, I conducted a thematic analysis. Firstly, I transcribed interviews into written text in Italian. Those parts that pertained to the topic were translated into English. Echoing the words of Braun and Clarke (2014), I retained information that was needed and in a way that did not change the original nature of the interview. This phase helped to narrow down the research scope and link relevant quotes with results from the questionnaire and observations. I subsequently underlined relevant words. They generated one or multiple codes. I chose those codes that were repeated in many statements and according to their relevance with the research purposes. Similar codes were grouped and collated together into four themes (see Section 3.4). These themes were meant to build a coherent storyline that was used to find possible strategies to support women cycling in Turin.

2.5. Field Observations

Data Collection

A first pre-phase consisted of the identification of four spots within the city of Turin (Figure 6). I chose those lanes that had different bike infrastructures one kilometer near the observation point. I used Google Maps and in-situ sampling to select these places. All four spots were chosen for their closeness with two facilities, schools and gyms. Observations were carried out in-situ by using a predefined form (see Appendix III) in which I noted down the cyclists' number by gender. Two observations were carried out for each lane, one from 3.45 pm to 4.45 pm and another from 8.20 pm to 9.20 pm. Additionally, I collected information on the temperature since it could have influenced the number of people cycling. All the days of observations were characterized by a range of 17-21 °C during the day and 13-18 °C during the night.

Riders, meaning those people who deliver food at home, were not considered in my survey for two main reasons: a) they are forced due to their work to use the bike as the only means of transportation b) their number was significantly higher during the night than during the day. Therefore, their count would have influenced the percentage women-men in favor of the latter and the cyclists' number between the day and the night. I also noted down the presence of kids on the seat or alone, pregnant women, the characteristic of cyclists based on their dresses and age.

Figure 6. Map of Turin with the four points of observation represented with red star (Google Maps, 2020)

Data Analysis

During my analysis, I subtracted riders from the total number of men cycling for the reasons mentioned above. In the same paper, at the end of each observation that lasted one hour, the number of women and men was translated as a relative percentage. Subsequently, I transferred all these results into an Excel spreadsheet to make graphics, tables and comparisons. All the graphics are presented in Chapter 3.

2.6. Calculating potential emission reduction through vehicle-emission factor

Data Collection

To answer the RQ3, I used three data sources: the results coming from the questionnaire, data from the Regional Environmental Protection Agency (IREA) and an emission factor from the UK database (Thomas et al., 2020). I referred to the answers from the questionnaire to assess the potential reduction in emissions from vehicles. The UK database provided passenger vehicle-emission factors expressed in CO_2 equivalent (CO_2e) for CO_2, CH_4, N_2O. Carbon dioxide equivalent is a standard unit to compare the three gasses in the database. It indicates the global warming potential (GWP) of CO_2, CH_4 and N_2O. These gasses were chosen as main transport emitters that threaten the air quality locally and because they are responsible for climate warming globally.

Data Analysis

All conversion factors in the UK database were expressed in units of "kilograms of carbon dioxide equivalent of Y per kilometer traveled by vehicle", where Y is the gas emitted from a vehicle (CO_2, CH_4, N_2O). I converted the kilograms of CO_2e into kilograms of CO_2, CH_4 and N_2O emission factor by using the '100-yr global warming potential' (*GWP*) as given by IPCC, AR4. In this report CO_2 has a GWP of 1, CH_4 of 28 and N_2O of 265. I thus divided all the conversion factors as showed in the database per 1 for CO_2, 28 for CH_4 and 265 for N_2O to obtain a new table with all the vehicle-emission factors (α).

Subsequently, I calculated kilograms of CO_2, CH_4, N_2O emissions from passenger vehicles as showed in the following equations:

$$E_{t0} = D_{t0} \times \alpha [s, p] \quad \text{Equation 1}$$

$$E_{t1} = D_{t1} \times \alpha [s, p] \quad \text{Equation 2}$$

Where E_{t0} indicates the emissions of one person based on current kilometers travelled (kg);

E_{t1} are the emissions of one person based on potential kilometers travelled in case bike infrastructures are improved (kg);

D_{t0} is the current distance travelled weekly by car by one person (km);

D_{t1} is the potential distance travelled weekly by car by one person in case bike infrastructures are improved (km);

α represents the vehicle-emission factor (kg km^{-1});

s is the size of the car (Small, Medium, Large);

p is the car power (Gasoline, Diesel, LPG, Methane, Hybrid, Electric);

As shown in equations 1 and 2, I calculated the current emissions of CO_2, CH_4, N_2O (1) by multiplying the car distance currently travelled by the respondents D_{t0} and the vehicle-emission factor α. D_{t0} used the average of the range expressed by respondents. As such, if a respondent claimed to travel weekly from 1-50 kilometers, 25 kilometers were chosen as D_{t0}. The α was selected according to two parameters: the size of the car (s) and its power (p). These two parameters were obtained by asking formerly the respondents through the questionnaire to indicate the car size and how it is powered.

Subsequently, I calculated the emissions E_{t1} based on a potential reduction in kilometers travelled (2) by asking respondents to choose between six options. These alternatives assessed their willingness to use the bike instead of the car (see question 12 Appendix I). For example, if a respondent declared to be willing to use the bike for ¼ of her current kilometers driven by car, D_{to} was divided by ¼. Afterwards, I obtained E_r (3) from the difference between the total emissions due to the current kilometers travelled by car E_{t0} and the total potential emissions E_{t1} based on $D_{10.}$ The equation (3) shows how I calculated the total potential emission reduction of CO_2, CH_4, N_2O for each person:

$$E_r = E_{t0} - E_{t1} \quad \text{Equation 3}$$

$$\Sigma E_r = \Sigma E_{t0} - \Sigma E_{t1} \quad \text{Equation 4}$$

Subsequently, the difference between the sum of E_{t0} and the sum of E_{t1} for all the respondents gave the total ΣE_r (4). Equation 4. showed how much the environment could benefit in terms of emission reduction in case of women-friendly infrastructures. This equation refers to the target population of 360 women living in Turin who claimed to use the car.

Finally, I compared E_r with the total emissions from the private vehicles in Turin, caused by all the population of the city. During this phase, I defined the contribution that 360 women living in Turin

could give in reducing the total emissions from vehicles. Nevertheless, my study did not rely on data gathered in the last few months since the reduction in travel due to COVID-19 restrictions could influence the level of pollution. Hence, I referred to IREA data collected in 2015. The IREA database provided the annual amount of emissions for CH_4, N_2O and CO_2.. I used these findings to evaluate the contribution in percentage of 360 women in the decrease of emissions for CO_2, CH_4, N_2O. I subsequently upscaled the emission data expressed in kilograms a week to the entire female population of Turin over 19, which counts 387,430 people (Tuttitalia.it, 2020).

Elisa Gallo, President of Bike Pride FIAB association in Turin

Results

3. Results

3.1. Introduction

To answer the RQ1, results from the questionnaire and field-observations will identify requirements and infrastructures for a bike system appealing to women. Secondly, interviews will address the RQ2 by investigating which strategies promote a gender-inclusive bike system. Finally, the RQ3 will tackle air-emissions reduction through results from the vehicle emission factor.

3.2. Results from the questionnaire

3.2.1. Sociodemographic characteristics of participants

The final dataset contained 360 women with different sociodemographic aspects (Figure 7). This sample included individuals roughly equally spread by age, ranging from the lower score of 22% among 18-25 and the higher score of 28% got by 36-50 aged women. Few respondents obtained lower (1%) and upper secondary (19%) education because 1) the questionnaire excluded those people under 18 who are still attending lower and upper secondary educations; 2) the current education system in Italy is compulsory until the second year of upper secondary education. As for nationality, the foreigners' percentage in Turin is equal to 15% (Tuttitalia.it; 2019). In my study I reached 8% of not Italians. More than half of participants were employed, whereas 24% were students.

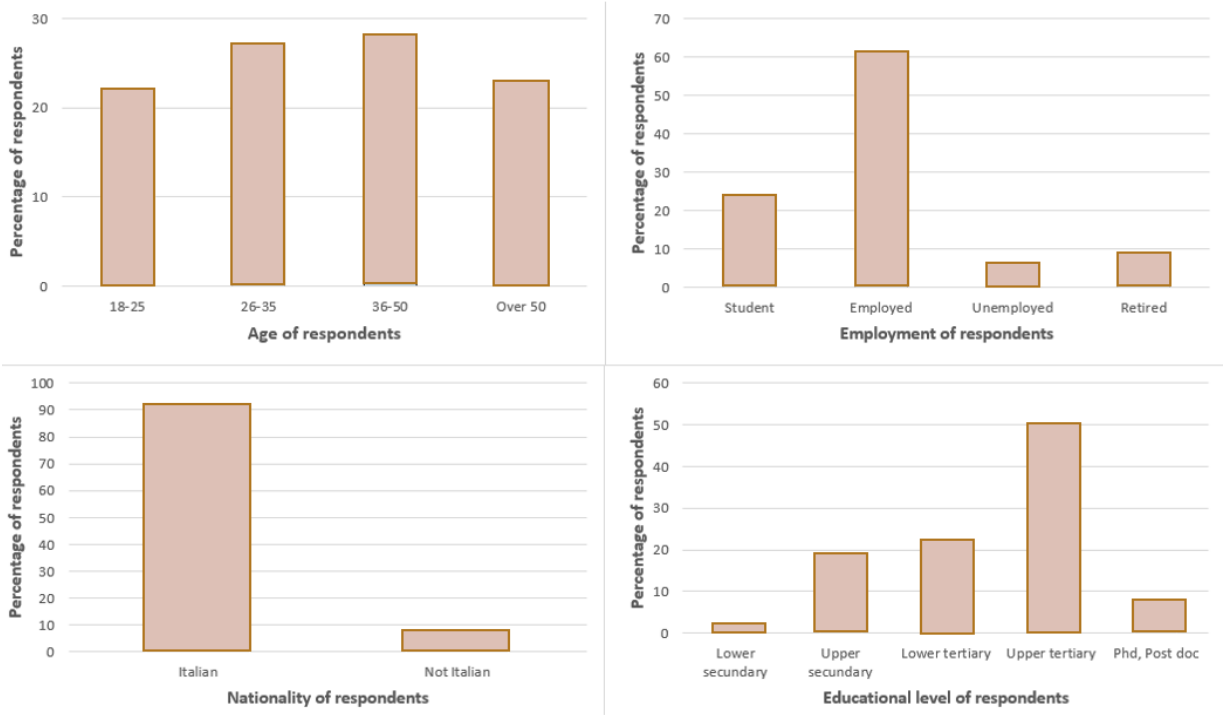

Figure 7. Sociodemographic distribution of citizens in Turin

3.2.2. Travel behavior of participants

Around 41% of the interviewees declared to do not use a car, compared to 37% of women who do not ride a bicycle in Turin. The tendency to use the car is age-dependent, as shown in the bar charts of Figure 8. Indeed, more than five-sixths (84%) of over 50 drive a car, in contrast with around two-sixths (35%) of 18-25 aged women.

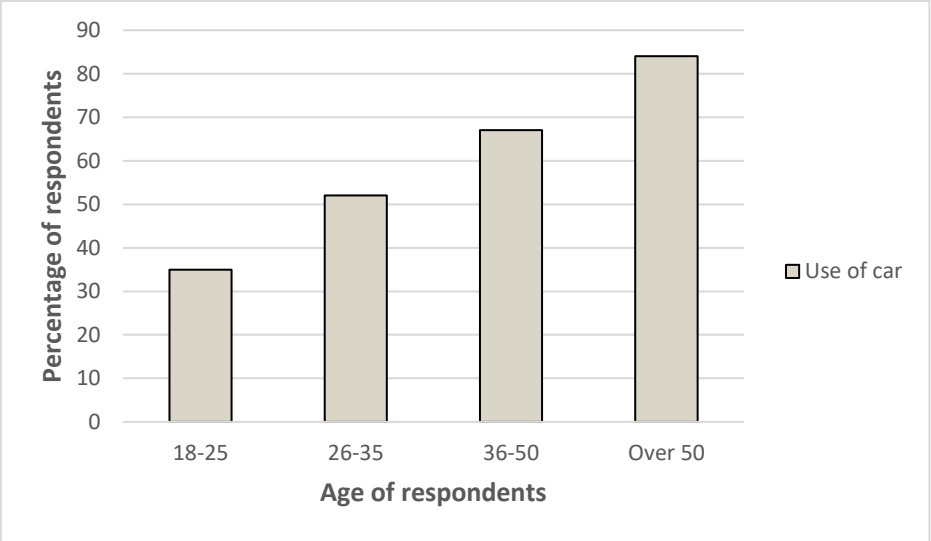

Figure 8. Women' percentage declaring to use a car in Turin based on age.

Among women who have a car, small-sized were used by around half of respondents (46%). Half of respondents who own a car declared that their vehicle was powered by petrol, followed by diesel (20%) and LPG (18%). Moreover, the car was a means of transportation mostly used for short distance travels since three in fours of respondents drive weekly 1-15 kilometers. This percentage sharply decreased for longer car-distances: a residual percentage of 1% drives for more than 200 kilometers every week. The bicycle instead turned out to be a mode of transportation more homogeneously distributed for people who make travels of different distances. Indeed, if around one-fifths (23%) of cyclists asserted to ride weekly 1-15 kilometers, the lowest percentage was reached by 5% of women who cycle for more than 60 kilometers every week.

3.2.3. Factors affecting the willingness to cycle among women

In the following parts, findings from the questionnaire will define reasons for cycling among women. Overall, twelve factors out of fourteen presented to encourage women cycling (see Appendix IV) showed agreement among respondents. These factors performed means' scores higher than 3.5 on a 5-point scale. Among factors discouraging women's decision to cycle (see Appendix IV) only three out of thirteen overcame 3.5 as means' scores.

Personal well being

Findings indicated that senses of comfort and empowerment positively affect the decision to cycle (Table 2). Being comfortable obtained the highest score of agreement (score 4.5 on the 5-point scale). A moderate majority of women cycle also to do physical exercises (score 3.8 on the 5-point scale). Hence, most respondents agreed that cycling is beneficial to their personal well-being.

Table 2. 'Personal well-being' explanatory factors

	Strongly Disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Strongly Agree (5)	Mean
Cycling is comfortable	1%	0%	8%	32%	59%	4.5
Cycling is empowering	2%	2%	13%	30%	53%	4.3
I cycle to have physical exercise	2%	8%	19%	49%	22%	3.8

Efficiency

Women tended to positively agree on bicycle as a convenient way to travel (Table 3). More than half of women strongly agreed that being independent from the public transport timetable encourages them to use the bicycle. Cycling to go fast followed with a score of means of 4.1, as the result of around four-fifths of women who agreed or strongly agreed with this factor. Around three in four of respondents positively agreed to use the bike to avoid parking problems. Finally, cycling as fruitful way to make multiple stops, got the lowest mean (score 3.8 on the 5-point scale) which still corresponds to a moderate level of agreement.

Table 3. Efficiency' explanatory factors

	Strongly Disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Strongly Agree (5)	Mean
Cycling helps me to get faster to my destination	4%	5%	13%	38%	40%	4.1
I cycle to avoid parking problems	2%	9%	14%	33%	42%	4.0
Cycling is an efficient way to travel because I do multiple stops	5%	8%	22%	36%	29%	3.8
I do cycle to not be bound the public transport timetable	3%	1%	10%	35%	53%	4.3

Other factors: economic & environmental reasons

Table 4 shows that environmental determinants influenced positively the women's willingness to cycle. Both cycling to protect the environment and to contribute to reducing air pollution obtained the same mean of agreement (score 4.4 on the 5-point scale). Specifically, more than 90% of women agreed or strongly agreed to cycle to reduce air pollution whereas only eight women out of 228 strongly disagreed or disagreed with it. Contributing to a more livable city obtained a large consensus among respondents: even in this case, around 90% of women positively agreed with this statement. Saving money got one of the lowest scores of mean among all these factors (score 3.7 on the 5-point scale).

Table 4. 'Economic & Environmental' explanatory factors

	Strongly Disagree (1)	**Disagree (2)**	**Neither agree nor disagree (3)**	**Agree (4)**	**Strongly Agree (5)**	**Mean**
Cycling is a way to save money	4%	9%	19%	47%	21%	3.7
I do bike to protect the environment	1%	2%	6%	38%	53%	4.4
By biking, I contribute to reduce the air pollution	2%	1%	5%	33%	59%	4.4
By biking, I contribute for a more livable city	1%	2%	6%	36%	55%	4.4

Safety & Security

Security-related factors obtained higher means (score 3.8 on the 5-point scale) when compared to perceived safety (score 2.9 on the 5-point scale) while cycling (see Table 5).

Safety risks, intended as the perceived feeling of being threatened by something or someone, did not negatively influence women to cycle. In my study, a brighter lane is a controversial factor: despite it obtained a low mean of agreement (score 3.2 on the 5-point scale), light poles were moderately chosen as fundamental bike infrastructure (see Chapter 3.2.4). Feeling safe on bike lanes due to potential verbal or physical harassment attained a score mean of 2.5 out of 5. This factor did not negatively determine women's choice to use the bicycle for over half of them.

Security-related factors, meant as those external threatens that do not protect women, significantly affected their decision to cycle. Bike lanes turned out to be not connected and not heterogeneously spread throughout the entire city for almost two-thirds of women. More than three-fifths of

respondents considered the car's speed as a discouragement to cycle. Almost the same percentage is affected by the structural lanes' quality.

Table 5. 'Safety & Security' explanatory factors

		Strongly Disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Strongly Agree (5)	Mean
Safety	I am not feeling safe in the bike lanes due to potential verbal or physical harassments	25%	28%	26%	17%	4%	2.5
	I am not feeling safe in the bike lanes because they are not enough lightened	11%	18%	23%	37%	11%	3.2
Security	Bike lanes are too dangerous due to their structural conditions	3%	14%	21%	40%	22%	3.6
	Cars drive too fast on the road to cycle safe	6%	14%	15%	37%	28%	3.7
	Bike lanes are not well connected to one another	3%	11%	14%	32%	40%	4.0

The security and safety perceptions based on age are displayed in Table 6. A general trend can be explained as follow: women 18-25 aged have higher concern for safety (score 3.1 on the 5-point scale) whereas the mean decreases for over 50 (score 2.8 on the 5-point scale). Over 50's, unlikely, feel more secure on bike lanes (score 3.6 on the 5-point scale) compared to 18-25 generations (score 4.0 on the 5-point scale). However, the low score of the Spearman index (R_s=0.1 for safety and R_s=-0.1 for security) demonstrated a not significantly high correlation between age and these two factors.

Table 6. The correlation between the safety and security perceptions of cycling and respondents' age

Age	Safety	Security
18-25	3.1	4.0
26-35	2.8	3.8
36-50	2.7	3.7
Over 50	2.8	3.6

Preference for other means of transportation

Results from the questionnaire indicated that other modes of transportation are not significantly preferred over the bike among women. The electric scooter, which has seen a sharply spread around the city over the last three years, was not able to replace the bicycle. Indeed, only 15 out of 360 women prefer to use electric scooters over bicycles. With two-fifths of respondents who positively agreed, walking was the most chosen substitute for the bicycle.

Table 7. 'Preferences for other means of transport' explanatory factors

	Strongly Disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Strongly Agree (5)	Mean
I rather prefer to walk than cycling	27%	25%	15%	20%	20%	2.7
I rather prefer to use the bus/ metro than cycling	31%	28%	15%	14%	12%	2.5
I rather prefer to use the electric scooter than cycling	66%	22%	8%	2%	2%	1.5

3.2.4. Infrastructures & services as incentives for cycling among women

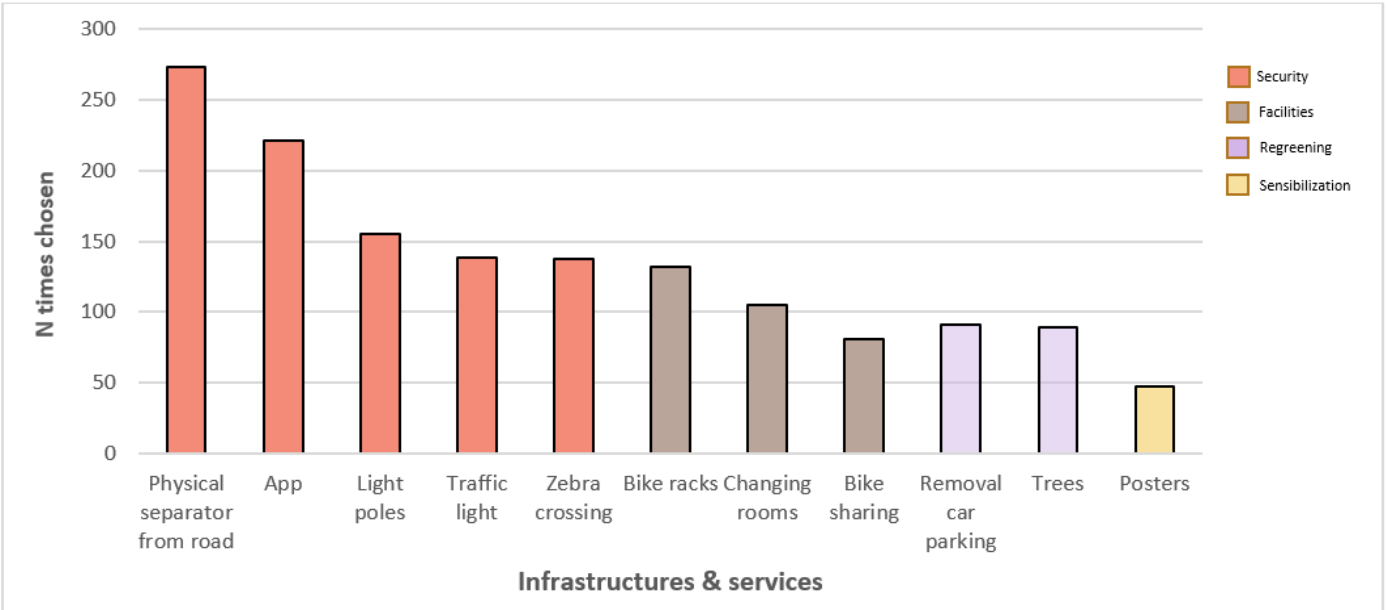

Figure 9. Eleven bike infrastructures and services as proposed in the questionnaire.

Respondents were also asked to select max five choices of preferred bike infrastructures or services to see implemented in Turin. Outcomes from this choice also ensure to deduce which factors encourage women to cycle. Indeed, all the eleven services are related to factors that negatively and positively affect the willingness to cycle. These infrastructures were grouped into four topics of relevance: facilities that guarantee a high security standard, those that facilitate the bike system's accessibility, infrastructures that initiate a greenery process of public spaces, and tools to raise awareness on gender and sustainability issues.

As shown in the bar charts of Figure 9, all the infrastructures and services related to security were the most preferred by women. This choice confirmed what emerged from the Likert Scale: women are encouraged to cycle in a secure and protected environment. Physical separator between bike lanes and road was the most preferred infrastructure. It was chosen 273 times. A bicycle app showing the bike network and most secure roads to take followed. However, this service was unequally chosen among ages since its choice decreased constantly with the increase of age. App as a service reached the highest preference among 18-25 aged (74%) and the lowest among over 50 (44%). Among middle ages, 67% of women 26-35 years chose this service, whereas 60% of 36-50 aged opted for it.

Facilities that increase accessibility of the bike system were moderately appreciated. For example, bike racks avoid wasting time to find parking and secure parking. Since bicycle theft is a problem in Turin, bike parking widespread throughout the city facilitates accessibility of cycling even in the most problematic areas. Bike racks got 132 preferences as infrastructure to set up for a woman-friendly design. Showers and changing rooms at work and school were chosen 105 times: this service is bond with social expectations and roles that women are still subjected in our society. This service was differently chosen between Italians and Not Italians. Specifically, Not Italians opted less for this service (11%) compared to Italians (31%).

The car parking removal, chosen 91 times, reduces the space available for cars, while increasing public spaces for bike lanes, sidewalks and green spaces. Bike corridors could also be locations for trees. With 89 votes, trees alongside the bike tracks modify the urban asset. Indeed, they make aesthetically beautiful bike lanes while promoting the regreening process in urban spaces. These two infrastructures contribute also to increase security for their functions as barrier-protector from roads. However, they got a low score compared to the installation of physical separators.

Lastly, posters were added in my study as a tool to raise awareness about gender and environmental issues alongside the bike lanes. This service was the least opted between all the bike infrastructures. It was selected 47 times.

3.2.5. The willingness to cycle and the travel purposes in a woman-friendly bike city

My questionnaire also assessed the willingness to change mobility behavior among respondents. Results of Figure 10 show that 92% of respondents declared to be willing to use (more) the bicycles in case bike system starts to reflect their needs. Among them, almost all the 18-25 and 26-35 aged respondents (99%) were highly motivated to increase their travels made by bike, whereas 75% of over 50 agreed. These results indicated that elderlies were the most reluctant to change their travel lifestyles.

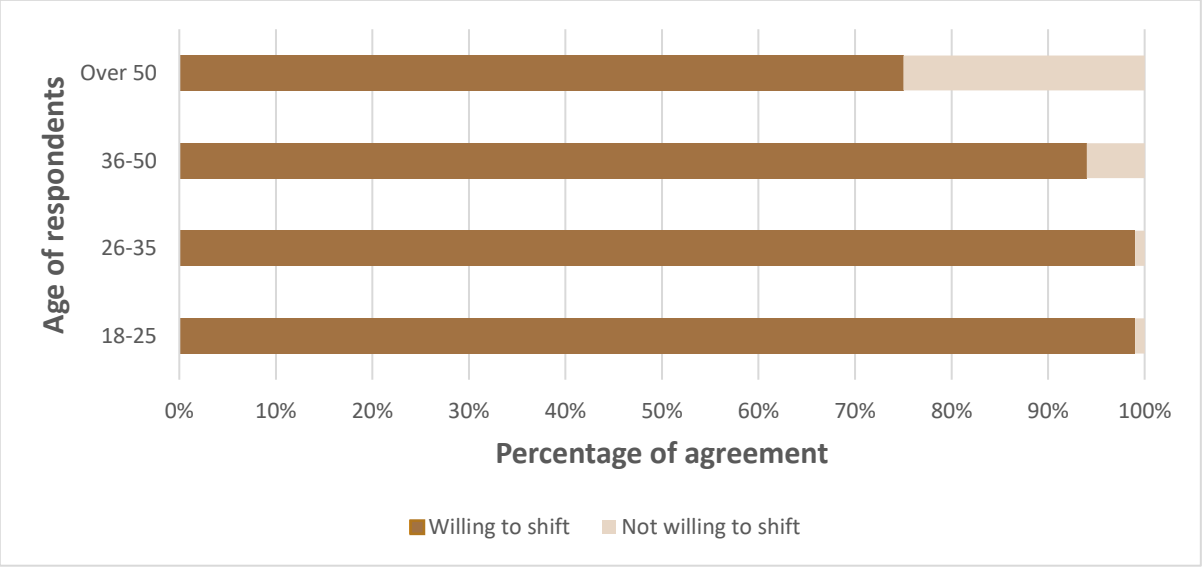

Figure 10. Willingness to shift from vehicles to bicycles in case of a woman-friendly bike system.

My study also analysed for which destinations or purposes women would be more inclined to cycle in case of a woman-friendly bike system (see Figure 11). Cycling activities can be grouped into two spheres according to the travel purposes: occupation and leisure.

Among the former, cycling to work was the most chosen destination towards which cycling (more). It was selected 204 times. Using the bike to go to school accounted for 77 votes. This destination is probably influenced by the respondents' age or by the fact that students, as mentioned in the Introduction, already cycle in Turin.

Among leisure activities, recreational activities were the most chosen, followed by going outside with friends. Cycling to do physical exercises and to have shopping were the least preferred purposes. Only 20 women would not be stimulated to cycle (more) in case of a woman-friendly bike system.

To summarize, a system that reflects women's needs could incentivize pro-pleasure activities since leisure pursuits together got 368 votes out of 669. However, cycling for work, under the occupational domain, is the main route that could see the highest improvements.

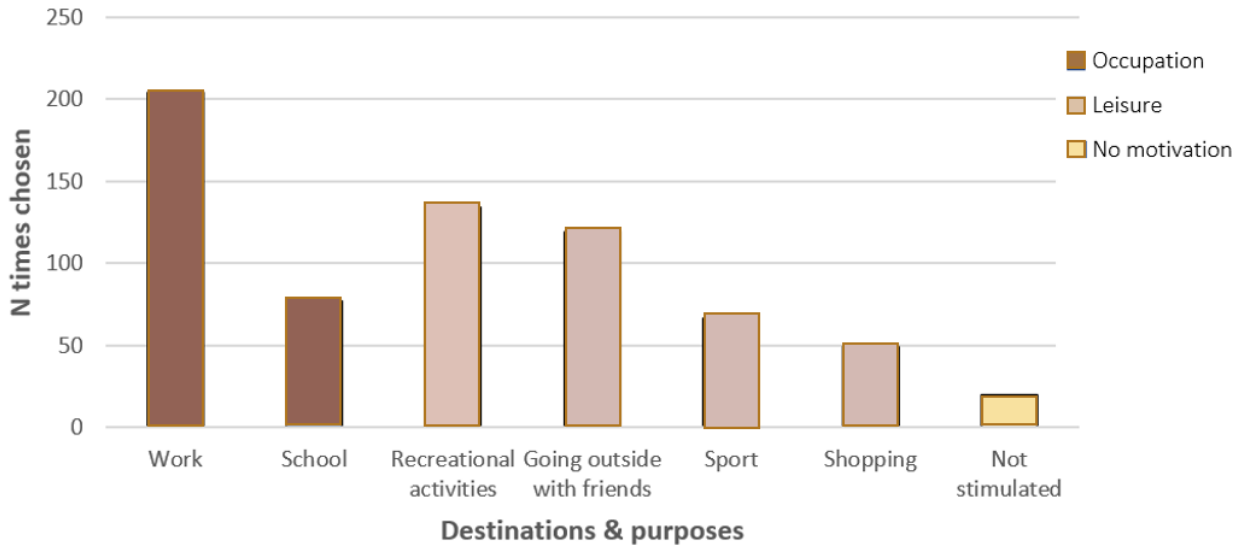

Figure 11. Destinations towards which respondents are more stimulated to cycle.

3.3. Results from field observations

During my field-observation, I observed less cyclists, both men and women, on roads with sharing facilities with vehicles (see Figure 12). Regarding the users' gender (see Figure 12a), during the day both the women's percentage and number riding the bike were higher where bike lanes were physically separated from the road. In separated roads, the ratio of women frequenting bike lanes was equal to half (Via Nizza) or higher than half (Corso Giacomo Matteotti) to the total cyclists' number. In bike-car shared roads instead the woman's percentage was always lower than 40%. Trees alongside the lane did not influence the number of women cycling since Corso Giacomo Matteotti was without trees but the most frequented by women. The impacts of bike racks and the bike-sharing service were not possible to tackle because these infrastructures were spread in all four bike lanes.

During the night (see Figure 12b), Corso Giacomo Matteotti had the highest relative women's percentage (47%) out of men (53%). Overall, women's percentage decreased during the night if comparing to the numbers reached during the day. Only Corso San Massimo slightly arose the

women's percentage, from 32% during the day to 33% during the night. The decrease was moderate in Corso Giacomo Matteotti (from 53% to 47%) whereas Corso Vittorio Emanuele and Via Nizza had a significant reduction of around 10 percentage points during the night. Besides, in bike lanes with no physical separation, women were more common on Corso San Massimo. This street was frequented by few cars and passing at slow speed.

To summarize, physical separation and a slow car's speed and car's number were those infrastructures and factors that most increased the ratio of women to men, respectively during the day and the night.

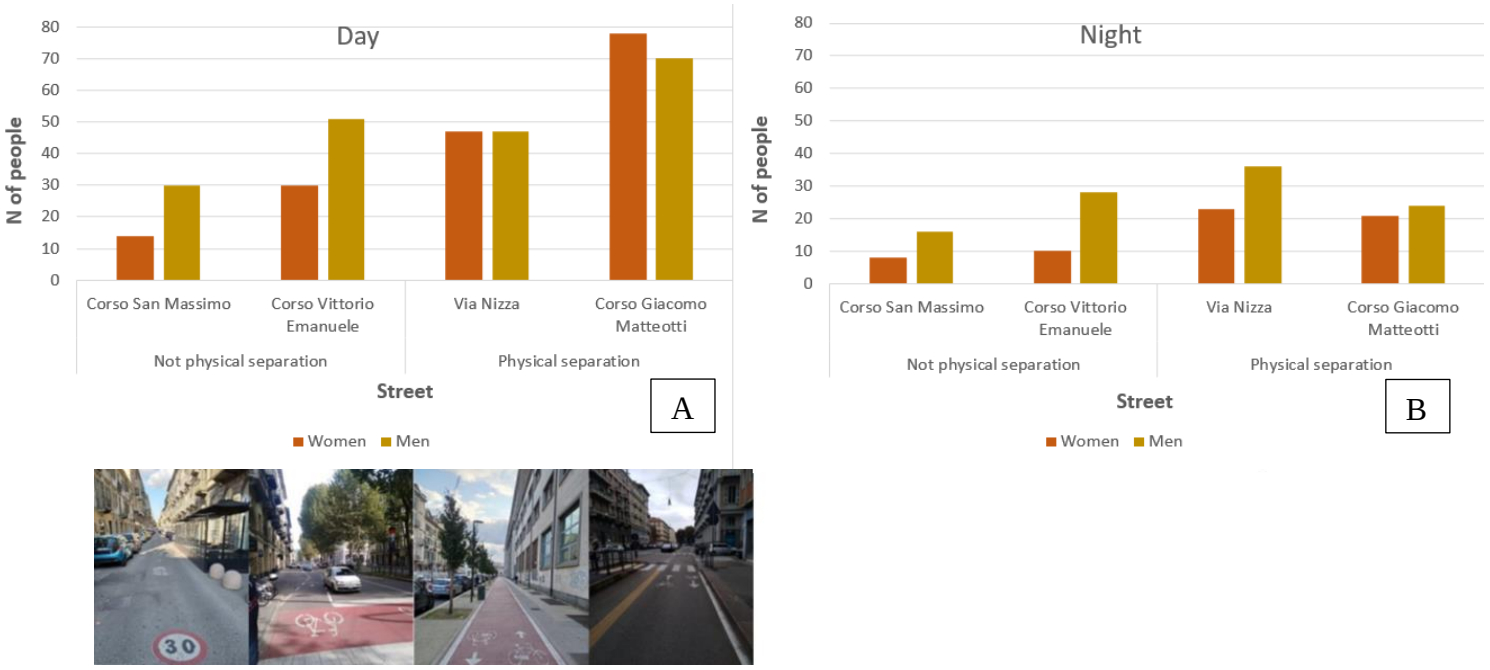

Figure 12. Women's and men's number riding in four road in Turin. Observations were carried during the (A) day and during the (B) night. The pictures show the four different bike lanes with different bike infrastructures and facilities.

Furthermore, field-observations provided insights into the kids' number traveling by bike with their parents and alone during the day. No kids were observed during the night. The highest number of kids with or without their parents was observed in Corso Giacomo Matteotti (see Figure 13). Fourteen kids were noticed in this street. Here, also one pregnant woman with a kid on her bike was observed. Eight kids were observed in Corso San Massimo. This road is crossed by cars at a low-speed rate.

As for the parenthood's gender, in total twelve women and eight men with kids on their bike seats were viewed. Whilst six kids were riding alone. The relative women's percentage out of men with kids was always higher in separated lanes than in roads shared with cars. On the contrary, roads with no physical separations were more frequented by men with kids. Hence, results from field-observations showed that gender of cyclists bringing kids was influenced by the presence of a separator from roads.

Besides, elderly women were mainly observed in separated lanes, whereas younger women were more spread between all the four lanes.

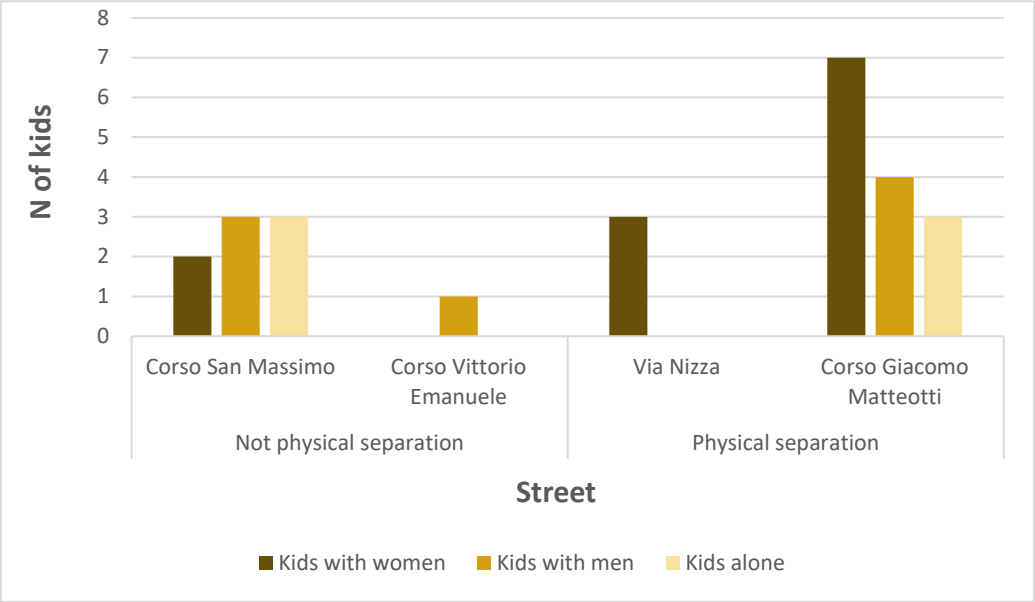

Figure 13. Kids' number who were carried by women, men or alone during the day.

3.4. Results from interviews

3.4.1. Actions to increase security and safety for women who cycle

Interviews with experts provided the ground to identify strategies that can address security and safety risks while cycling. Their opinions support potential actions to reduce the feeling of danger among women cyclists. According to the experts, the promotion of a safe and secure environment increases the attractiveness of cycling as a mode of transportation. Target-specific campaigns should also be lauched by Institutions to encourage women who want to start cycling. These strategies aim to promote solution-oriented initiatives that change women's perception of security and safety.

1. Increase the cyclists' number

According to experts' opinion, a high number of cyclists using the bike lanes makes cycling and walking secure for everyone. Accordingly, the perceived safety to cycle increases. Peter Jacobsen (2015) was the first who referred to this phenomenon by calling it 'safety in number' (Figure 14). Maria La Pietra called the critical mass of cyclists as a strategy to feel less in danger when using the bike. Likewise, as stated by Anna Donati "the cyclists' number and the target of cyclists increase safety on bike lanes". As she asserted, kids most likely benefit from safety in number phenomenon

because a safe environment 1) stimulates them to cycle and 2) mothers are more willing to let children cycle alone in a city frequented by many cyclists.

Figure 14. Cyclists occupied peacefully streets during the Bike Pride in Turin (Manfredi, 2018)

2. Make bike lanes and cyclists visible

The architect Chiara Lucchini said that cyclists' visibility reduces the risk and the severity of road accidents. Thus, the designing phase of a bike lane needs to incorporate visibility as fundamental factor. Likewise, for Cristina Fabrizio, bike infrastructures should be designed to make the cyclist visible from every road's user. Alongside, the cyclist herself must see other people to have control over security. In the Piedmont regional guidelines, Cristina Fabrizio suggests not to cycle on those roads with walls alongside the lane and choose those bike lanes with escape routes. As such, the Piedmont Region advises women cycling in well-marked, clearly visible and safe lanes.

3. Encourage specific routes: Bike to Work & Bike to School

The promotion of protected roads between strategic places increases women who cycle, experts said. As stated by Maria La Pietra, the safety and security of school-work routes needs to be the Municipality priorities. This opinion is shared by Samuele Bavuso and Cristina Fabrizio. Cristina affirmed that " social and cultural initiatives such as *Bike to Work* and *Bike to School* facilitate women's accessibility to active modes of transportation". These strategies incentivize more people to cycle. As a result, they make cycling more secure.

3.4.2. Woman mobility through a not gendered based perspective

The design phase of a bike system goes beyond the perspective of lanes as a priority of only one gender, Anna Donati and Cristina Fabrizio said. As asserted by Giovanna Rossi, "a woman's perspective is certainly useful to promote a system that encourages women to cycle because she knows what other women need". However, one-way information source most likely compromises the accessibility of cycling for both women and men. Cristina Fabrizio supported this assumption: "As a woman, I do not need something reserved only for me but a system that supports my needs". Therefore, both men's and women's perspective should be included in the design phase of the bike system since they have different needs in relation to mobility. As Cristina Fabrizio asserted, "a woman could focus on security, visibility and lighting issues whereas a man could think about maintenance and efficiency".

Besides, safety, accessibility and comfort pass by looking at children when designing a bike lane. Instead, Cristina Fabrizio said that as a Regional employee, she "always look at the children [in designing a bike lane]. If they feel safe and happy in the road, it means that the lane is accessible for everyone".

3.4.3. An inclusive narrative to support women cycling: exploring positive discourses & rhetoric strategies

In my study, Maria Cristina Caimotto investigated the historical and cultural meaning to choose the car as a means of transportation. Her contribution outlined the social context when car-centric mentality dominated over other transportation modes. This milieu has excluded women in mobility due to a distorted narrative that has been built over time, she asserted. As such, in the past women were relegated to the function of transport users. The women's contribution in initiating the revolution towards new forms of mobility needs therefore to be tackle. For example, "[…] there used to be resistance from women in the past, who fought to remove cars in the city because children could no longer play safely in the street. This is a whole narrative that is being removed by a distorted one. The dominant narrative is that women as soon as they had a chance to use the car, they did it".

Table 8 explores words, sentences and linguistic narratives to restore the real contribution that women have made to mobility. The below section gives the ground for a new innovative approach towards a gender-inclusive language. This rhetorical strategy could be adopted by institutions, media, organizations and citizens.

Table 8. Words and sentences to be avoided on the left and to be promoted on the right according to Maria Cristina Caimotto.

N	Words/sentences to avoid	Words/ sentences to promote
1	Cycling is only to promote the environment	Cycling is for the environment, for yourself and to feel good
2	Sweet Mobility	Active Mobility
2	Weak users	Users
3	News: "The car hit the cyclist"	News: "The driver* hit the cyclist with his/her car"
4	Cyclists	People cycling
4	Car drivers	Car-dependency
5	"You need physical preparation to cycle"	"Everyone can cycle"
5	"You need a proper sportswear to cycle"	"Every cloth is for cycling"
6	Roads are for drivers	Roads are for people
7	Promoting cycling among cyclists	Promoting cycling among everyone

** refer to the person whenever possible*

1. Differentiate the message: marketing tactics to employ cyclists

Cycling is generally seen as a healthy and environment-friendly practice. Instead, the bicycle is a complex service of factors that provide multiple benefits for people. Proper rhetoric ensures that all the multiple benefits of cycling are communicated through differentiated messages. For example, Maria Cristina Caimotto asserted that sustainability for cycling does not work for everyone. This factor likely reinforces all those clichés against cyclists, environmentalists, and women. She suggested promoting personal wellbeing as a reason to cycle. "Cycling for yourself!", Maria Cristina Caimotto said. In this way, the intrinsic value passes to the cyclist who is now able to 'express' her feelings. As an example, she mentioned the communicative strategy promoted in Bristol in 2015. Posters depicted people riding bikes while wearing daily life dresses. These figures were flanked by messages such as those shown in Figure 15.

Figure 15. Posters of the Bristol Cycle Strategy 2015 (Bristol European Green Capital, 2015)

2. Words to be abolished to break down prejudices

Both cycling and cyclists suffer from a rethoric problem because vehicular-cycling campaigns still embody a patriarchal mentality in Turin. This section investigates words that promote cycling and at the same time break social prejudice down. Firstly, according to Maria Cristina Caimotto, the term *sweet mobility* (mobilita' dolce) should be removed in the campaigns of Turin and replace with *active mobility* (mobilita' attiva). Indeed, the term sweet mobility reinforces the idea of women as the weaker sex. Secondly, the term *weak users* should be abolished to refer to those who cycle. This concept strengthens patriarchal and paternalistic mentality since it bolsters cycling as a hobby for women who are weak. These words promote wrong rhetoric which in turn feeds prejudices of "the bike is not a serious means of transportation. It is a hobby, it's for those who don't work that often are women" Maria Cristina Caimotto said.

3. The media roles to communicate right messages

Maria Cristina Caimotto analysed newspaper articles and institutional documents to demonstrate how linguistic strategies influence the readers' interpretation of the cyclist. Her work aims to promote a new discourse to inspire an inclusive communicative strategy. This in turn contributes to a fruitful debate. Specifically, I chose newspapers as a powerful example to stimulate a positive discourse about road users. As stated by Maria Cristina Caimotto, headlines often used are *"The car hit the cyclist. The driver provided help to the victim"*. As such, the person causing the accident is objectified as the car whereas the person who lends the rescue is identified as the car driver. Vehicles are thus blamed

while the driver has no agency on the accident. This linguistic strategy shows car drivers as good people even when they cause road accidents. “The message given is that the car goes crazy, not the person causing the accident” she said. For Maria Cristina Caimotto, a good communicative strategy subjectivizes who cause the accident and avoids labelling people according to their modes of transportation.

4. Institutional linguistic strategy

Maria Cristina Caimotto introduces the communication strategy employed in 2018 by the Londoner Transport Strategy as an example to debate about vehicular-cycling campaigns made by institutions. The Londoner strategy incentivized women using bikes and avoided an ‘us-them’ approach that leads to conflict among road users. In a 160-page document, the word ‘*cyclist’* was substituted by ‘*people cycling*’. Likewise, car issues were translated into ‘*car-dependency*’. Hence, this strategy highlighted the social and medical problems of using the car.

In Turin, driving a car, Maria Cristina Caimotto continued, is often not a choice because the city’s infrastructures make people addicted to the private vehicle. Car-dependency is largely a consequence of institutional automobility in Turin. This phenomenon brings to an institutional responsibility. However, as she claimed, institutions often call for individual choices because citizens have the agency to abandon their cars. This is a distortive narrative in which the individual responsibility is passed off as freedom of choice, she said. Indeed, “over time the dominant narrative has depicted the car as a beautiful, efficient and preferred choice to travel”.

5. Social expectation to go at work well dressed and increase social status

Social expectations and cultural attitudes influence how women travel. For example, a dominant narrative to be broken is that women are expected to go to work by car. This is motivated by the fact that women should avoid sweating, wear a proper dress, and have their hair carefully slicked. “These notions are often not implied for a man”, Maria Cristina Caimotto said.

During my study, I asked two architects to define how being nicely dressed impacts their profession. One of them mentioned that the architect “implies mobility totally incompatible with the bicycle” because credibility is mined when a freelance architect meets the clients all sweaty. “My job is based on appearance. The architect is entrusted with the rich client and thus I have to look credible”, she said. Of other opinion was Genny Stefanelli. She cycles to work because she has chosen to not have a car: “I do not care how I dress at work. I care about my social status. In Turin the bicycle is still perceived as a means of transportation for the poor”.

6. The promotion of coexistence on road among users

Social frames play an influence in shaping the streets' role and design. The car-oriented identity of Turin led to look at the street as a separated cluster of spaces with different purposes. As such, streets reserved for car subjugate bike lanes. Meanwhiles, the driver assumes a role of dominancy among other road users, Maria La Pietra said. The promotion of coexistence between means of transportation on the same road breaks down the car-centric mentality of Turin and removes tension between road users, she said. Her vision of inclusiveness starts by designing a road heterogeneity used by different people. As such, Maria La Pietra strives to define roads as space for every citizen. Finally, as Pedro Blazquez Espi told, coexistence is promoted by avoiding labeling people based on their means of transportation. This strategy prevents disputes among different road users.

7. The promotion of a "personalized" communication in the volunteer sector

In my study, Genny Stefanelli contributed to delineating communicative strategies as adopted by bike volunteer associations in Turin. Bike Pride's rhetoric flags of reaching people who do not cycle. Equal accessibility in the cycling network is threatened by a communication strategy that does not consider personal solutions, she said. Indeed, not personalized communication strategies reach only a limited target of people. As a solution, Genny Stefanelli stated that bike volunteer associations need to promote more inclusive rhetoric. Their aims should look at the most marginalized women who still do not cycle. Local associations should investigate the personal needs of each citizen to go in-depth with the problems that she faces when using the bike, Genny concluded.

3.4.4. Women as vector of change in mobility

In the past years, the transport meaning has changed. This historical change has, in turn, influenced the women's role in the mobility departments. In my study, experts were asked to retrace the key-characteristics of mobility over time and the contribution women gave to it. Anna Donati defined a past in which mobility was meant as a way to improve travel efficiency. Maria La Pietra added "power and money" as words that characterized the mobility departments in the past. These mobility's aspects according to Giovanna Rossi, were inaccessible for women since their role within the society excluded them from power.

In recent years, mobility changed its identity due to new challenges to be addressed, from environmental degradation to social inequalities. Social welfare and accessibility started to be associated to mobility, while efficiency was flanked by its sustainable determinant (e.g. energy

efficiency). This socially equal and environmental-oriented mobility transition required to rethink the entire sector and to promote innovative solutions for tackling old and new problems. Women's tendency towards change "was what mobility needed", Giovanna Rossi said. Anna Donati contributed to define the social women's role as a vector for changing the way to intend mobility: "Women found their space when mobility had to be changed and treated in Italy". All experts concluded that social and personal conditions of being a woman make her a powerful vector of change. Indeed, the woman's attitude towards change and innovative solutions contributed to internally revolutionized the urban transports in Italy. Better women's accessibility promoted a mobility transition both in social and environmental terms. Anna Donati pointed out women as not naturally predisposed towards change. However, their past marginalized role in the Italian society has urged them to adapt their lifestyle to a hostile environment.

Woman's awareness to find innovative solutions is amplified by being a potential mother. Indeed, a mother emphasizes on the health and future of her child(ren). As such, women with kids are more likely to change their lifestyle, Chiara Lucchini and Giovanna Rossi conveyed. According to Anna Donati, women are flexible to embrace environmentally friendly daily behaviors, such as cycling, because they are aware of being directly threatened and to extend this threat to the next generation.

Accordingly, women's accessibility in mobility contributed to redefine the bicycle as a multifunctional tool that ensures multiple benefits. Cristina Fabrizio asserted that cycling is not anymore only using the bicycle. It is a complex system of perceptions of the surrounding space. "Mobility strategies require a system thinking approach. If you promote the bike use, you incentivize also those policies aimed at social interactions within the city. Public spaces become more pleasant, livable, sustainable, and accessible to everyone. Finally, this space shaped by the bike changes the woman's perception of security and the space around the city" she concluded.

3.5 Results from the vehicle-emission factor: air emission reductions in Turin

My study demonstrated that the transition from using vehicles to riding a bicycle affects the amount of CO_2, CH_4, N_2O emitted in the atmosphere of Turin. This potential shift cuts around one-third of emissions (see Table 9). Nitrous oxide showed the highest reduction in percentage (33%) saving every week about $0.8*10^{-2}$ kilograms of pollutant emitted into the atmosphere. The carbon dioxide emission decreased by 500 kilograms every week. This is equivalent to a reduction of 31% of the current CO_2 emissions. The methane was instead the gas that displayed the lowest reduction in percentage (29%).

Table 9. Current and potential CO_2, CH_4 and N_2O emissions based on the current and potential kilometers travelled weekly by car by 360 respondents.

Distance	CO_2 (kg/week)	CH_4 (kg/week)	N_2O (kg/week)
Emissions based on current distance travelled (km)	$1.5*10^{3}$	$6.2*10^{-2}$	$2.3*10^{-2}$
Emissions based on potential distance travelled (km)	$1.0*10^{3}$	$4.4*10^{-2}$	$1.5*10^{-2}$
Difference of emissions (kg)	$5.0*10^{2}$	$1.8*10^{-2}$	$0.8*10^{-2}$
Difference of emissions (%)	31%	29%	33%

According to the Regional Environmental Protection Agency (IREA, 2020), $15*10^{6}$ kilograms of CO_2, $8.7*10^{2}$ kilograms of CH_4 and $7.1*10^{2}$ kilograms of N_2O are emitted every week from the private vehicle sector in Turin. I calculated the contribution of 360 respondents in reducing the total emissions by comparing the values of Table 9 with data from IREA (2020). Carbon dioxide was reduced by $3.3*10^{-3}$% compared to the total CO_2 emitted in Turin. Methane decreased by $2.1*10^{-3}$% whereas Nitrous dioxide accounted for $1.1*10^{-3}$%. These percentages referred to my target population of 360 respondents. However, women over 19 living in Turin are 387,430 (Tuttitalia.it, 2019). Since the total population over 19 of both male and female of Turin is 731,182 and they contribute for $15*10^{6}$ kilograms of CO_2 every week (IREA, 2020), 387,430 women emit proportionally $7.9*10^{6}$ of CO_2 kilograms weekly. A reduction of 31% was equal to $2.5*10^{6}$ kilograms of CO_2 emissions that all the women of Turin contribute to cut. Methane amount was equal to $4.6*10^{2}$ kilograms every week. With the reduction of 29%, women potentially contribute to cut every week $1.3*10^{2}$ kilograms of CH_4. Lastly, N_2O reduced by $1.3*10^{2}$ kilograms every week out of the total N_2O emitted by the woman population of Turin, equivalent to $3.8*10^{2}$ kilograms.

To conclude, Figure 16 shows 1) on the left columns the amount of pollutants as currently emitted in Turin; 2) on the right columns a potential situation in which women over 19 of Turin contribute to cut the amount of CO_2, CH_4, N_2O by respectively 31%, 29%, and 33%. These graphics maintained unchanged the contribution of men in the amount of gas emitted into the atmosphere.

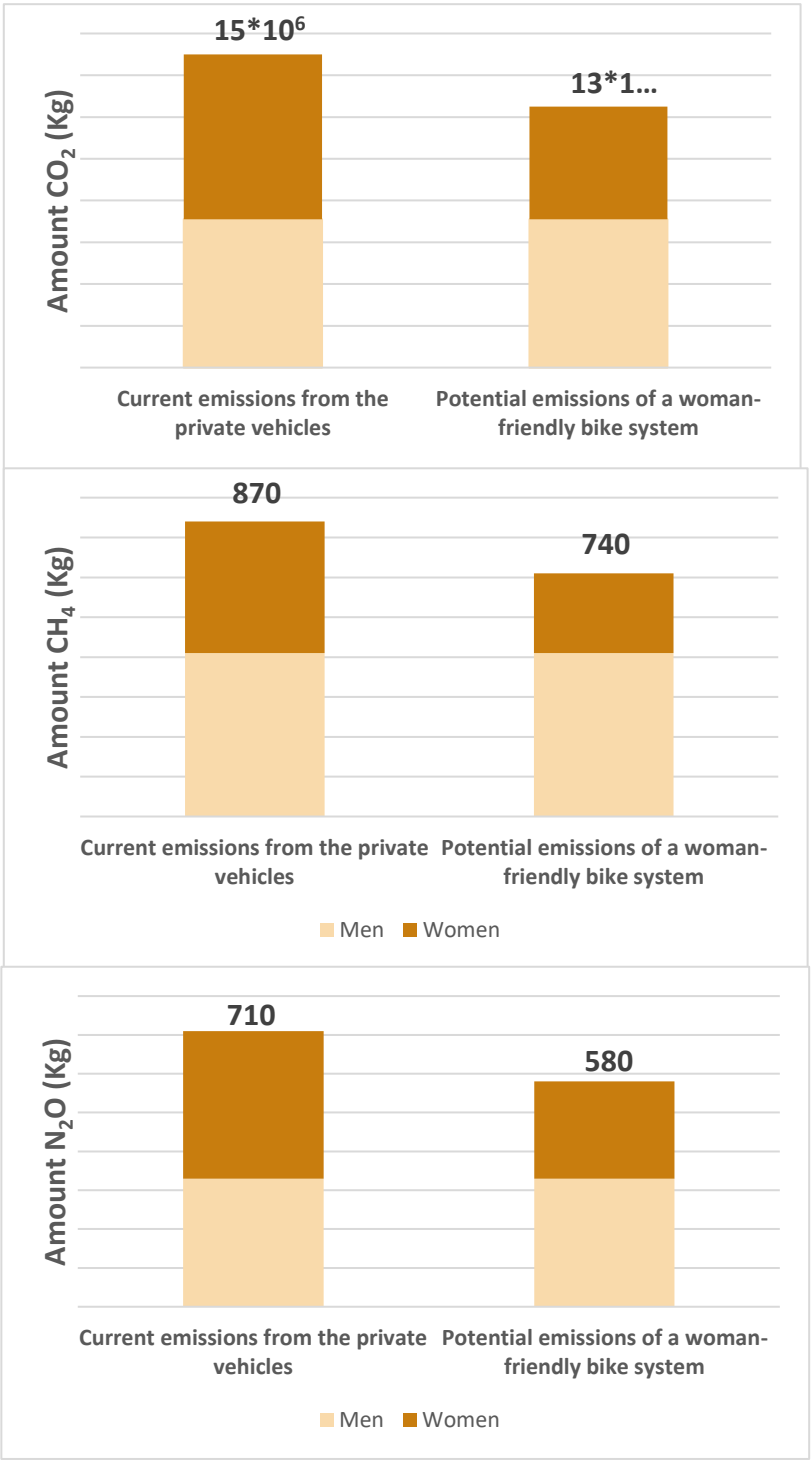

Figure 16. Gas amount emitted by women and men. As for men (47% of the population of Turin) their potential emissions were not reduced but kept equal to those levels currently emitted. Men are responsible for $7.1*10^6$ CO_2, $4.1*10^2$ CH_4, and $3.3*10^2$ N_2O emitted.

Martina Spallone, student cycling in Turin

Discussion

4.Discussion

4.1. Factors and infrastructures affecting women to cycle: comparisons with other studies

In my study I demonstrated that certain motivations and infrastructures are more relevant than others to encourage women to cycle. The below sections summarize my findings as they compare to earlier publications. In particular, my findings are in line with Pérez Brandón's (2019) results, who carried the research in Spain. On the contrary, the Norwegian research (Lunke *et al.*, 2018) presents the strongest misalignment as regards motivations to cycle (e.g. perceived-safety). Additionally, I demonstrated that women universally agreed on some factors (e.g. comfortability) and infrastructures (e.g. physical separators) as essential to cycle. These requirements are shared by women regardless of the country and sociodemographic conditions.

On the contrary, my study showed that other factors (e.g. environmental sensitivity) have different influences on women's willingness to cycle and depend on the study area and the sample population. These factors are thus country and societal-related.

Below, I will discuss more in-depth some of these similarities and differences. In particular, I will focus on those factors that 1) are the main findings of my study and 2) have strongest similarities or differences with other studies.

4.1.1. Environmental reasons to cycle: a country-related element

In Norway women are less likely to use bikes for environmental reasons and more likely to cycle because it is an efficient way to move (Lunke *et al.*, 2018). This is not in line with my study's results. Indeed, I demonstrated that women are likely to cycle to embrace environmental-friendly behaviors. An explanation of discrepancies between my findings and the Norwegian study probably relies on the fact that poor-air quality problems are strongly visible in Turin and much less in Norway. Respondents of my study consider using bicycles not only to be environmental-friendly but also because they want to reduce pollution and to make the city more livable. Therefore, their environmental-friendly behaviors are motivated by their interest in improving personal and collective well-being which is threatened by the poor air-quality. Results of my study thus show how social and environmental domains are considered interwoven by women in Turin.

4.1.2. Aspects that influence security while cycling

I also confirmed that security influences women cycling alone and with their kids. Comparable results emerge in the US (Dill *et al.*, 2014), in China (Lusk *et al*., 2014) and England (Sustrans, 2018). However, these results require an in-depth interpretation. Countries differ for multiple co-variating factors. Thus, countries have different aspects that influence security while cycling. For example, in Northern countries, longer hours of darkness affect perceived security while cycling. Indeed, Sustrans (2018) demonstrated that in England the perception of a secure environment declines by half in the darkness compared to the day.

My study also highlighted that physical separator is likely needed to ensure a secure cycling system. This infrastructure has been chosen as essential to be secure in all the studies (Dill *et al.*, 2014; Lusk *et al*., 2014; Lunke *et al.*, 2018). In my research, I proved that this security-related infrastructure is particularly needed to counteract the high car's speed. By contrast, in Norway, the speed of cars does not significantly influence women's security perception (Lunke *et al.* 2018). The difference probably relies on different aspects country-related. Indeed, some of them pertinently contribute to an objective higher risk to be injured by cars in Italy. Road security is a tangible concern in Italy. In Italy, 253 cyclists died on the streets in 2020 (ISTAT, 2020) in contrast to none on the streets of Oslo (Hartmann & Abel, 2020). These numbers likely justify greater concern among people from Turin on their security on road. These numbers show the actual risk cyclists encounter when they travel, but they reveal nothing about the perception of risk women have while they cycle.

4.1.3. Perceived safety as societal-related factor

Camp (2013) demonstrated that in the US women cyclists are strongly affected by unsafe circumstances. On the contrary, risks related to safety are not perceived as a source of risk among respondents in my study. Specifically, not feeling safe due to potential harassment while cycling got a low mean's score compared to studies by Camp (2013), Lubitow (2019) and Lunke et al. (2018). For example, in Oregon, women claimed to fell in danger because traveling by bike makes them more visible by other people (Lubitow, 2019). Contrarily, during my study an interviewee affirmed that visibility increases the safety level (see Chapter 3.4.1). Different perceptions of danger between countries probably justify the discrepancy in results. The city culture could contribute to amplify the safety-perception and to consider certain actions as harassment. The same source of danger, such as compliments on the street, can be experienced differently between people living in different cities. Moreover, personal and sociodemographic differences likely influence the perception of safety when cycling (e.g. age and nationality). Lastly, my study relied upon both respondents' preferences and

experts' opinions. As such, safety-risks were looked at different degrees of interest. This approach ensured to frame safety in mobility towards a multi-dimensional perspective.

4.1.4. Being a mother: potential factor affecting motivation to cycle

Different studies recognize that being a mother determines the choice to opt for certain factors and infrastructures (Dill *et al.*, 2014; Ravensbergen, 2019). In my study, lifestyle factors such as having a child or being pregnant, probably influenced answers collected through the questionnaire. Women with kids looked at mobility under both their and their kid(s) needs. For example, mothers most probably pay more attention to secure lanes instead of aesthetically beautiful roads flanked by trees. My study initially avoided to correlate woman as a potential mother for two main reasons: 1) this implies that every woman eventually wants to be a mother but this not necessary happens and 2) leads to misinterpretation and ambiguity on the women's role who have to take care of child(ren). The lack of questions related to the influence of having a child, excluded these conditions from the questionnaire. However, my results assessed implicitly a mother-friendly bike system. Only the questionnaire did not assess whether certain bike infrastructures are more preferred among mothers than single women.

Aware of this lack, during my field-observations, I counted the kids' number with their mothers. I noticed that being a potential mother is a factor that influences her to prioritize certain bike lanes. I additionally identified those strategies that likely encourage mothers to cycle through interviews. Indeed, some of experts were also mothers who proposed strategies to stimulate mother-friendly mobility. This finding represents powerful information to change policies in favor of a mother-friendly environment when cycling.

4.1.5. Discrepancies between willingness to cycle and real behavior

My study showed that almost all participants are willing to cycle more when the bike system reflects their needs. This result is in line with a study carried out by Pérez Brandón (2019). However, in all earlier studies, only the willingness to cycle is investigated, not real behavioral change. Although many women could state to be willing to change their travel-lifestyle, this does not directly lead to many women using a bike. My study was the first one to combine results from the questionnaire with field-observations. The questionnaire demonstrated a high willingness to change mobility behavior in case of a woman-friendly bike system. The field-observations assessed the real influence of a woman-friendly bike system on women's decision to cycle. As such, triangulation of my results

helped to define both the willingness to cycle and the influence that infrastructures have on women's participation.

4.2. Mobility strategies as drivers for a woman-inclusive city

Good infrastructures alone would be insufficient to start a transition towards a woman-friendly bike city without adeguate mobility strategies. For example, I mentioned appropriate communicative strategy to contrast the car-dominant narrative and to eradicate the car-centric culture. The study of Emond et al. (2009), finds that in western cities the concept of *needing a car* as a primary means of travel is an important factor discouraging women to ride a bicycle. Similarly, in my study experts presented the influence of Turin's history and available infrastructures on cars' dependency. This influence determines the high use of cars in the city, rather than an intrinsic need of cars as primary means of transportation. According to my work, recognizing the car-dependency pass by having more women willing to change internally and externally the mobility system of Turin. Hence, all those strategies outreached at the inclusion of women in the mobility sector, likely start the transition from a car-dependent to a gender-inclusive bike city.

4.3. Methodological Limitations

4.3.1. COVID-19 as limitation of the results

Some methodological limitations are recognized due to external validities. The current travel limitations to limit the spread of COVID-19, likely affected the cyclists' number during my field-observations. This unprecedented situation has led more people to use the bike instead of public transports (DECISIO, n.d.). This mobility-shift most likely was driven by the fear to be infected by COVID-19 rather than a real willingness to change modes of transportation. As such, my study probably overestimated the number of cyclists observed. However, both men and women have been affected by recent travel restrictions. I thus assume that the ratio of women to men did not change during my period of analysis. Research after the pandemic could tackle this.

4.3.2. Weaknesses and strengths to address cycling from a woman perspective

My study focuses on the key-concepts of woman-friendly bike systems by designing a lane that reflects women's requirements. As such, my research did not focus on differences between woman-man patterns. As mentioned in the Introduction, the implementation of a woman bike lane supports the accessibility for every citizen (Camp, 2013; Garrard *et al.*, 2008). Therefore, by investigating requirements among women, I implicitly provided strategies to promote cycling also for men. Additionally, my choice of focusing on the women's perspective was motivated by the ethical purpose to give them voice in a strictly male sector, as mobility emerged to be in the past.

4.3.3. Limitations to address the potential emissions of a woman-friendly bike system

To my knowledge, no studies have compared requirements for a woman-friendly bike system with the potential reduction in gas emissions from vehicles. Drawing conclusions on the air impact from the questionnaire is challenging due to the simplification of formulating questions (e.g. small, medium and large-sized cars). These wording affected results of the RQ3. However, my questionnaire intended to be simple and accessible and, therefore, I avoided to formulate long and complex questions (e.g. brand of car). This decision made the questionnaire more appetible for respondents. As such, all respondents completed the questionnaire until the end.

Additional limitations are visible in the calculations to answer the RQ3. Indeed, the values obtained in my study, when compared with the amount of emissions of Turin, are below the average estimated by IREA. This is due to 1) data from IREA refers to both men and women living in Turin. Men probably drive more kilometers by car and they use more polluting cars than women, as demonstrated by several studies (DECISIO, n.d.; Civitas, 2020); and 2) my questionnaire was launched during a period of travel restrictions, during which travels made by car were less common.

Moreover, my findings ignore that a woman-friendly bicycle system most probably incentivize men to cycle more. This assumption highlights that a woman-friendly bike system could have more strongly reduced emissions in Turin than what my study estimated. However, my results are not conceptually affected by these assumptions since my research focused on women's contribution in reducing emissions. Therefore, the overall emissions reduction in case of a bike system that encourages both men and women is out of scope of my research. Even if my focus was on only one gender, this does not imply that the consequences of my study affect only women. To conclude, I

suggest further studies that broaden the target population to both men and women. These studies could provide support on the Camp's assumption (2013) that a woman-friendly bike system also incentivizes men to cycle.

Volunteers of Food Not Bombs at the Bike Pride Manifestation in Turin

Conclusions

5. Conclusions

My research explores how women's requirements for bicycling combined with the effect of bicycle infrastructure and possible ways to promote a woman-friendly mobility strategy, helps to stimulate women to cycle, decrease air pollutants and make Turin a sustainable city as depicted in SDGs.

The results of *research question 1* demonstrates that personal and collective wellbeing are factors that mostly encourage women to cycle in Turin. Women ride a bicycle to feel comfortable and to contribute to a more livable and environmental-friendly city. Moreover, women see the bike as an efficient way to move around the city, rather than a convenient means of transportation to save money.

Besides, my study demonstrates that women, when deciding to cycle, are demotivated by an unsecure bike system rather than by the fear to be in unsafe situations. For example, women are more discouraged to cycle, either with or without their child(ren), due to the car's speed on the roads than to potential harassment.

Therefore, a woman-friendly bike system in Turin is equipped with bike infrastructures aimed at increasing the sense of security while cycling. Physical separators, an app showing the bike lanes of Turin, and other security-related infrastructures are indeed preferred most by women. All these factors and infrastructure likely encourage women to shift from car to bike. This change most probably starts the phenomenon of *security in number* because more citizens are incentivized to use their bikes. As such, a woman-friendly city starts the transition towards a bike-friendly Turin.

Alongside the implementation of women-friendly infrastructures, in *research question 2*, I demonstrate that cycling strategies promoting women role on several levels, additionally contribute boosting gender-inclusive mobility in Turin. *Bike to Work* and *Bike to School* routes and improving the visibility of cyclists are two potential strategies to increase perceived security on the road. Moreover, the promotion of a woman-friendly bike system starts from designing a lane in which both men and women are involved in the project. Finally, gender-inclusiveness is achieved by promoting a positive narrative that breaks down stereotypes about cyclists. All these strategies in turn start a sustainable transition towards a woman-friendly bike city.

Mobility strategies and infrastructures to make women-friendlier bike lanes and to promote women's accessibility to the bike system, certainly reduce CO_2, CH_4 and N_2O emissions from private vehicles in Turin by around one-third (*research question 3*). The high women's willingness to switch from

private vehicles to cycling, confirms their key-role to promote an environmental-friendly city. Indeed, my study demonstrates that a woman-friendly bike city is also environmental-friendly.

To conclude, my study shows that developing mobility strategies in line with women's needs devotes Turin as a sustainable city, in which principles of inclusiveness and environmental sustainability are embedded in its identity.

Woman participating at Black Lives Matter manifestation (Rebuffo, 2020)

Recommendations

6. Recommendations

My study demonstrated that a bike system in line with women's needs has multi-benefits for civil society. Cycling as an environmental and social strategy ensures better accessibility and improved air-quality in Turin. For this reason, I recommend to the Municipality of Turin to define goals and possible scenarios before designing a bike system that includes the needs of every social group, from women to kids. Ensuring better women's accessibility, by for example setting up a lane physically separated from the road, needs to be a fundamental phase of the designing project. This in turn, makes a bike system accessible and secure for every citizen. As such, more people will be incentivized to cycle. Even the city will benefit from women-oriented policies in terms of livability, social welfare and inclusivity.

Additionally, the linguistic strategies of media need to reconsider those words and articles' titles that exclude women from access to the cycling system of Turin.

Bike associations are essential as a channel to raise awareness of the benefits of cycling. In particular, they could be the driver for changing the way to move around the city particularly for the most marginalized women. As such, their strategies need to look at those women who are currently not cycling. These people usually are the most excluded in our society due to where they live and the inaccessibility to proper bike lanes in their neighborhood.

To conclude, women themselves need to abandon the idea of mobility as an inaccessible sector. Cycling is a multi-dimensional domain that promotes welfare, social inclusiveness, economic and environmental benefits. Women thus have never been as essential as now for mobility as depicted by United Nations. Their roles as cycling users and mobility policymakers are what is needed to start a sustainable transition in Turin.

References

Aldred, R., Woodcock, J., & Goodman, A. (2016). Does more cycling mean more diversity in cycling?. *Transport reviews*, *36*(1), 28-44.

Asian Development Bank. (2013). Gender Tool Kit: Transport. Maximizing the Benefits of Improved Mobility for All. Mandaluyong City. Department of External Relations

Baker, L. (2009). How to get more bicyclists on the road. *Scientific American*, *301*(1), 28-29.

Barajas, J. M. (2020). Supplemental infrastructure: how community networks and immigrant identity influence cycling. *Transportation*, *47*(3), 1251-1274.

Braun, V., & Clarke, V. (2014). What can "thematic analysis" offer health and wellbeing researchers?. *International journal of qualitative studies on health and well-being*, *9*.

Camp, A. (2013). Closing the bicycling gender gap: The relationship between gender and bicycling infrastructure in the nation's largest cities. University of Oregon. Department of Planning, Public Policy, & Management.

Chakraborty, I., & Maity, P. (2020). COVID-19 outbreak: Migration, effects on society, global environment and prevention. *Science of the Total Environment*, 138882, 728.

Cioffi, J., Schmied, V., Dahlen, H., Mills, A., Thornton, C., Duff, M., ... & Kolt, G. S. (2010). Physical activity in pregnancy: women's perceptions, practices, and influencing factors. *The Journal of Midwifery & Women's Health*, *55*(5), 455-461.

Città di Torino. (2019). Fase 2. Torino si prepara al cambiamento. *Health and Medicine*. Torino

Città di Torino. (2013). Piano della mobilità ciclabile (Biciplan). *Direzione Infrastrutture e Mobilità, Direzione Ambiente,* 1-47. Torino.

Civitas. (2020). Smart choices for cities. Gender equality and mobility: mind the gap!. *Policy note.* Trento.

Costa, D. D., Rippen, N., Dritsa, M., & Ring, A. (2003). Self-reported leisure-time physical activity during pregnancy and relationship to psychological well-being. *Journal of Psychosomatic Obstetrics & Gynecology*, *24*(2), 111-119.

Dave, S. (2010). Life cycle assessment of transportation options for commuters. *Massachusetts Institute of Technology*. Boston.

Davis, B., Dutzik, T., & Baxandall, P. (2012). Transportation and the new generation: Why young people are driving less and what it means for transportation policy. U.S. PIRG Education Fund.

DECISIO. (n.d.). La mobilità pendolare. Vol II: Analisi della domanda di mobilità. Torino.

Dell'Olio, L., Ibeas A., de Oña J., de Oña R. (2018). *Public Transportation Quality of Service*, pp.49-61. Elsevier.

Department for Business, Energy & Industrial Strategy. (2019). 2019 Government greenhouse gas conversion factors for company reporting. Methodology Paper for Emission Factors Final Report. London.

Dill, J., Goddard, T., Monsere, C., & McNeil, N. (2014). Can protected bike lanes help close the gender gap in cycling? Lessons from five cities. *Urban Studies and Planning Faculty Publications and Presentations*, 123. Portland.

Dozza, M., & Werneke, J. (2014). Introducing naturalistic cycling data: What factors influence bicyclists' safety in the real world?. *Transportation research part F: traffic psychology and behaviour*, *24*(1), 83-91. Sweden.

Dröge, R., Kuenen, J. J. P., Pulles, M. P. J., & Heslinga, D. C. (2010). The revised EMEP/EEA Guidebook compared to the country specific inventory system in the Netherlands. *Atmospheric Environment*, *44*(29), 3503-3510. Utrecht.

Emond, C. R., Tang, W., & Handy, S. L. (2009). Explaining gender difference in bicycling behavior. *Transportation Research Record*, *2125*(1), 16-25. California.

Fishman, E., Böcker, L. and Helbich, M. (2015). Adult active transport in the Netherlands: An analysis of its contribution to physical activity requirements. PLoS ONE, 10(4). Utrecht.

Garrard, J., Handy, S., & Dill, J. (2012). *Women and cycling* (Vol. 2012, pp. 211-234). Cambridge, MA: MIT Press.

Garrard, J., Rose, G., & Lo, S. K. (2008). Promoting transportation cycling for women: the role of bicycle infrastructure. *Preventive medicine*, *46*(1), 55-59. Australia.

Grudgings, N., Hagen-Zanker, A., Hughes, S., Gatersleben, B., Woodall, M., & Bryans, W. (2018). Why don't more women cycle? An analysis of female and male commuter cycling mode-share in England and Wales. *Journal of Transport & Health*, *10*(1), 272-283.

Gupta, J., & Vegelin, C. (2016). Sustainable development goals and inclusive development. *International environmental agreements: Politics, law and economics*, *16*(3), 433-448. Amsterdam.

Hartmann, A., & Abel, S. (2020). How Oslo Achieved Zero. *Institute of Transportation Engineers. ITE Journal*, *90*(5), 32-38. Oslo.

Haughton, G. (1999). Environmental justice and the sustainable city. *Journal of planning education and research*, *18*(3), 233-243.

Hawkins, A.J., (2020). There's no better time for cities to take space away from cars. New York, NY: Verge.

Heinen, E., Maat, K. and Van Wee, B. (2010). The role of attitudes toward characteristics of bicycle commuting on the choice to cycle to work over various distances. Delft University of Technology.

Helmers, E., Leitão, J., Tietge, U., & Butler, T. (2019). CO2-equivalent emissions from European passenger vehicles in the years 1995–2015 based on real-world use: Assessing the climate benefit of the European "diesel boom". *Atmospheric Environment*, *198*(1), 122-132. Berlin.

Honey-Roses, J., Anguelovski, I., Bohigas, J., Chireh, V., Daher, C., Konijnendijk, C., ... & Oscilowicz, E. (2020). The Impact of COVID-19 on Public Space: A Review of the Emerging Questions

Jacobsen, P. L. (2015). Safety in numbers: more walkers and bicyclists, safer walking and bicycling. *Injury prevention*, *21*(4), 271-275.

Jennings, G. (2018). Biking towards social inclusion. A collection of creative bicycle ideas – by Olivia Svensson, Henrik Nolmark, Maria Dermitzaki (Living Cities and Pedalista). *Research Gate*

Johansson, C., Lövenheim, B., Schantz, P., Wahlgren, L., Almström, P., Markstedt, A., ... & Sommar, J. N. (2017). Impacts on air pollution and health by changing commuting from car to bicycle. *Science of the total environment*, *584*, 55-63. Stockholm.

Judge, A. H. (2011). Designing More Inclusive Streets: the Bicycle, Gender, and Infrastructure.

Kenworthy, J. R. (2006). The eco-city: ten key transport and planning dimensions for sustainable city development. *Environment and urbanization*, *18*(1), 67-85. Perth.

Krenichyn, K. (2006). 'The only place to go and be in the city': women talk about exercise, being outdoors, and the meanings of a large urban park. *Health & place*, *12*(4), 631-643.

Ilhana, A., & Fietkiewicza, K. J. (2017). Think green–bike! The bicycle sharing system in the smart city Barcelona. Researchers Satisfaction to the Library Services (The Case Study in the Library of Indonesia Research and Development Center for Marine and Fisheries Product Competitiveness and Biotechnology), 309.

ISTAT. (2018). Anno 2017. Spostamenti quotidiani e nuove forme di mobilità. In: *statistiche report*

ISTAT. (2020). Comunicato stampa. Incidenti stradali in Italia. In: *statistiche report*

Legambiente office, Poggio, A., Laurenti, M., De Santis, S., Izzi. A. (2020). Mal'Aria di città 2020. Dossier di Legambiente, 23 gennaio 2020

Lindsay, G., Macmillan, A., & Woodward, A. (2011). Moving urban trips from cars to bicycles: impact on health and emissions. *Australian and New Zealand journal of public health*, *35*(1), 54-60. Auckland.

Lubitow, A., Tompkins, K., & Feldman, M. (2019). Sustainable Cycling For All? Race and Gender-Based Bicycling Inequalities in Portland, Oregon. *City & Community*. Portland.

Lunke, E. B., Aarhaug, J., de Jong, T., & Fyhri, A. (2018). *Cycling in Oslo, Bergen, Stavanger and Trondheim: a Study of Cycling and Travel Behaviour* (No. 1667/2018). Oslo.

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 & Health*, *1*(2), 124-133. Hangzhou.

Lusk, A. C., da Silva Filho, D. F., & Dobbert, L. (2018). Pedestrian and cyclist preferences for tree locations by sidewalks and cycle tracks and associated benefits: Worldwide implications from a study in Boston, MA. *Cities*.

Mason, J., Fulton, L., & McDonald, Z. (2015). A global high shift cycling scenario: The potential for dramatically increasing bicycle and e-bike use in cities around the world, with estimated energy, CO2, and cost impacts. University of California.

McDonald, N.C. (2012). Is there a gender gap in school travel? An examination of US children and adolescents. J. Transp. Geogr. 20 (1), 80–86. Chapel Hill.

Normatiu, M. (2014). Pla de Mobilitat Urbana de Barcelona PMU 2013-2018. In: *Ajuntament de Barcelona*. Barcelona.

Ntziachristos, L., & Samaras, Z. (2013). Passenger cars, light commercial trucks, heavy-duty vehicles including buses and motor cycles. *C. Kouridis, C. Samaras, D. Hassel, G. Mellios, I. McCrae, J. Hickman, et al., EMEP/EEA emission inventory guidebook*.

O'Leary, Z. (2017). The essential guide to doing your research project. Sage. London.

Ortiz Escalante, S., & Gutiérrez Valdivia, B. (2015). Planning from below: using feminist participatory methods to increase women's participation in urban planning. *Gender & Development*, *23*(1), 113-126. Oxfam GB, Routledge.

Pan-European Programme. (2014). Fourth high-level meeting on transport, health and environment. Retrieved from Paris Declaration: World Health Organisation & United Nations, Paris

Pérez Brandón, N. (2019). Gender differences in cycling participation in Spain. Comparison between Norway and Spain (Master's thesis, NTNU).

Prati, G. (2018). Gender equality and women's participation in transport cycling. *Journal of transport geography*, *66* (1), 369-375.

Pucher, J., Komanoff, C., & Schimek, P. (1999). Bicycling renaissance in North America?: Recent trends and alternative policies to promote bicycling. *Transportation Research Part A: Policy and Practice*, *33*(7-8), 625-654.

Rabl, A., & De Nazelle, A. (2012). Benefits of shift from car to active transport. *Transport policy*, *19*(1), 121-131.

Ravensbergen, L., Buliung, R., & Laliberté, N. (2019). Toward feminist geographies of cycling. *Geography compass*, *13*(7), e12461.

Regione Piemonte. (2017). Mobilità veicolare in Piemonte. 5.1, 59-82. Torino.

Rissel, C., Bonfiglioli, C., Emilsen, E., & Smith, B. J. (2010). Representations of cycling in metropolitan newspapers — changes over time and differences between Sydney and Melbourne, Australia. BMC Public Health, 10, 371. doi:10.1186/1471-2458-10–371

Robledo-Colonia, A. F., Sandoval-Restrepo, N., Mosquera-Valderrama, Y. F., Escobar-Hurtado, C., & Ramírez-Vélez, R. (2012). Aerobic exercise training during pregnancy reduces depressive

symptoms in nulliparous women: a randomised trial. *Journal of physiotherapy*, *58*(1), 9-15. Australian Physiotherapy Association.

Ruffino, P., Jarre, M., Van Ommeren, K. (2020). Summary report: Social costs and benefits of post COVID-19 lockdown mobility scenarios in Italy. Decision. Version: 1.1. Torino.

Sistema Piemonte. (2013). IREA Inventario Regionale delle Emissioni in Atmosfera. Retrieved from: http://www.sistemapiemonte.it/fedwinemar/elenco.jsp. Torino.

Strange L.S., & Brown, R.S. (2002). The bicycle, women's rights, and Elizabeth Cady Stanton. Women's Studies, 31(5), 609-626. Ashland University, Ohio.

Susan Hanson. (2010) Gender and mobility: new approaches for informing sustainability, Gender, Place & Culture, 17:1, 5-23, DOI: 10.1080/09663690903498225

Sustrans. (2018). Inclusive city cycling: reducing the gender gap. 3-19

Tapp, A., & Parkin, J. (2015). The use of social marketing in promoting cycling. *Cycling Futures: From Research into Practice*, 183. Ashgate.

Thomas, C., Rolls, J., & Tennant, T. (2020). The GHG indicator: UNEP guidelines for calculating greenhouse gas emissions for businesses and non-commercial organisations (p. 61). Paris: UNEP.

Tuttitalia.it. (2019). *Popolazione Torino 2001-2019*. ISTAT. Torino.

United Nations. (2020). *The Sustainable Development Goals Report 2020.* UN, DOI: 978/92-1-101425-9

United States Census Bureau. (2019). *QuickFacts. Portland city, Oregon.* Oregon.

Unito News. (2018). Torino è una città di universitari o una città universitaria?. Retrieved from: https://www.unitonews.it/index.php/it/news_detail/torino-citta-dei-giovani

Università degli studi di Torino. (2018). Sostenibilità ambientale. Retrieved from: https://www.unito.it/ateneo/chi-siamo/sostenibilita-ambientale

Wang, Y., Chau, C.K., Ng, W.Y. and Leung, T.M. (2016). A review on the effects of physical built environment attributes on enhancing walking and cycling activity levels within residential neighborhoods. Cities 1–15. Hong Kong.

Williams, D., Chatterton, T., & Parkhurst, G. (2020). Using disruption as an opportunity to change travel practices.

Appendices

Appendix I: Structure of the questionnaire

Dear participant,

I am an Italian student from Wageningen University, who want to assess which are those factors that affect women's mobility in Turin. Your responses are extremely valuable and will help to take actions to support cycling among women in Turin. The survey should take a few minutes of your time. The questionnaire developed for this study is anonymous and it will not be used for any other purpose. If you have questions, please contact me, Andrea Rosso: andrea.rosso@wur.nl

1)Which gender do you identify with?
Woman
Man
Other

2) Do you live in Turin?
Yes
No

3) Which size is the car you usually use in Turin?
Small car
Medium car
Large car

I do not use a car in Turin *(go to question n. 6)*
4) Is the car you use powered by…
Petrol
Diesel
LPG
Methane
Hybrid
Electric

5) Approximately, how many km per week do you use to drive a car in Turin?
0 km
1-50 km
50-100 km
100-150 km
150-200 km
More than 200 km

6) Approximately, how many km per week do you cycle in Turin?
0 km (go to question n.8)
1- 15 km
15-30 km
30 - 45 km
45-60 km
More than 60 km

7) Please indicate whether you (strongly) agree or (strongly) disagree with the following statements

Factors	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I bike because I do not have a driving license					
Cycling helps me to get faster to my destination					
Cycling is comfortable					
I feel secure when using the bike					
Cycling is empowering					
I cycle to have physical exercise					
It is a way to save money because public transport/cars are too expensive					
I cycle to avoid parking problems					
It is an efficient way to travel because I do multiple stops					
I do bike to protect the environment					
By biking, I contribute to reduce space reserved for cars					
By biking, I contribute to reduce the air pollution					
By biking, I contribute for a more livable city					
I do cycle to not be bound by the public transport timetable					

8) I am not encouraged to bike because…

Factors	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I am not feeling safe in the bike lanes due to potential either verbal or physical harassments					
I am not feeling safe in the bike lanes during the night because they are not enough lightened					
Bike lanes are too dangerous due to their structural conditions (es. holes in the lanes)					
Bicycling is time-consuming according to my destinations					
It is difficult to find a place where to park the bike					
I rather prefer to walk than cycling					
I rather prefer to use the bus/ metro than cycling					
I rather prefer to use the electric scooter than cycling					
Cars drive too fast on the road to cycle safe					
Bike lanes are not well connected to one another					
There are not enough bike sharing available					
When I cycle, I am bothered by the air quality					
I do not have bike associations that support me to use the bike					

9) Which bike infrastructures/services would encourage you to cycle (more)? *Choose max. 5 infrastructures that are most relevant for you*
Sufficient light poles to ensure good lightning during the night
Raised zebra crossing to facilitate to cross the road
Removing car parking alongside bike lanes
Installing bike racks alongside the bike lane
Installing traffic light with bike priority
Implementing the service of bike sharing
Planting line of trees alongside the bike lane
Separating bike lane from road
Posters alongside bike lanes raising awareness on gender and environmental issues
Changing/showers room at work/university
Bicycle app showing the bike network and the safest road to take in Turin

10) Whether a bike infrastructure according to your choices selected above is implemented, would you be stimulated to cycle (more)?
Yes
No

11) Towards which destination or purposes would you cycle (more)? *Choose max. 2 reasons that are most relevant for you.*
School
Work
Sport
Recreational

Shopping
Going outside during the night to meet friends
I will not be stimulated anyway

12) According to the amount of km you have expressed in question 5., how many km a week are you willing to shift from cars to bikes if the five bike infrastructures you have chosen are implemented?
Not at all (no shift)
Very little (shift of 1/10 km travel by car a week)
Somewhat (shift of ¼ km travel by car a week)
Much (shift of half km travel by car a week)
Very much (complete shift of km travel by car a week)
I do not use a car in Turin

13) Please indicate your age:
18-25
26-35
36-50
Over 50

14) Is your nationality…
Italian
Other European countries
From the African continent
From North/Centre/South America

From the Asian continent (included Middle east)
Other

15) What is your level of education?
Lower secondary education
Upper secondary education
Lower level tertiary education
Upper level tertiary education
Phd or Post Doc

16) Which is your current occupation?
Student
Employed
Unemployed
Retired

Appendix II: Schedule of interviews

Date	Participant(s)	Organization	Topic of the interview
04/09/20	Maria Cristina Caimotto	Researcher at University of Turin	Looking at rhetoric strategies and positive narrative
08/09/20	Anna Donati	Ex green political party member, member at *Kyoto Club*, *Rete Mobilita' Nuova* and *Osservatorio Nazionale sulla Sharing Mobility*	Historical change of mobility and the women's role in the mobility departments
14/09/20	Giovanna Rossi	Academic researcher on sustainable urban mobility	The contribution of women towards sustainable change
15/09/20	Samuele Bavuso	Engineer and president at *Consulta della Mobilita' Ciclistica* of Turin	Designing an inclusive bike lane
16/09/20	Chiara Lucchini	Architect, professor at Politecnico di Torino and member at *Urban Lab Torino*	Implementing lanes according to women requirements
23/09/20	Cristina Fabrizio	Architect at Piedmont Region	Promoting security in the bike lanes of Turin
29/09/20	Genny Stefanelli & Pedro Blazquez Espi	Architects and volunteers at *Bike Pride*	The role of volunteer associations in promoting cycling among women
30/09/20	Maria La Pietra	Assessor of Mobility in Turin	Historical change of mobility and the goal of the Municipality to increase

			women's participation in cycling

Appendix III: Observation form

Observation N. Date ___/___ /20

(Photo of the street)

Location/street_____

Time____-____ Weather _____

Bike infrastructure within 1 km:

❑ Light Poles ❑ Bike racks

❑Car parking alongside bike lanes ❑ Free floating service

❑Trees alongside the bike lanes ❑Connected bike lane

❑Separated bike lanes from the road ❑ Zebra crossing

Women	Men	Kids

Further information:

Appendix IV: SPSS results about factors influencing women to cycle

Factors encouraging women to cycle	Mean	Std. Deviation
I bike because I do not have a driving license	1.52	1.06
Cycling helps me to get faster to my destination	4.07	1.02
Cycling is comfortable	4.48	0.72
I think cycling is empowering	4.30	0.91
I feel safe when using the bike	3.11	1.16
I cycle to have physical exercise	3.80	1.00
Cycling is a way for me to save money	3.71	1.02
I cycle to avoid parking problems	4.04	1.04
Cycling is an efficient way to travel because I do multiple stops	3.75	1.11
I do bike in order to protect the environment	4.39	0.80
If everyone cycles, the city will benefit due to the reduction of space reserved for cars	3.70	1.21
By biking, I contribute to reduce the air pollution in my city	4.43	0.83
By biking, I contribute for a more livable city	4.43	0.80
I do cycle to not be bound by the timetables of the public transport	4.32	0.90

Factors discouraging women to cycle	Mean	Std. Deviation
I am not feeling safe in the bike lanes due to potential verbal or physical harassments	2.47	1.15
I am not feeling safe during the night because lanes are not enough lightened	3.18	1.19
Bike lanes are too dangerous due to their structural conditions (es. holes in the lanes)	3.64	1.06
Bicycling is time-consuming according to my destinations	2.61	1.24
I find it difficult to find a place where to park the bike	2.90	1.29
I rather prefer to walk than cycling	2.68	1.40
I rather prefer to use the bus/ metro than cycling	2.49	1.38
I rather prefer to use the electric scooter than cycling	1.52	0.89
Cars drive too fast on the road to cycle safe	3.66	1.20
Bike lanes are not well connected to one another	3.97	1.10
There are not enough bike sharing available in the city	3.37	1.14
When I cycle, I am bothered by the air quality of Turin	3.07	1.23
I do not have bike associations that support me to use the bike	2.51	1.12