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Summary

Urban cycling tourism represents a cornerstone of sustainable mobility strategies aimed at reducing motorised travel and improving environmental and social well-being in cities. However, despite the crucial role of safety in encouraging cycling uptake, research has seldom examined how urban bike tourists adjust their behaviour to mitigate risk and cope with perceived road unsafety. Likewise, the influence of information on cycling accidents and risk perception on the intention to engage in urban cycling tourism remains largely overlooked in the literature. This study advances knowledge in this field by analysing data from an Italian online survey of city cyclists, adopting the Protection Motivation Theory (PMT) and a two-step empirical approach. First, an ordered probit model investigates how socio-demographic and travel-related characteristics shape the use of information sources and perceptions of road safety among cyclists. Second, after validating PMT constructs and identifying latent dimensions through confirmatory and exploratory factor analysis, a structural equation model estimates the effects of information sources on health-protective intentions and behaviours relevant for sustainable cycling mobility. Results show that information on risks exerts both direct and indirect effects, mediated by PMT constructs, on the intention to avoid urban bike tourism. The findings offer insights for policy interventions aimed at enhancing perceived and actual safety, thereby supporting a modal shift toward more sustainable urban travel choices.

Keywords: Bike tourism; Accident risks; Sustainable mobility; SEM model; Factor analysis

JEL Classification: Z3, R41, O18

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Abstract

Urban cycling tourism represents a cornerstone of sustainable mobility strategies aimed at reducing motorised travel and improving environmental and social well-being in cities. However, despite the crucial role of safety in encouraging cycling uptake, research has seldom examined how urban bike tourists adjust their behaviour to mitigate risk and cope with perceived road unsafety. Likewise, the influence of information on cycling accidents and risk perception on the intention to engage in urban cycling tourism remains largely overlooked in the literature. This study advances knowledge in this field by analysing data from an Italian online survey of city cyclists, adopting the Protection Motivation Theory (PMT) and a two-step empirical approach. First, an ordered probit model investigates how socio-demographic and travel-related characteristics shape the use of information sources and perceptions of road safety among cyclists. Second, after validating PMT constructs and identifying latent dimensions through confirmatory and exploratory factor analysis, a structural equation model estimates the effects of information sources on health-protective intentions and behaviours relevant for sustainable cycling mobility. Results show that information on risks exerts both direct and indirect effects, mediated by PMT constructs, on the intention to avoid urban bike tourism. The findings offer insights for policy interventions aimed at enhancing perceived and actual safety, thereby supporting a modal shift toward more sustainable urban travel choices.

1. Introduction

In the last ten years, bicycle tourism has gained huge popularity in the EU countries. In 2012 a seminal study commissioned by the European Parliament to the European Cyclists' Federation (ECF) outlined the relevance of the sector, accounting for 2.3 billion cycle tourism trips every year, with €44 billion in economic value (ECF, 2012). These results confirmed early studies' findings, that have defined bike tourism as a *global sustainable* activity (Lamont, 2009; Horton, 2006; Lumsdon, 2000), but also a slow and active way to visit a variety of landscapes and to interact with local people and culture (Han et al., 2017). More recently the growth of cycling tourism in the EU has been largely favoured by investments by EuroVelo, a network of 17 long distance and high-quality cycle routes that cross and connect the whole continent, especially in Germany, The Netherlands, Denmark, Belgium and France (ADFC, 2024; ECF, 2021). This infrastructure development makes the cyclists' journeys safer and more enjoyable and contributes to the implementation of the UN Agenda 2030 Sustainable Development Goals related to the

green transition and a healthy lifestyle (UNWTO, 2021). Urban tourism, that was defined as "*a type of tourism activity which takes place in an urban space with its inherent attributes characterized by non-agricultural based economy such as administration, manufacturing, trade and services*" (UNWTO, 2021), outpaced the leisure sector at national levels in terms of overnight rates between 2010 and 2019 (ECM, 2019). The flows of pro-environmentally minded tourists using bikes to visit cities (Nilsson, 2019; Ho et al., 2015) and looking for healthy travel experiences have steadily increased in post-Covid times (Pantelaki et al., 2023; Banet et al., 2022). However, at urban destinations, bike tourists may incur greater safety risks than in other contexts for several reasons: traffic volumes (Berghoefer & Vollrath, 2023), roadway factors and speed limits (Isaksson-Hellman & Toreki, 2019), crowding (Uijtdewilligen et al., 2024) or travel behaviours (Crotti et al., 2025; Salmon et al., 2022; Wang et al., 2015). According to the European Road Safety Observatory, among all the road users, only for cyclists' category the number of fatalities, fluctuating between 1,800 and 2,100 cases per year, has not decreased since 2010. Given that the total number of road fatalities decreased by 34%, the proportion of cyclist fatalities on the total has increased, from 7% in 2011 to 10% in 2020. Notably, while cyclists are often involved in crashes with cars, other cyclists and pedestrians, most fatalities occurred on urban roads, i.e., 57% for cyclists compared with 40% for all road fatalities (EC, 2023). Furthermore, accidents involving bikes occur more often (68%) in daytime during working week, meaning that cycling tourists are likely exposed to fatalities all year long, also due to growing seasonal adjustments in the overall EU tourism offer (Ferrante et al., 2018).

Research problem and research aim

Even though both residents and tourists can be harmed by road risks when using bikes in urban contexts, the latter group is ex-ante conceivably less protected due to lacking information about routes, built environment, traffic and local regulations at destination (Scarano et al., 2023). Since collecting information about road conditions at destination but also being aware of fatalities risks during holidays are of utmost importance for tourists, previous studies show a significant role of perceptions of safety on bicycling (e.g., Horton, 2006). Focusing on the effect of sad news about cycling, Lee et al. (2014) found that hearing about incidents involving cars exacerbated discomfort with bicycling, and notably the crashes experienced by other cyclists have negatively impacted attitudes toward bicycling. More, recent evidence suggests a strong influence of attitudinal factors on cycling behaviour, as leisure (non-regular) cyclists are highly sensitive to traffic volume, facility separation, and bike lanes quality (Berghoefer & Vollrath, 2023). For these reasons, but also to prevent litigations and increase tourists' satisfaction (Wang et al., 2019; Wilks et al., 2013), institutions, associations, and tourism practitioners have been motivated to promote campaigns and policies aimed at fostering cyclists' safety by both increasing the number of people walking or biking and enforcing road traffic rules for drivers and cyclists. According to the UK Safety in Numbers campaign, collisions rates indeed declined with increases in the numbers of people walking or bicycling (Elvik & Goel, 2019; Jacobsen, 2003)[1]. More, within the European Declaration on Cycling, the former EU Commissioner for Transport, Adina Vălean**,** said that: "[…] *Alongside safer infrastructure such as separated cycle paths, all elements of the Safe System approach should apply to both bikes and cars. These include safe speeds and road use, and proper enforcement of road traffic rules.* […]" (EC, 2023).

Despite the presence of studies focused on the major concerns for cyclists in urban areas (Uijtdewilligen et al., 2024; Abbasi & Ko, 2024; Desjardins et al., 2021; Branion-Calles et al., 2019), yet in literature there is still a gap on strategies and behaviours adopted by urban bike tourists to reduce risks and to cope with perceptions of unsafety on the roads. Analogously, except for very few studies that explored how

[1] https://www.cyclinguk.org/campaign/safety-in-numbers

tourists in general behave to protect themselves (e.g., Wang et al., 2019; Chien et al., 2016), to the best of our knowledge, no studies have so far examined how information about bike fatalities and related risks perception might harm the intention to experience urban cycling tourism.
Regarding the evolution of cycling tourism as a growing sector with positive implications on economic growth, sustainability, and public health, in this study the application of Protection Motivation Theory (PMT) to urban bike tourism has a two-fold aim to fill gaps in the tourism literature. First, this paper attempts to investigate socio-demographic and travel-related factors that might influence the sense of concern and health protection of bike tourists in city contexts. Second, PMT has been mostly applied to tourism to study either intentions to travel (e.g., Slevitch & Sharma, 2008; Law, 2006) or to undertake preventive behaviours (Wang et al., 2019; Fisher et al., 2018; Lu & Wei, 2018), but the role of information and awareness of cycling fatalities in urban contexts was not adequately considered yet (exceptions are Schroeder et al., 2013; Lo et al., 2011). In this paper we explicitly separate a direct effect of sources of information and perception of road risks among city bike tourists on travel avoidance from an indirect effect mediated by PMT constructs, analysing data collected by a national on-line survey on a sample of Italian bikers.
The paper is structured as follows. Section two is dedicated to review the literature on bikers' safety perception in city areas, the role of urban bike tourism and road safety in Italy and, finally, on the conceptual framework of PMT and its application to tourism. This section ends with the presentation of the research hypotheses. The methodology and the PMT framework are described in the paragraph three, while the results are discussed in the section four. The conclusions and theoretical and managerial implications are drawn in the last paragraph.

2. Literature review

This section illustrates various concerns of cyclists about safety in cities and focuses on factors affecting road risks perception in urban bike tourism in Italy, which is the context of this research. The section concludes with a brief review of PMT applied to tourism and the conceptual model of this study.

2.1 Cyclists' safety perception in city contexts

In the literature on safety perception, cyclists' concerns depend on locations and related road conditions (Scarano et al., 2023), as rural places clearly display different harms from urban ones (e.g., Hosseinpour et al., 2021; Boufous et al., 2012). In city contexts, several studies found that major concerns for bikers are correlated with motorized vehicles, including high motorized traffic volumes, high traffic speeds and parked cars along the route (e.g., Campos-Ferreira et al., 2022; von Stülpnagel et al., 2022; Desjardins et al., 2021). More, the quality of cycling infrastructure positively affects the safety perception, as dedicated tracks, bike lanes with coloured pavement, bicycle priority streets, the width of cycling infrastructures play a key role in city areas (e.g., Berghoefer & Vollrath, 2022; von Stülpnagel & Binnig, 2022; Branion-Calles et al., 2019; Chen et al., 2018; Rossetti et al., 2018).

Individual features were also found to be important in safety perception in urban locations. For instance, older cyclists are more likely to perceive cycling as safe compared to younger cyclists (von Stülpnagel & Binnig, 2022; Lawson et al., 2013). Females perceive cycling as less safe than males, as well as cyclists with kids (e.g., Branion-Calles et al., 2019). For what concerns fatalities risks at city places, regular cyclists are found to take a longer detour to avoid crash locations (if aware of fatalities occurred at those locations) compared to occasional cyclists (Shah & Cherry, 2021). Moreover, as emphasized by Wang et

al. (2019), it is important to notice that objective safety is often not aligned with perceived safety, especially when talking about tourists compared to habitual commuters or, in general, bikers who are acquainted with local road conditions and issues (see Myftiu et al., 2024; Muñoz et al., 2016). For instance, von Stülpnagel et al. (2022) argued that bike tourists are often unaware of actual crash risks at specific places in the urban cycling network, meaning that awareness of past fatalities and information-seeking about safety conditions at destination should be given a proper attention in terms of risk-reduction strategies for tourists (see also Lo et al., 2011).

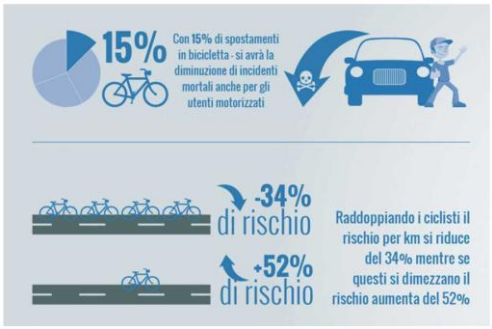
2.2 Urban bike tourism and road safety in Italy

In general, it has been clearly acknowledged that cycling tourism is not exclusively an extra-urban tourism phenomenon (e.g., Dickinson & Lumsdon; 2010), where various studies imply that cycling helps city destinations transforming built environments and slowing down urban routes (Nilsson, 2019) but also boosting their sustainability reputation (Moscardo et al., 1996). Since cycling infrastructures (i.e., bike lanes, cycle stands, etc.) have constantly spread out in city environments (e.g., in Paris, Fishman, 2016; Fremiot, 2013, or in Berlin, Cramer, 2014), as noted by Han et al. (2017), bike tourists are seen as slow and active travellers which can stimulate the development of infrastructure in urban areas to the benefit of the entire society.

The research context of this paper is Italy, which plays a significant role in the EU cycling tourism sector (e.g., Crotti et al., 2025; Piras et al., 2024; Pantelaki et al., 2023; Mazzulla et al., 2021; Maggi et al., 2021; Magris & Ross, 2018; Gazzola et al., 2018). According to the Observatory of the Economy of Tourism of the Chambers of Commerce, as of 2023, more than 56 million bike tourism presences were registered in Italy, and the direct economic impact was estimated at more than 5.5 €billions, i.e., +19% over 2019, and +35% over 2022 (Isnart-Legambiente, 2024). Considering the presence of bike tourists in Italian cities, their expenditure on cultural experiences, i.e., events, tickets/cards, museums, monuments, etc., amounted to 15% of the total holidays spending (compared to the 13.3% displayed by general tourists), while 37.1% of bike tourists reported to be interested in the cultural and artistic heritage present in Italian cities (Isnart-Legambiente, 2024). Despite the growing popularity of urban bike tourism, many concerns might harm Italian cycling travellers and have a negative impact on their decision to visit cities. According to 2023 data on road accidents in Italy, they have decreased from 2022 (ISTAT, 2023). Yet, compared to rates on highways (-9.7%) and extra-urban roads (-3.3%), the figures of urban roads are rather unchanged (-0.1%). More importantly, reductions of mortality rates in urban contexts are lower than extra-urban ones (-7% vs. -9%), and, while in last 20 years the mortality has decreased by 60% for car passengers, that of cyclists went down just by 37,4% (EC, 2023a). For those reasons, the issue of cyclists' road safety is of utmost importance for associations, like FIAB (Federazione Italiana Ambiente e Bicicletta), the ECF Italian member and EuroVelo Italian coordinator, whose activities have included highly impactful events, such as the 300 nationwide "Bimbimbici" events promoting cycling for children, its "Comuni Ciclabili" project to foster the bike accessibility across Italy, the Trenitalia's new train service with 900 cycle spaces daily, and more recent appeals to national politicians about road safety according to the Safety in Numbers paradigm (Jacobsen, 2003), especially after witnessing a sad streak of fatalities involving urban cyclists in Italy (see Image 1).

Image 1. (a) "Basta morti in strada" sit-in organized by FIAB, Legambiente, Touring Club Italiano and other 12 associations in December 2022; (b) FIAB's campaign to increase the number of bicycles on the Italian roads, inspired by the UK Safety in Numbers project (https://fiabitalia.it/safety-in-numbers/)

A Roma davanti al ministero delle Infrastrutture e dei Trasporti il presidio per chiedere strade più sicure © Legambiente



As for the factors that might influence the risks perception of Italian bike tourists, the existing literature is very recent and scant, nevertheless it has displayed interesting results. By considering a sample of 129 cyclists, interviewed along three bike lanes of an urban area of southern Italy, Mazzulla et al. (2021) applied an importance-performance analysis (IPA) to identify main issues for potential city tourists. Their results confirmed that the criticalities of the bike paths are linked to the degree of protection in relation to accidents, but also to the presence of walking people along the paths, whereas physical separation from pedestrians may produce an increase in cycling comfort. In a study on the role of transport systems in the development of urban bike tourism in Italy, Crotti et al. (2023) explored factors determining the joint decision to visit cities by bike and to use public transportation in a multimodal way. Notably, the authors found that the odds of visiting cities by bike are positively affected by the length of stays, available commercial and bike recovery services, while the negative effect of road traffic in urban bike tourism is present, suggesting the deterrent impact of road unsafety on city tourism mainly caused by motorized vehicles. Taking into account attractions in Italian cities by the sea, Piras et al. (2024) focused on the city of Cagliari (Sardinia Island) to study the local tourism mobility connected with cycling routes. Aimed at evaluating the level of accessibility of city beaches by bike, the authors applied a GIS-based procedure and showed how the heterogeneity in accessibility due to the quality, safety and location of bike lanes could strongly impact the willingness to mix cultural and seaside activities in city tourism, with a clearcut effect on stays and local tourism development. Recently, the study by Crotti et al. (2025) unveiled latent effects of behavioural spillovers between non-urban and urban bike tourism, that are boosted when using public transportation for inter-destination movements. Albeit less numerous than in other countries, those few studies highlighted that cycling tourists' risks perception in Italian cities is mostly linked to the quality of infrastructure (i.e., bike paths, pavement, etc.) but also to the coexistence of bike tourists with either motorized vehicles or pedestrians, in line with general trends identified in Scarano et al. (2023). Differently from what studied in other European countries where cycling tourism has a longer tradition and is more developed in urban contexts too (e.g., Germany, Belgium, The Netherlands, Denmark, Ireland, etc.; Uijtdewilligen et al., 2024; Vedel et al., 2017; Caulfield et al., 2012), in our case the effect of cycling crowding was not considered, since the presence of other cyclists at city destinations as a source of risk perception is not seen as being relevant yet (e.g., Mazzulla et al., 2021). Instead, the literature review on the Italian case has unveiled an important gap in terms of information-seeking and awareness about road risks and fatalities.

2.3 PMT in tourism and conceptual model

As a comprehensive model to study people's health protection behaviours (Floyd et al., 2000), the PMT approach implies that, influenced by environmental (i.e., communication, observational, and learning processes) and/or intrapersonal information (i.e., personality traits, prior experiences, etc.) about sources of health issues (the so-called *sources of information*), people may go through two mediating processes, i.e., *threat* and *coping appraisal*, which result in corresponding health protective behaviour, or *adaptive coping* (Milne et al., 2000). The former construct includes the perceived severity of risks (i.e., how serious the individual believes that the threat would be to his or her own life) as the main component, while in the latter one the self-efficacy (i.e., individual's beliefs about whether he or she is able to perform the proper coping response) represents the most effective way to cope with perceived threats (e.g., see Conner & Norman, 2005). Normally, concerning the relationship among the PMT constructs, it was observed that increasing severity might trigger the self-efficacy response, resulting in stronger odds of adapting habits (Floyd et al., 2000). Apart from notable early exceptions (Wang et al., 2019; Tanner et al., 1991; Rippetoe & Rogers, 1987), less importance has been devoted to another construct, i.e., the maladaptive coping, that usually causes people's decisions to inhibit the corresponding protective behaviour (Milne et al., 2000).

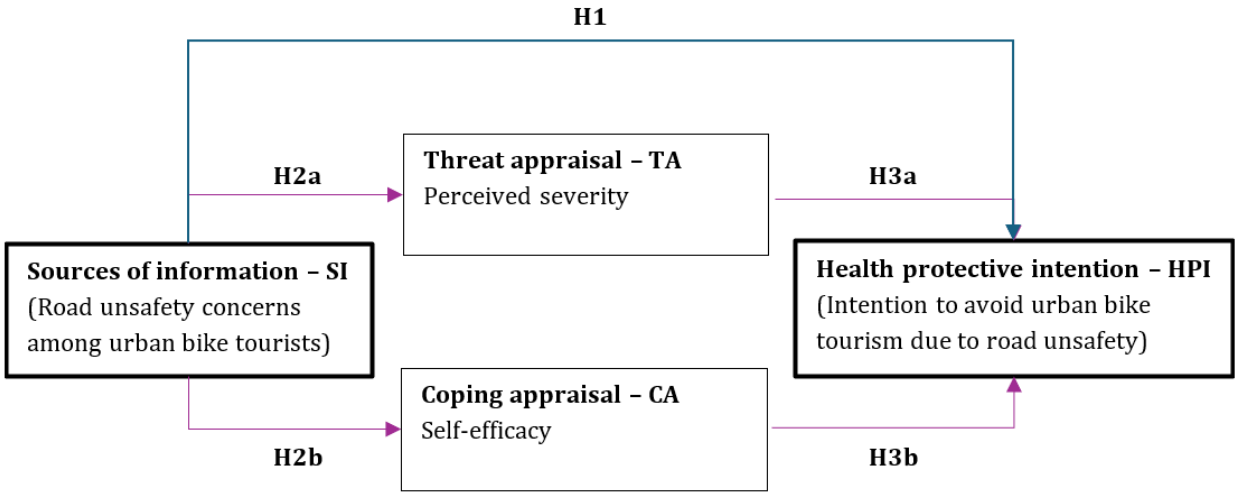
In the travel and tourism literature, PMT was devoted a limited but significant attention (e.g., Wang et al., 2019; Slevitch & Sharma, 2008; Law, 2006), however cycling tourism has been so far neglected. Overall, concerning threat appraisal items, few studies were focused on tourists' perceived severity based on early psychological studies (Rogers, 1975), dealing with risks' consequences (Yang & Nair, 2014; Law, 2006) that appear consistent with the conditions of cycling tourists, seen as "planning" decision-makers (Conner & Norman, 2005). As for coping appraisal items, self-efficacy is particularly relevant in tourism contexts, since protection behaviours might not be always feasible due to personal and/or environmental reasons at destination (Slevitch & Sharma, 2008). Lastly, since it is often difficult to observe actual tourists' protective behaviour (e.g., real-time choices and/or shelters), PMT's health protective behaviour has been often studied through protection intentions in order to consider tourists' propensity to adopt effective safeguarding habits when travelling. Considering tourism overcrowding in China, for instance, Lu & Wei (2018) notably found that risk perception mediated the influence of past overcrowding experiences on people's intention to adopt precautionary measures. This finding is particularly relevant because it stresses the importance of PMT's source of information block (Milne et al., 2000) when studying tourists' protection intentions (Lo et al., 2011). In a study concerning travellers' habits in Australia, Wang et al. (2019) tested a full PMT model (encompassing maladaptive items) to explore the link between risks prevention and protective intentions. Due to the striking predictive role of the coping appraisal, the authors suggest increasing the perceived efficacy of preventive measures among tourists by campaigns and communication strategies. Notably, some studies dealing with PMT in travel activities or in post-Covid transport choices considered the health protective intention in the form of travelling avoiding or potential decision to reduce own tourism activities (e.g., Mashrur et al., 2023; Ruan et al., 2020).

Given the key importance of PMT items such as the sources of information (SI) and the health protective intentions (HPI) in the urban bike tourism domain, in this study we developed a conceptual model where the former construct is represented by people's knowledge about concerns that road unsafety can provoke among bike tourists, i.e., information that could be conveyed by personal observation, media coverage, campaigns, and or any other sources of information about cyclists' road risks and fatalities in city areas. The latter construct is the bike tourists' protective intention, that we tackle in the form of avoiding (or at least reducing) urban bike tourism experiences due to road unsafety and/or

cyclists' fatalities that we consider as the core dependent variable. In our framework (Figure 1), we tested both a direct effect of SI on HPI and an indirect effect when threat (TA) and coping (CA) appraisal are entered as the PMT mediating variables, and considering the following hypotheses:

H1. Italian bike tourists' intentions to avoid visiting urban destinations (HPI) are positively influenced by their knowledge about other tourists' concerns and cyclists' fatalities in city contexts (SI).
H2a. Threat appraisal (TA) construct is positively associated with Italian bike tourists' knowledge about other tourists' concerns and cyclists' fatalities in city contexts (SI).
H2b. Coping appraisal (CA) construct is positively associated with Italian bike tourists' knowledge about other tourists' concerns and cyclists' fatalities in city contexts (SI).
H3a. Italian bike tourists' intentions to avoid visiting urban destinations (HPI) are positively associated with threat appraisal (TA) process.
H3b. Italian bike tourists' intentions to avoid visiting urban destinations (HPI) are positively associated with coping appraisal (CA) process.

Figure 1 Conceptual model of PMT constructs affecting bike tourists' protective intentions at urban destinations.



3. Methodology

Data collection

In this study, the data collection implied two phases. Considering the specific PMT-based purposes of the paper, firstly, a focus group involving the University of Insubria's research team and FIAB's members was organized in March 2023 to discuss and define the more suitable TA and CA items to be used in the analysis (and reported in Table 3). Then, few interviews were undertaken between April and May 2023 with representatives of the other two research partners, i.e., the CIAB (Club Imprese Amiche della Bicicletta) association which promotes active mobility and cycling in Italian companies, and Active Italy, a tour operator specialized in bike trails, in order to refine the outcomes of the focus group and help finalizing the design of a questionnaire. In the second phase of the data collection, a self-administered on-line national survey was conducted between June and September 2023 using the above-mentioned questionnaire. By newsletters, open calls on web magazines and tourist-related websites to advertise the purposes of the research, the survey was conducted among bike tourists living in different Italian

regions, amounting to 1,747 observations. Apart from standard questions on individual characteristics (e.g., age, gender, education, having children, residence), specific queries were devoted to respondents' use of bikes in leisure time, and other features related to tourism habits, such as length of stay, and travel groups. For what concerns the research focus, two questions were posed to evaluate how the sampled bike tourists adopt information-seeking before travelling on the presence of technical services for bikers (e.g., repair and maintenance, assistance, etc.) and the quality of bike lanes at city destinations.

In terms of descriptive statistics, as shown in Table 2, the sample consists of 1,747 participants identified as cycle tourists. The demographics and travel behaviour of our sample reveal some striking patterns. A significant proportion of respondents are male (61%) and predominantly in the 41-60 age group (45%). Many also have children aged between 0 and 13 (65%). Geographically, they are mainly located in the North-West (42%) and North-East (39%) regions of Italy. The majority of respondents classify themselves as occasional cyclists (60%), prefer to travel in groups (68%) and use the bicycle exclusively for their trips (75%). These trips typically cover between 60 and 80 kilometres per day (40%). Interestingly, urban destinations are a popular choice for these tourists, with 60% frequently choosing urban areas as their cycling destination.

Measurement of PMT constructs

Since no previous studies have applied PMT constructs to cycling tourism, the measurement scales used in this research were developed based on both general literature (Floyd et al., 2000; Milne et al., 2000) and insights from focus groups and interviews with experts in the field. These scales are presented in Figure 1 and explained in detail below

To measure the role of *sources of information (SI)*, respondents were asked to rate how they agree on the fact that road unsafety and cyclists' fatalities represent a concern for urban bike tourism on a 5-point Likert scale (1 = totally disagree, 5 = totally agree). In this case, with that item we aimed at capturing the participants' exposure to observational knowledge and/or the effectiveness of media, newspapers, etc.

To measure the *perceived severity*, participants were asked to rate, on a 5-point Likert scale (1 = totally disagree, 5 = totally agree), how they agree on the fact that they feel unsafe when facing three kinds of potential risk situations, which represent the threat appraisal (TA) items of the proposed conceptual model: (i) the road traffic is intense, (ii) limited traffic zones are crowded by pedestrians, and (iii) the pavements are poorly maintained. As for the coping appraisal (CA) items, we measured the *self-efficacy* of recommended coping responses by asking the respondents if they agree on statements which imply that they are able to reduce corresponding risks in urban cycling tourism, again on a 5-point Likert scale (1 = totally disagree, 5 = totally agree).

Lastly, in order to measure *health protective intentions (HPI)*, the respondents were asked to rate the extent to which they agreed with avoiding city bike tourism due to road unsafety and cyclists' fatalities (1 = totally disagree, 5 = totally agree).

Two-step analysis

As shown in next section, by considering sampled cycling tourists in Italy, in the first analysis step we investigated socio-demographic and travel-related factors that may influence the sources of information (SI) block. In particular, we tested the extent at what those factors can affect the respondents' feeling about road safety concerns and fatalities among urban cycling tourists. Given the Likert-scale structure of the SI variable (here treated as a dependent variable ranging from 1 = totally disagree to 5 = totally

agree), a standard ordered probit modelling (Greene & Hensher, 2010) has been adopted. In the second step, by now taking SI as the independent variable of the PMT framework, a confirmatory and exploratory factor analysis (CFA and EFA; Brown & Moore, 2012) is performed to check the validity of TA and CA items, and a structural-equation modelling (SEM; Maruyama, 1998) is then used to estimate direct and indirect effects of the proposed PMT framework. Formal details on the models are provided in Appendix A.

4. Results and discussion

Table 1 shows the descriptive statistics of the two main variables related to the PMT constructs, the *source of information*, represented as the initial variable in our model, and *health protective intentions*, the final target variable in our model (see Fig. 1). As we can see, when respondents are asked whether they agree, on a scale of 1 to 5, that the *road unsafety raises concerns for bike tourists in urban destinations*, we immediately see a high level of agreement (4.6) in the answers, which are characterised by low variability (0.80). On the other hand, if we look at the responses relating to health protective intentions, we see a greater dispersion in the responses (1.3) to the question of whether the *road unsafety negatively affects my choice of doing bike tourism in urban destinations*, with an average response rate of 3.5 out of 5, which already points to the possibility of some latent factors that could explain this dispersion.

Table 1 Descriptive statistics of source of information and health protective intentions PMT construct

5-point Likert scale (N = 1,747)	**Sources of information - SI**		**Health protective intentions -HPI**	
	Road unsafety raises concerns for bike tourists in urban destinations		*Road unsafety negatively affects my choice of doing bike tourism in urban destinations*	
	N	%	N	%
1 – totally disagree	7	0.4	153	8.7
2	49	2.8	284	16.3
3	162	9.3	381	21.8
4	231	13.2	421	24.1
5 – totally agree	1,298	74.3	508	29.1
Mean (SD)		4.582 (0.803)		3.484 (1.297)

In the following sections, the factors influencing the source of information are examined using an ordered probit model, followed in section 4.2 by the application of confirmatory factor analysis to identify the latent factors of the PMT construct, and finally in section 4.3 by a system of structural equations model to test the model hypotheses presented in section 2.3.

4.1 Ordered probit model

In Table 2, the estimation results of the ordered probit model are presented, and the effects of socio-demographic and travel-related variables on the sources of information (SI) variable are displayed.

In contrast to recent studies focused on risk perception by cyclists (e.g., von Stülpnagel & Binnig, 2022; Branion-Calles et al., 2019), in this Italian case study gender and residence areas are not significant. Yet, possible misalignment may be due to different ways in which cyclists' risks are investigated in other EU studies. Compared to younger cyclists (baseline: 18 – 30 years old), those aged more than 60 years old are more sensitive to road unsafety concerns in urban bike tourism. Whereas neither the presence of kids in own household nor the education level seem to be of statistical relevance, instead the general

use intensity of bikes for leisure activities is positively associated with the SI variable, suggesting that being acquainted with cycling along the year likely exposes bike tourists to feelings of risks and health harms, in line with Shah & Cherry (2021). Regarding to travel-related features, road unsafety concerns for city bike tourists seem to be more acknowledged by cyclists using only bikes during cycling holidays (i.e., unimodal travellers), while taking trains to reach city destinations is not significant. Also travelling alone or in group is not a key factor, suggesting that risk awareness is perceived as individual in Italian bike tourism. Notably, longer stays (i.e., six nights and more) increase the probability that bikers have a stronger feeling of health concerns in urban places. More importantly, considering information-seeking in the analysis allowed to identify a clearcut effect of the pre-travel importance given to bike-related services and bike paths quality on risk concerns. This finding means that, in this Italian case, gathering information on cycling conditions at destination is conceivably associated to the awareness of health risks, thus implying that information-seeking is worth being considered when studying tourists' habits (Lo et al., 2011).

Table 2 Estimation of the ordered probit model.

Variables	N	%	Coefficient	Standard error
Gender				
(baseline: Male)	1,065	61.0		
Female	682	39.0	.0193	.0693
Age				
(baseline: 18 – 30 years old)	70	4.0	-	-
31 – 40 years old	201	11.5	.1579	.1669
41 – 60 years old	780	44.6	.2317	.1554
More than 60 years old	696	39.8	.3580**	.1625
Italy residence area (NUTS 1)				
(baseline: North-West)	736	42.2		
North-East	689	39.4	-.0746	.0706
Centre	192	11.0	.0688	.1091
South and Islands	130	7.4	-.1412	.1194
Education				
(baseline: High school or lower)	738	42.2		
University degree or higher	1,009	57.8	-.0519	.0666
Children (0 – 13 years old)				
(baseline: No)	615	35.2		
Yes	1,132	64.8	-.0143	.0748
Use of bike in leisure time				
(baseline: Seldom)	508	29.1		
Often	1,239	70.9	.5207**	.2334
Travelling alone				
(baseline: Seldom)	1,194	68.3		
Often	553	31.7	.0349	.0724
Reaching city destinations by train				
(baseline: Seldom)	634	36.3		
Often	1,113	63.7	.0961	.0669
Using only bikes during cycling holidays				
(baseline: Seldom)	444	25.4		
Often	1,303	74.6	.1492**	.0729
Long stays (six nights or more)				
(baseline: Seldom)	1,346	77.1		
Often	401	22.9	.2337***	.0851
Information-seeking: bike-related services at destination				
(baseline: Seldom)	971	55.6		
Often	776	44.4	.1451***	.0336
Information-seeking: quality of bike lanes at destination				
(baseline: Seldom)	378	21.6		
Often	1,369	78.4	.2615***	.0384
Thresholds parameters				
Threshold 1			-.3661	.3037
Threshold 2			.5136	.2951
Threshold 3			1.3036	.2994
Threshold 4			1.8526	.2999

4.2 Factor analysis

To estimate the key latent factors within the PMT framework, both exploratory and confirmatory factor analysis (EFA and CFA, respectively) were conducted (Jomnonkwao and Ratanavaraha, 2016). Factor analysis seeks to describe the covariance relationships between numerous variables in terms of a few underlying but unobservable random quantities, known as factors (Johnson and Wichern, 2007). The method assumes that all variables within a particular group are highly correlated with each other but have relatively low correlations with variables in other groups. Thus, each group of variables can be represented by a factor, such as threat appraisal and coping appraisal in this case, that accounts for the observed correlations. CFA was utilized to assess the appropriateness of the measurement model for the extended PMT and to determine the internal consistency of items and their construct validity.

In factor analysis, the selection of the appropriate number of factors involves several criteria rather than a single rule that applies in all cases. The Kaiser criterion (Kaiser, 1960) suggests retaining factors with an eigenvalue equal to or greater than one. Another criterion, proposed by Turner (1998), recommends retaining factors when the cumulative variance explained by $n + (n - 1)$ factors exceeds 60% of the total variance. In addition, the scree plot (Cattell, 1966), which plots the eigenvalues against the number of factors, can be used. An 'elbow' in the plot indicates a plausible latent structure; relevant factors are those above (and optionally at) the elbow. Finally, it is often suggested that the number of factors selected should be about one third of the original variables.

Using these criteria, we selected a set of factors that explained at least 60% of the total variability (see Table 3). We also followed the elbow rule from the scree plot (see Fig. A.1 in Appendix B) and selected about one third of the available factors for our analysis.

Table 3 Confirmatory factor analysis of PMT constructs and means of composite variables.

PMT constructs and items	Mean	SD	Loading	Eigenvalue	% of variance	Reliability α
Threat appraisal TA				3.211	.535	.725
In urban areas, doing bike tourism makes me feel unsafe when the road traffic is intense (TA_1)	4.329	.983	.604			
In urban areas, doing bike tourism makes me feel unsafe when limited traffic zones are crowded by pedestrians (TA_2)	3.385	1.257	.841			
In urban areas, doing bike tourism makes me feel unsafe when the road paving is poorly maintained (TA_3)	3.908	1.108	.784			
Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy = 0.674, Bartlett's test of sphericity: $\chi2$ = 1,071.95, p < .000						
Risk coping appraisal CA				0.815	.671	.771
To avoid risks, when doing urban bike tourism, I prefer visiting areas with low road traffic congestion (CA_1)	4.035	1.078	.844			
To avoid risks, when doing urban bike tourism, I prefer visiting areas with low pedestrian congestion (CA_2)	2.977	1.268	.557			
To avoid risks, when doing urban bike tourism, I prefer visiting areas with well-maintained bike lanes (CA_3)	4.019	1.099	0.863			
Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy = 0.687, Bartlett's test of sphericity: $\chi2$ = 1,416.70, p < .000						

Table 3 presents the results of the factor analysis of the PMT constructs, along with the means and standard deviations of the individual items included in the analysis. The items included in the analysis were developed from interviews and focus groups with experts in the field, resulting in three items measuring threat appraisal (i.e., motorized vehicles traffic, crowding pedestrians, and bad-quality road pavement) and corresponding coping appraisal items, equally measured on a 5-point Likert scale.

The most strongly represented factor in the analysis is threat appraisal (TA) with an eigenvalue of 3.211, means that this factor explains a significant portion of the variance in the threat appraisal items, accounting for 53% of the total variance, suggesting a strong representation of the underlying construct.

Among the items used in the analysis, "*In urban areas, doing bike tourism makes me feel unsafe when limited traffic zones are crowded by pedestrians"* has a factor loading of 0.841, indicating a strong correlation with the underlying factor. This is followed by "*In urban areas, doing bike tourism makes me feel unsafe when the road paving is poorly maintained"* and *"In urban areas, doing bike tourism makes me feel unsafe when the road traffic is intense*" with factor loadings of 0.784 and 0.604 respectively.

The second factor, risk coping assessment (CA), has an eigenvalue of 0.844 and explains 67.1% of the total variance, which is quite high and indicates a strong representation of the underlying construct. The very high factor loading of 0.863 of *"To avoid risks, when doing urban bike tourism, I prefer visiting areas with well-maintained bike lanes"* indicates a strong correlation with the risk coping appraisal factor, followed by *"To avoid risks, when doing urban bike tourism, I prefer visiting areas with low road traffic congestion"* and *"To avoid risks, when doing urban bike tourism, I prefer visiting areas with low pedestrian congestion"* with factor loadings of 0.844 and 0.557 respectively.

The table also shows alpha values, which indicate the reliability and internal consistency of the items used to measure the PMT constructs, as well as threat and coping appraisals. Given the alpha values of 0.725 and 0.771 for threat and coping respectively, we can statistically validate the internal consistency between the items. We also report two other tests that are very important when applying factor analysis, namely the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity; both tests validate the adequacy of the items for performing factor analysis. Table A.1 (see Appendix B) also shows the expected values of each item, the KMO and the uniqueness[2] values obtained from the factor analysis. In summary, the results of the factor analysis show that the majority of the items used to assess threat and risk coping in urban cycling tourism have good sampling adequacy and are well explained by the common factors. The uniqueness values indicate that most items have a significant proportion of their variance explained by these factors, particularly for the items related to risk coping appraisal. This suggests that the measurement model is robust and that the factors identified are meaningful representations of the underlying constructs.

[2] Uniqueness values in factor analysis represent the portion of a variable's variance that is not explained by the common factors identified in the analysis. In other words, they indicate how much of each variable is unique with respect to the common factors.

4.3 Structural Equation Modelling – SEM

Moving on the last step analysis, we tested both a direct effect of SI on HPI and an indirect effect when TA and CA appraisal are entered as the PMT mediating variables, and considering the hypotheses highlighted in the section 2.3 above.

Starting with the first hypothesis, there is a significant positive direct effect of SI on HPI (0.114, p-value = 0.000). This implies that Italian bike tourists' intentions to avoid visiting urban destinations due to road unsafety are positively influenced by their knowledge about other tourists' concerns and cyclists' fatalities in city contexts. This supports hypothesis H1 related to the direct effect of SI on HPI.

Moving on the second one, there is a significant positive relationship between SI and TA (0.346, p-value = 0.000). This indicates that knowledge about other tourists' concerns and cyclists' fatalities in urban areas is associated with higher perceived severity of threats among Italian bike tourists. This supports hypothesis H2a.

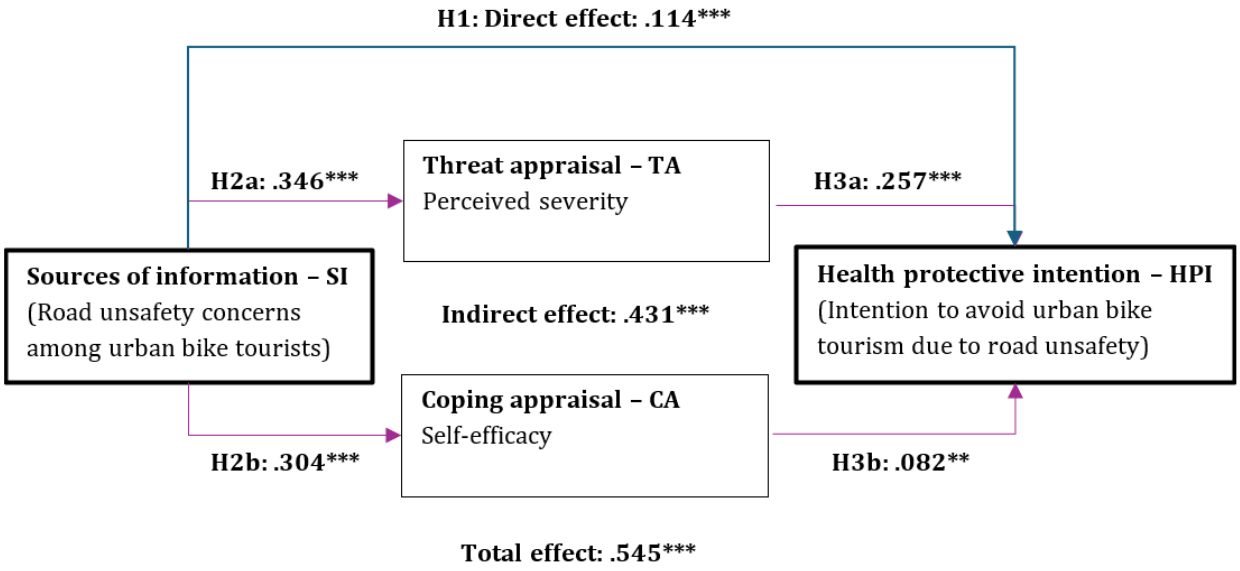
The hypothesis H2b is also confirmed, since there is a significant positive relationship between SI and CA (0.304, p-value = 0.000). This suggests that information about urban cycling risks leads to increased self-efficacy and perceived ability to cope with these risks.

There is a significant positive relationship between TA and HPI (0.257, p-value = 0.000). This indicates that higher perceived severity of threats leads to stronger intentions to avoid urban cycling, confirming hypothesis H3a.

Lastly, there is a significant positive relationship between CA and HPI (0.82, p-value = 0.009), albeit weaker compared to TA. This suggests that self-efficacy and coping strategies also contribute to the intention to avoid urban cycling, supporting hypothesis H3b.

The SEM analysis validates the proposed framework, demonstrating significant direct effect (0.114, p-value = 0.000) and indirect (0.431, p-value = 0.000) effects of SI on HPI through TA and CA, indicating that the impact is partially mediated by the PMT constructs. These findings highlight the importance of information dissemination regarding urban cycling risks and suggest that enhancing cyclists' threat perception and coping strategies can effectively influence their travel intentions.

Figure 2 PMT model testing results through the application of SEM



*Note: * p – value = 0.05; ** p-value = 0.01; *** p-value = 0.000*

We also wanted to test the correlation between TA and CA and found a weak but significant value (-0.068**). This suggests that while there is a slight tendency for an increase in threat perception to be associated with a decrease in coping ability, this relationship is very tenuous and probably influenced by additional variables not directly considered in this analysis. Further studies could explore additional mediating factors and the impact of different types of information sources on cycling behaviours.

5. Conclusion and implications

Road safety and health protection are of key importance for urban bike tourism and its growth potential. Since the number of fatalities involving bikers has not decreased over the time and its incidence on the whole road fatalities has increased, the problem needs urgent solutions and in-depth analysis about its effect on the tourism. In this study, we combine the PMT approach (Rogers, 1975) and tourism science to analyse the cycling tourists' engagement in protective behaviour against road risks at city destinations.

In particular, the study presents the first application of the PMT framework on cycling tourism, giving a relevant contribution to the analysis of, from the one hand, the behaviours adopted by urban bike tourists to reduce risks and to cope with perceptions of unsafety on the roads and, from the other hand, the role of information on bike accidents in influencing the decision of bike tourists to visit urban areas as travel destination. These topics, indeed, have so far been neglected by the literature.
Summarizing the results of the applied two steps' methodology, the order probit model outlines that older persons and people cycling with a high frequency and staying at the destination for longer period (at least six nights) are more sensitive to road unsafety concerns in urban bike tourism, suggesting that the past and very intense experience strongly influences the risk perception, increasing the probability to affect bikers' decisions, including the type of destination. Moreover, the importance of gathering before travelling information on the availability of bike-related services and the quality of bike paths is confirmed by the analysis. These factors also influence the destination choice.
As concerns the factor analysis, its results strongly validate the robustness of the constructed PMT framework, suggesting that the identified items used to estimate threat and risk coping are appropriate.

The most important contribution of the study regards the validation of all the hypotheses above proposed with the SEM approach, as outlined in the previous section. The conceptual model shows that the sources of information about risks have a direct effect on city bike tourism avoidance but also an indirect effect mediated by PMT constructs.

From a managerial perspective and a policy-makers point of view, the findings highlight that the investments in physical infrastructure and in congestion policies to make safer bike paths and reduce roads' traffic are a necessary but not sufficient pre-condition to attract more and more bike tourists in the urban areas. These strategies should be complemented by investments in digital infrastructure, signals, app and services and in marketing campaign to make users aware of the higher safety of the destination to respect of the average of the other cities. In fact, in absence of information the urban environments are perceived by bikers as less safe than other destinations and the cities lose the opportunity to include the growing cycling tourism sector within the sources of local economic growth.

Limitations and future research

This study has some limitations that can suggest future research. First, the national data used in this study were collected by self-reported online survey, therefore only people with access to Internet were reached. More, since the main channels used to spread out the questionnaire, in general, referred to bikers' associations, a share of respondents might somehow convey bias research findings. For future research on the topic, different data collection strategies could be tested. Second, we consider Italy as a relevant case study, however, for a broader contribution to the bike tourism literature, further studies should be stimulated in other key EU countries for cycling, such as Germany, Belgium France, The Netherlands, etc. Finally, as emerged by this study, the estimated relationship between threat and coping appraisal might have unveiled unobserved maladaptive responses (e.g., Wang et al., 2019) among urban bike tourists that future research should consider and investigate, together with a wider set of road risks.

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Appendix A

Ordered Probit Model

For the first step of the analysis (see Section 3), we develop an ordered response model (Greene & Hensher, 2010), where the latent propensity y^* is written as follows:

$$y_n^* = \boldsymbol{\beta} \boldsymbol{x}_n + \varepsilon_n \qquad \text{for} \qquad y_n = k \text{ if } \mu^k < y_n^* < \mu^{k+1} \tag{1}$$

Where: n: index for respondents ($n = 1, 2, \ldots 1{,}747$); k: index for ordinal levels of dependent variables; $k \in \{1, 2, 3, 4, 5\}$; μ^k: lower-bound threshold for the ordinal category k of the dependent variable SI; $\boldsymbol{\beta}$: vector of coefficients (to be estimated) associated to $\boldsymbol{x}_n$, i.e., the vector of exogenous variables (socio-demographics, travel-related features); ε_n: standard normal errors (assumed as independent and identical across individuals).

For $y_n = k$, the likelihood is:

$$L_n(\boldsymbol{\beta}, \mu^k; y_n | \boldsymbol{x}_n) = \Phi(\mu^k - \boldsymbol{\beta} \boldsymbol{x}_n) - \Phi(\mu^{k-1} - \boldsymbol{\beta} \boldsymbol{x}_n) = \int_{\mu^{k-1} - \boldsymbol{\beta} \boldsymbol{x}_n}^{\mu^k - \boldsymbol{\beta} \boldsymbol{x}_n} f_{\varepsilon_n}(\varepsilon_n) d\varepsilon_n, \tag{2}$$

Where: $\Phi(\cdot)$ is the cumulative normal distribution.

Factor Analysis Model

The factor analysis tries to describe the covariance relationships among many variables in terms of a few underlying, but unobservable, random quantities called factors (e.g., see Johnson and Wichern, 2008). This method assumes that all the variables within a particular group are highly correlated among themselves, but they have relatively small correlations with variables in a different group. As a result, it is conceivable that each group of variables is represented by a factor, responsible for the observed correlations. In matrix notation, the factor analysis model is as follows:

$$\boldsymbol{PMT} - \boldsymbol{\mu} = \boldsymbol{L} \times \boldsymbol{F} + \boldsymbol{\epsilon} \tag{3}$$

where the vector $\boldsymbol{PMT}$ = (*PMT1*, …, *PMT6*) consists of 6 observable covariates related to PMT construct about threat and coping appraisal (as listed in Table A1 in the Appendix B). The mean of each of those components is collected into the vector $\boldsymbol{\mu} = (\mu 1, \ldots, \mu 6)$, and the covariance matrix is:

$$\boldsymbol{\Sigma} = Cov\,(\boldsymbol{PMT}) = E\,(\boldsymbol{PMT} - \boldsymbol{\mu})\,(\boldsymbol{PMT} - \boldsymbol{\mu})' \tag{4}$$

The factor model postulates that the vector $\boldsymbol{PMT}$ is linearly dependent upon unobservable random variables, collected into vector $\boldsymbol{F} = (F1, F2, \ldots, Fq)$, called *common factors*, whose number is determined by the related $(6 \times q)$ matrix of factor loadings $\boldsymbol{L}$ and unique variances (see Table 3). Additional sources of variation – called *errors* or, sometimes, *specific factors* – are included into the vector $\boldsymbol{\epsilon} = (\epsilon 1, \ldots, \epsilon 6)$, whose components are individually linked to PMT variables.

Structural Equation Modelling – SEM

In this study, we developed a conceptual model to analyse the influence of sources of information (SI) and health protection intentions (HPI) in urban cycle tourism. The SI construct represents people's knowledge about the concerns that road insecurity may raise among cycle tourists, knowledge that may be acquired through personal observation, media coverage, campaigns or other sources of information about road risks and fatalities for cyclists in urban areas. The HPI construct concerns the intention of cycle tourists to avoid (or at least reduce) urban cycling experiences due to road insecurity and/or cyclist fatalities, which we consider to be the main dependent variable.

The structural model represents the causal relationships between the latent variables, derived from the factor analysis developed in the second step (Kline, 2015; Bollen, 1989).

The specified structural equations are:

$$TA = \beta_1 SI + \varepsilon_1 \quad (5)$$

$$CA = \beta_2 SI + \varepsilon_2 \quad (6)$$

$$HPI = \beta_3 SI + \beta_4 TA + \beta_5 CA + \varepsilon_3 \quad (7)$$

Where: β_n : regression coefficient (n = 1, 2, 3); ε_n: structural error associated with the latent variable (n = 1, 2, 3). This term captures the part of variability that is not explained.

This SEM model allows testing both the direct effects of SI on HPI, and the indirect effects mediated by TA and CA. The specified hypotheses, highlighted in the section 2.3, will be tested using the maximum likelihood method to estimate the model parameters.

Appendix B

Figure A.1 scree plot of eigenvalues after factor

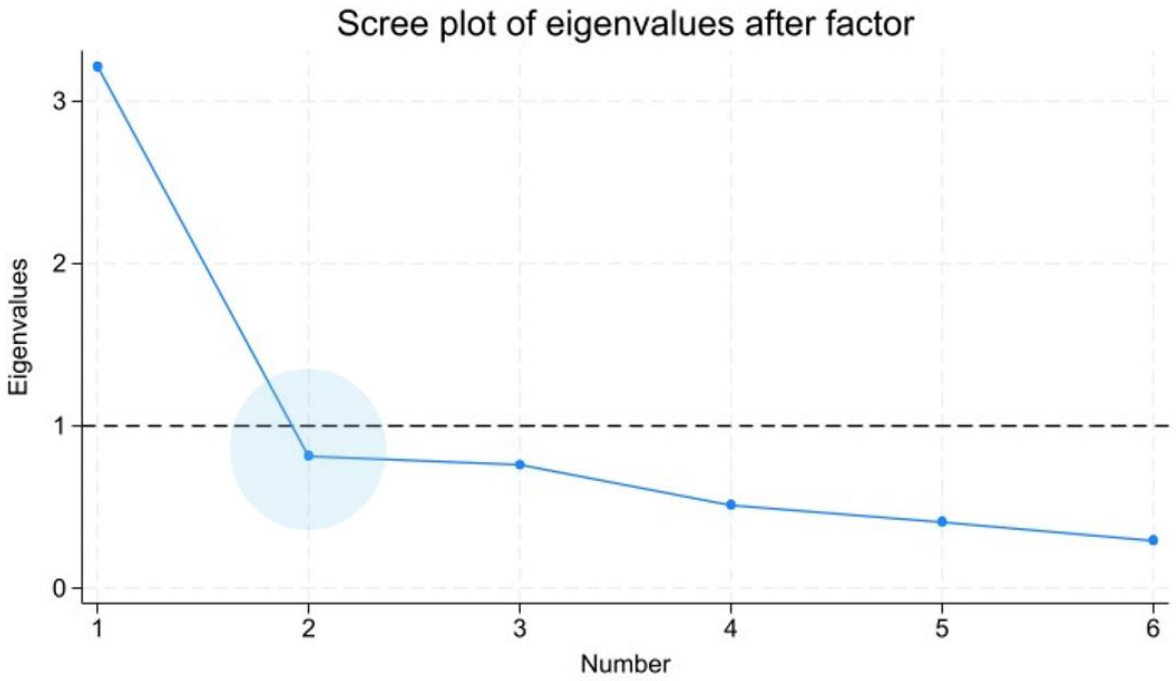

Table A.1 Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and uniqueness value

Variable	KMO	Uniqueness
Threat appraisal TA		
In urban areas, doing bike tourism makes me feel unsafe when the road traffic is intense (TA_1)	0.7984	0.5213
In urban areas, doing bike tourism makes me feel unsafe when limited traffic zones are crowded by pedestrians (TA_2)	0.7403	0.2497
In urban areas, doing bike tourism makes me feel unsafe when the road paving is poorly maintained (TA_3)	0.8540	0.3336
Risk coping appraisal CA		
To avoid risks, when doing urban bike tourism, I prefer visiting areas with low road traffic congestion (CA_1)	0.7746	0.2239
To avoid risks, when doing urban bike tourism, I prefer visiting areas with low pedestrian congestion (CA_2)	0.7451	0.4173
To avoid risks, when doing urban bike tourism, I prefer visiting areas with well-maintained bike lanes (CA_3)	0.8329	0.2276
Overall	0.7859	

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