Global Transitions 3 (2021) 55–71

Contents lists available at ScienceDirect

Global Transitions

journal homepage: www.keaipublishing.com/en/journals/global-transitions/

# Transportation in the Mediterranean during the COVID-19 pandemic era

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ARTICLE INFO

*Article history:*
Received 28 August 2020
Received in revised form
17 December 2020
Accepted 28 December 2020
Available online 9 January 2021

*Keywords:*
Sustainable mobility
COVID-19
Daily commuting
Public transport

ABSTRACT

The recent pandemic has considerably changed urban transportation while highlighting the weaknesses of the current transport modes. The crisis provided a unique opportunity to redesign the urban mobility plans in a more sustainable and resilient way. This study captured the impact of the COVID-19 outbreak and the subsequent restrictive measures on citizens' commuting habits and travel mode choice in two Cretan cities with academic communities and intense seasonality of tourism, in two phases (four periods) before, during, and after the quarantine. The sample consisted of 308 (1st phase) and 193 (2nd phase) citizens, 60% and 30% permanent residents of Chania and Rethymno, respectively.

During the weeks before the pandemic, 4/10 participants opted for travelling by car daily, either as a driver or as a passenger; almost the same ratio chose walking; 1/10 used public transport (bus). During the first week of the quarantine, one-quarter had decreased car usage and opted for sustainable transport modes (walking, cycling, public transport). The population who chose walking 1–2 times weekly almost doubled.

Nevertheless, most factors were found to affect men and women differently; personal safety and road safety are significantly more important for women; ecological footprint is a less essential parameter for men's travel mode choice.

Private vehicle use still holds a considerable role in urban transportation, and noteworthy is due to the sharp decline in public transit in January–February and April and the meager percentage of public transport ridership (1%).

The analysis and modelling could be useful in the future design of more sustainable and resilient mobility strategies.



## 1. Introduction

Nowadays, over half of the global population (55%) resides in urban centres, and, by 2050, this percentage is projected to increase by 68% [1]. As cities are expanding, travel demand is escalating, and consequently, urban transportation planning and management become a formidable challenge.

The dominance of private motorised transport in urban areas contributes substantially to air and noise pollution, traffic congestion, and physical inactivity; thus, it has detrimental effects on public health and quality of life [2–4]. Furthermore, a growing body of evidence underscores the health and well-being implications of long commute time [5–7].

Considering the above mentioned, urban planners and transport policymakers are shaping the future of mobility services in a way that is not only sustainable and addresses the increasing travel demand but also ensures public health and safety.

Although transportation plays an essential role in cities' socio-economic development [8], it generates a series of non-negligible health adversities. Numerous studies highlight the positive correlation between transport-related exposures and increased risk of disease, morbidity, and premature mortality [9–11].

When we refer to safety, the first issue that crosses our mind is road or personal safety. However, the COVID-19 outbreak has

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Production and Hosting by Elsevier on behalf of KeAi

https://doi.org/10.1016/j.glt.2020.12.003

brought our attention to another parameter: the risk of contamination. Mobility and particularly public transit might contribute to the disease's spread due to the enclosed spaces and the peoples' agglomeration. For that reason, public transport systems are highly vulnerable to disease outbreaks [12]. On the other hand, the social distancing that epidemiologists encourage, that is to say, at least 2 m distance between individuals, is incompatible with public transit. Hence, questions such as "How do we keep people using public transport but ensure their safety at the same time?" emerge and demand a feasible and efficient solution.

Besides public transportation, the shared mobility sector was also severely affected by the pandemic, provided that according to experts, the SARS-CoV-2 virus can live for hours or even days on hard surfaces [13]. Therefore, shared vehicles could be vectors for transmissions. In the same vein, carpooling might likewise be a source of contagion due to the small and confined space.

Nevertheless, the changes in transport activities stemmed from COVID-19 exert a substantial impact on environmental quality. Since road transport in cities with lockdowns in place declined between 50% and 75% [14], air quality improved significantly. More precisely [15], estimated that the decrease in daily fossil $CO_2$ emissions from the quarantine policies was 17%, and surface transport accounts for roughly half of it. Similarly, numerous studies demonstrated the dramatically positive impact of the restrictive measures on air quality and the significant reduction in atmospheric pollution in India [16], China [17] or other cities globally [18]. Moreover, the increase in active travel modes (walking, cycling) is another benefit of the pandemic, given that it is not only environmentally friendly but also has attributes of social distancing, which is desirable at the moment.

The recent pandemic has considerably changed the face of urban transportation. On the one hand, significant changes in the citizens' travel patterns were observed. On the other, issues such as public transport, shared mobility (e.g., carpooling), and sustainable mobility need to be reconsidered, not only because of the sharp decline in travel demand but also due to behavioural change of individual users. Furthermore, the COVID-19 outbreak has brought to light the weaknesses of the current transport systems/operations. Although it is not the first time humankind comes across a public health emergency, there is a gap in the transport policies regarding mobility and public health during a pandemic. However, this public health crisis also provided us with a unique opportunity to rethink and redesign the urban mobility plans in a more sustainable, more accessible, and more resilient way. Henceforth there will be longer-term changes in transportation designing that will also include pandemics or other types of crises that can cause health implications.

Although transport research might appear as a paradox in the challenging period of the pandemic due to the daily commuting restrictions, the ability to register the changes in travelling could be significantly useful for future transport demand management schemes and city planning. As people still need to transport either for work, doctor visits, or their basic needs (supermarket, pharmacy, etc.), a series of questions emerge. What transport mode have the commuters chosen, and to what extent has the coronavirus outbreak affected their travel habits? Is there a shift towards active transport modes (walking, cycling)? Could be detected a general change of mobility behaviour? How has quarantine affected people's mobility behaviours? Have the citizens developed travel patterns that they maintain and after the lockdown lifting? Do they feel safe to use public transport or to share a car ride? Those above are only some issues that were seeking answers. The end of the current crisis will require the redesign of sustainable transport systems from a different perspective. Consequently, it is critical to investigate and identify provoked changes to develop effective transport systems.

## 2. Study area and research methodology

### 2.1. The COVID19 chronicle in Greece till summertime 2020

The Hellenic government, on March 11, 2020, with a legislative act, decided the temporary suspension of schools/educational institutions, courts, and prosecutors' offices. Three days later, on March 14, 2020, shopping malls, restaurants, cafes, entertainment centres, libraries, cinemas, theatres, sports facilities, hairdressers and beauty salons closed. Furthermore, the authorities forbade access to religious places (16/3/2020) and alongside suspended the retail stores' operation, except for supermarkets, grocery stores, and pharmacies (18/3/2020). Banks and gas stations also remained open. Concomitantly, on March 16, 2020, the government suggested self-isolation and applied restrictions to citizens' movement, while a week later, on March 23, set in effect a curfew [19]. Furthermore, to enhance social distancing, remote working policies were implemented.

From 4 May 2020, citizens could move freely within their prefecture of residence, and the smaller retailers and some services were allowed to reopen (e.g., bookstores, electric appliance stores, sports stores, hairdressers). One week later (11/5/2020), all retail stores reopened, while senior high school students resumed classes. The next stage towards normalisation implemented on 18 May 2020, with the opening of middle and high school classes as well as shopping malls, botanical gardens, zoo, and archaeological sites. Moreover, free travel between regions on the mainland and to the island of Crete also restarted.

Subsequently, restaurants and cafes (with customers only in outdoor space) returned to business (25/5/2020), and ferry services resumed. Later, on 1 June, lockdown restrictions were lifted for hotels, open-air cinemas, and public swimming pools. Primary school students also returned to classes. The next phase of the measures' relaxation involved the reopening of gym centres and seasonal tourist accommodation facilities, as well as the restoration of international flights (Various, 2020d).

### 2.2. Study area

The cities of Chania and Rethymno were the selected research area: the municipal units of Chania downtown, Akrotiri, and Souda, with 61,275 inhabitants; also, the municipality of Rethymno which amounts to 55,525 permanent citizens, whilst approximately 34,300 of them reside in the city [20].

The climate is the subtropical Mediterranean, with sunny, dry summers and very mild, rainy winters. Snow and frost are rare near the coast but quite frequent in the highlands. Concerning the topography, the town's centre can be described as mild, with minimum elevations in both cities. However, in the city of Chania, altitude differences of over 200 m can be observed in the Akrotiri peninsula, which extends northeast of the city. The campus of the Technical University of Crete, a significant part of the city's life, is located in the peninsula mentioned above. In the city of Rethymno, three Schools of the University of Crete are located, and, therefore, the city accommodates a significant number of students.

### 2.3. Research methodology

The current research shed light on the transformations in daily commuting and analysed the mobility trends. Since the implemented curfew has changed people's life dramatically and therefore their mobility patterns, the research design set it as a milestone, and the survey was performed in two phases (four periods), before, during and after the quarantine.

- o Phase 1: i) the pre-pandemic period (January–February), ii) the first week of the complete lockdown and the guidelines for self-isolation/movement restrictive measures (16/3–22/3/2020), and
- o Phase 2: i) the curfew period (April), and ii) the summertime post-quarantine/lockdown period (1/6–7/6/2020).

Another under investigation topic was the travel mode choice determinants, alongside the trend on private vehicle use. Last but not least, shared mobility could not be excluded from this study, as an essential component of urban mobility systems, and, furthermore, as critically impacted by the COVID-19 outbreak. More specifically, the research aimed to assess how safe people feel about travelling in this transport mode.

The study was implemented using a structured questionnaire created by bibliographical search, research team collaboration and tested through a pilot study [21,22]. The questionnaire included both closed (yes-no, ranking, multiple-choice, etc.) and open-ended questions [23]. Moreover, participants had the opportunity to state their viewpoint freely on the issue and make suggestions.

The survey was conducted online (due to the restrictive measures) and addressed to adult citizens of Chania and Rethymno through several sites (public, university, etc.), thoroughly checked for any kind of biases (for example, non-independence of its members) and finally suitably weighted. The adequacy of the sample size can be seen from indexes like KMO etc.

The 1st phase was implemented between March 25, 2020, and March 31, 2020, and the 2nd one between June 8, 2020, and June 14, 2020 (Table 1).

The sample was composed of interviewees of both sexes, from a variety of age classes, professions etc., in numbers proportional to their % in the target populations (% according to the [20] census).

In all cases, participants' consent was obtained, and since the questionnaire was anonymous, there was not compliance issue with the General Data Protection Regulation. The questionnaire was created online, employing 'Google forms', and the collected data were analysed statistically. Furthermore, it was tested for face-value validity, while its reliability was assessed with the Cronbach alpha coefficient [24].

## 3. Results

### 3.1. Travel characteristics

#### 3.1.1. Travel mode choice

(i) Phase 1

a. First period (January–February)

Car use and walking were common modal choices for everyday commutes (Table 2). 4/10 participants opted for travelling by car daily, either as a driver or as a passenger; almost the same share chose walking; 10% used public transport (bus).

Although the willingness for daily car-sharing was relatively low, this attitude increased significantly concerning the trips made once or twice a week. As for public transport, the higher usage was observed for commutes made 3–4 times weekly. Finally, regarding cycling, almost 3/4 of interviewees did not use the bicycle for commuting during this period.

b. Second period (16/3–22/3)

During the first week of the restrictive measures, people limited their daily or regular (3–4 times weekly) commute, mainly only for their basic needs. Most citizens reported opting for driving a vehicle or walking for daily commuting. It is notable the substantial decline in public transport use, and individuals who did not use the bus at all during this period (16/3–22/3) were 30% more versus those of the previous period (January–February) (Table 2).

As concerns to walking, although there was no significant difference for the non-daily commute (3–4 times weekly), a sharp decline of 15.9% observed for daily transport. On the contrary, the

**Table 1**
Research sample profile during the two phases.

| | Phase 1 | Phase 2 |
|---|---|---|
| Sample number | 308 | 193 |
| **Sex (Men/Women)** | 56.5% women 43.5% men | 55% women<br>45% men |
| **Residence** | 60% (Chania)<br>30% (Rethymno)<br>10% (not defined) | 55% (Chania)<br>45% (Rethymno) |
| **Age (%)** | | |
| 18-24 | 31.2 | 42.5 |
| 25-34 | 17.9 | 14.5 |
| 35-44 | 24.4 | 16.6 |
| 45-54 | 16.6 | 17.1 |
| 55-64 | 8.1 | 8.3 |
| 65+ | 1.9 | 1.0 |
| **Employment (%)** | | |
| University students | 33.8 | 45.1 |
| Self-employed | 21.8 | 15 |
| Public sector employees | 24.4 | 21.2 |
| Private sector employees | 13.3 | 12.4 |
| Retired | 2.6 | 2.1 |
| Homemaker/Unemployed | 1.6 | 3.1 |
| Non defined | 2.5 | 1.1 |
| **Car ownership/license (%)** | | |
| Valid driver's license | 84.7 | 78.8 |
| Car ownership in the family | 7/10 | 6/10 |
| Two or more car ownership in the family | 73.3 | 65.9 |
| No car ownership in the family | 3.9 | 2.6 |
| **Bike ownership** | 30 | 33 |
| **Motorcycle/scooter ownership** | 18.8 | 16.1 |

**Table 2**
Travel mode choice (%) (Phase 1).

| | Daily | | 3-4 times weekly | | 1-2 times weekly | | Never | |
|---|---|---|---|---|---|---|---|---|
| | January–February | 16/3–22/3 | January–February | 16/3–22/3 | January–February | 16/3–22/3 | January–February | 16/3–22/3 |
| Car (driver) | 39.3 | 29.5 | 15.6 | 8.4 | 10.1 | 24.0 | 27.3 | 38.0 |
| Car (passenger) | 3.9 | 4.5 | 12.0 | 6.5 | 26.0 | 25.6 | 24.0 | 63.3 |
| Motorcycle (driver) | 9.4 | 6.8 | 4.2 | 2.9 | 3.2 | 7.1 | 80.5 | 83.1 |
| Motorcycle (passenger) | 1.0 | 0.3 | 2.6 | 3.2 | 3.6 | 3.6 | 86.7 | 92.9 |
| Bus | 9.7 | 2.6 | 12.7 | 2.9 | 6.5 | 8.8 | 56.8 | 85.7 |
| Taxi | 0.6 | – | 1.9 | 2.9 | 2.6 | 3.9 | 75.6 | 93.2 |
| E-scooter | 0.6 | – | 2.6 | 2.3 | 1.0 | 2.3 | 94.5 | 95.5 |
| Bicycle | 3.9 | 2.3 | 6.2 | 4.2 | 7.1 | 10.4 | 73.7 | 83.1 |
| Walking | 42.5 | 26.6 | 19.5 | 19.8 | 14.6 | 27.3 | 11.7 | 26.3 |

proportion of the participants who chose walking one to two times a week almost doubled.

Furthermore, 10.7% more citizens avoided driving their private vehicle (compared to January–February) (Fig. 1). Moreover, the commuters who did not travel by car as passengers increased by 39.3% (24% in January–February, versus 63.3% the week 16/3–22/2). A similar trend was observed for taxi use, given that 17.6% more participants did not opt for that transport.

Contrary to expectations, no increase was observed in the number of bike users during the first week. The number of citizens who did not use a bicycle during the week 16–22/3 increased by 9.4% compared with the previous period (January–February). This unanticipated finding suggests that although cycling is an ideal transport mode during the pandemic as it ensures physical distancing, people did not opt immediately for it due to cultural barriers, and lack of infrastructure. Apart from that, during that week, most citizens significantly limited their daily commutes, and either did not travel at all or transported only for their basic needs (e.g., supermarket), which might not be so convenient to perform by riding a bike.

In order to integrate the above results and identify a possible (psychological) explanation of the respondents' behaviour for the time interval 16/3–23/3, the research team run exploratory factor analysis trying to find out factors/latent variables explaining the data. The analysis provided two (new) factors:

- one factor loads the variables "car (driver)", "walking" ("restrictions' driven, transport means, choices"), which were the usual means of transport during the restricted measures' week
- the other one loads the variables "car (passenger)", "motorcycle (driver)", "motorcycle (passenger)", "bus", "bicycle", "e-scooter" and "taxi" ("secondary, transport means, choices") which were not the usual means of transport

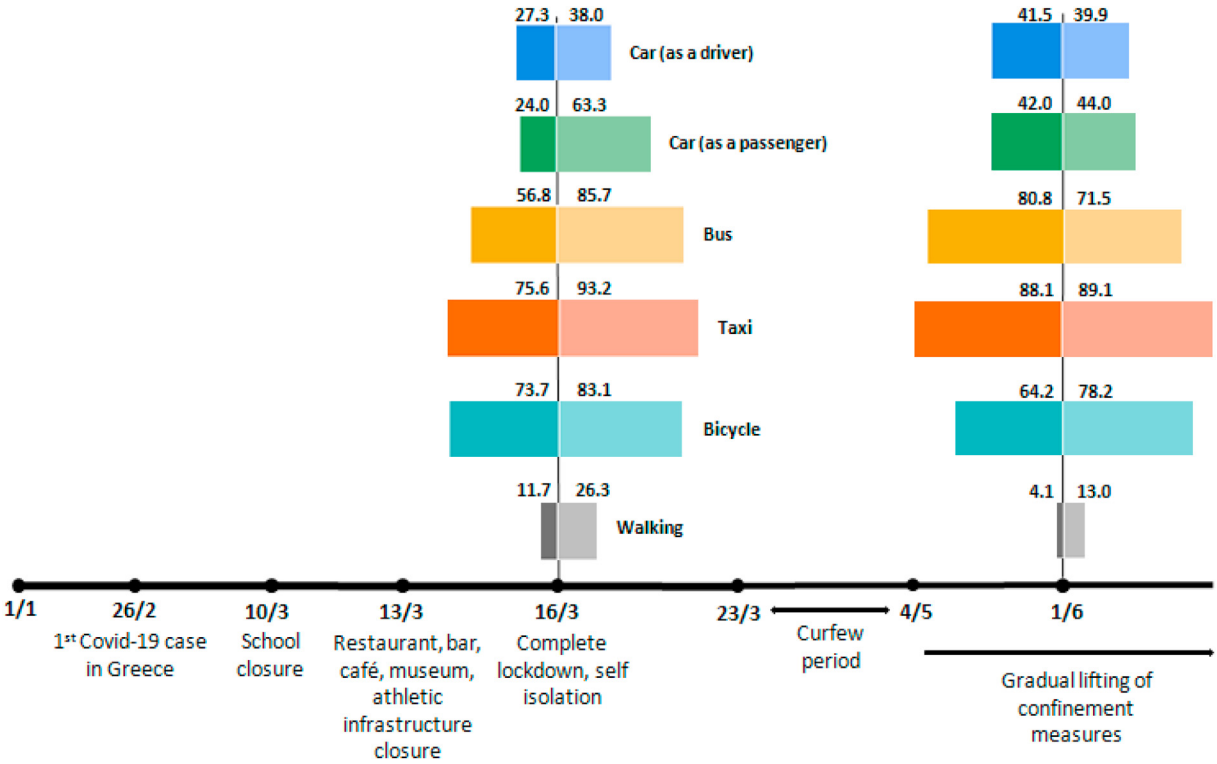


**Fig. 1.** Not using transport mode (%) between the two periods (pre-quarantine and post-quarantine).

Here, for the requirements of the analysis, KMO = 0.801 showing sampling adequacy, for Bartlett's test $p < 0.05$. Using Varimax rotation, the loadings on the latent variables represented in the following two equations:

$$Y_1 = -0.760*\text{Car (driver)} + 0.712*\text{walking}$$

$$Y_2 = 0.517*\text{Car (passenger)} + 0.505*\text{motorcycle (driver)} + 0.785*\text{motorcycle (passenger)} + \\ +0.626*\text{bus} + 0.601*\text{bicycle} + 0.900*\text{scooter} + 0.849*\text{taxi}$$

The loadings of the two equations are above 0.5 and, in many cases, above 0.7, which indicates a strong correlation between a variable and a factor, so the variable contributes significantly to its interpretation. These results are in accordance with the ones of the above analysis, as well as with common sense since the usual means of transport during the restricted measures' week were car (as a driver) and walking (Fig. 2).

(ii) Phase 2

(a) First period (April)

More than half of the study population chose driving a car or walking for everyday urban mobility (Table 3). However, no similar trend detected for cycling, provided that bike trips did not exceed 11.9%.

Furthermore, the share of car drivers during quarantine was relatively low, with no significant differences between the daily trips and the less frequent ones. On the other hand, the number of car passengers tripled for commutes made once or twice a week compared to the more frequent ones (daily/3–4 times weekly). It is considered that citizens followed the regulations and limited their transportation significantly to once/twice weekly.

Unfortunately, during April, the proportion of public transport (bus) users was deficient.

(b) Second period (1/6–7/6)

As the city gradually recovered from the first lockdown, car use re-emerged, and held a dominant position in urban transportation (Table 3). On the other hand, the car passengers increased remarkably for the journeys realised once/twice a week, while an uptake was observed for the more regular commutes (3–4 times weekly).

The observed increase in daily car use might be correlated with the decline in walking (from 53.9% to 46.1%). Moreover, the 9% rise in the individuals who preferred travel by other means of transport than walking, underlines the fact that the shift towards active transportation was not permanent and subsided alongside with the lifting of the lockdown measures.

Unfortunately, in the first week of June, the number of people who avoided cycling increased by 11%. This might be attributed to the increased number of cars and the subsequent limited road safety, given the lack of bike networks. Nonetheless, a small

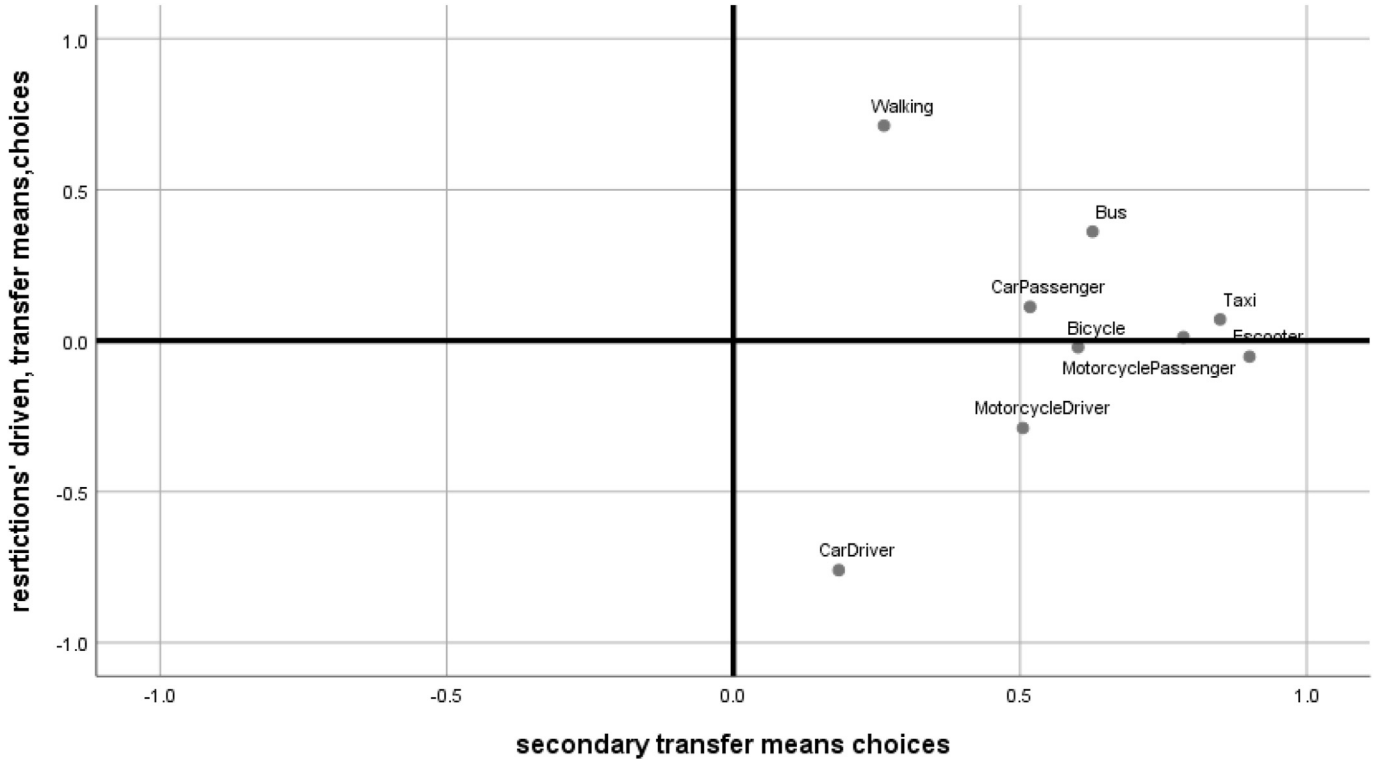


**Fig. 2.** Coordinates of the variables (means of transport) in factors' space.

**Table 3**
Travel mode choice (%) (phase 2).

| | Daily | | 3-4 times weekly | | 1-2 times weekly | | Never | |
|---|---|---|---|---|---|---|---|---|
| | April | 1/6–7/6 | April | 1/6–7/6 | April | 1/6–7/6 | April | 1/6–7/6 |
| Car (driver) | 15.0 | 32.6 | 16.1 | 17.6 | 17.1 | 9.8 | 41.5 | 39.9 |
| Car (passenger) | 5.7 | 5.2 | 6.2 | 15.0 | 19.2 | 35.8 | 42 | 44.0 |
| Motorcycle (driver) | 5.7 | 7.3 | 7.3 | 8.3 | 4.1 | 3.6 | 80.3 | 80.8 |
| Motorcycle (passenger) | 2.1 | 1.0 | 4.1 | 6.2 | 3.1 | 7.3 | 84.5 | 85.5 |
| Bus | 1.0 | 1.0 | 5.2 | 9.8 | 3.1 | 17.6 | 80.8 | 71.5 |
| Taxi | 0.5 | – | 4.1 | 4.7 | 1.6 | 6.2 | 88.1 | 89.1 |
| E-scooter | 1.0 | 1.0 | 4.7 | 3.6 | 0.5 | – | 91.7 | 95.3 |
| Bicycle | 6.2 | 8.8 | 9.3 | 6.2 | 11.9 | 6.7 | 64.2 | 78.2 |
| Walking | 53.9 | 46.1 | 19.7 | 21.8 | 17.1 | 19.2 | 4.1 | 13.0 |

percentage of people used more their bicycles daily in early June than in April.

Regarding public transport, although no difference was detected for daily trips, the regular journeys (3–4 times weekly) were increased by 4.6% in June (1/6–7/6). However, the rise in bus commutes realised once or twice per week was substantially higher, 14.5%. Notably, participants who avoided using public transport were 9% less versus those of the previous period (April). This fact illustrates that citizens become less reluctant and sceptical concerning using public vehicles. In other words, there are signs that the public transportation sector recovers slowly and regains its ridership. Nonetheless, it is a long way ahead, provided that seven out of ten persons did not use the bus at all during this period (1/6–7/6).

Besides, almost 90% of the study population avoided using a taxi both in April and early June.

Comparing the daily travel mode choice in the four different time periods, January–February, 16/3–22/3, April, and 1/6–7/6, reveals that in both cities, Rethymno and Chania, the predominant transport mode is walking. 11.4% more citizens chose walking for daily commutes during curfew versus the period January–February, and, although a decline was observed after the lifting of restrictive measures, the proportion (46.1%) remains higher than the one that registered at the beginning of the year (42.5%).

The daily bike trips increased by 4.9% in the post-curfew period (3.9% in January–February, versus 8.8% the week 1/6–7/6). The previously mentioned observations dictate a slight increase in active transportation that is not ignorable.

In parallel, the number of daily car journeys performed in early June was approximately 7% lower than those who realised in January–February indicting a slight change in the citizen's travel behaviour towards environmentally friendly transport modes. However, private vehicle use still holds a considerable share, which might be associated with the sharp decline in public transport between January–February and April, and the remarkably low percentage of public transport ridership (1%).

Moreover, although there was a relative increase in daily bike journeys after lockdown, 4.5% more citizens did not use a bicycle during the week 1/6–7/6 (compared with the beginning of the year) (Fig. 1). It might be assumed that the increased traffic and the lack of proper infrastructure hinder people from cycling, considering that bike users increased during April. However, cultural barriers also impede city cycling from blossoming since the proportion of non-cyclists is relatively high for Rethymno and Chania, considering they are small, coastal Mediterranean cities.

A run of the exploratory factor analysis for the period 1/6–7/6 gave two factors: one factor for the variables "car (driver)", "walking", "motorcycle (driver)" ("most frequent transport means choices") and the other for "car (passenger)", "motorcycle (passenger)", "bus", "bicycle", and "taxi" ("less frequent, transport means choices".

(in this case, KMO = 0.617 showing again sampling adequacy, Bartlett's test $p < 0.05$). The equations of the two new variables (using Varimax rotation) are:

$$Z_1 = -0.697*\text{Car (driver)} - 0.687*\text{walking} + 0.544*\text{motorcycle (driver)}$$

$$Z_2 = 0.485*\text{Car (passenger)} + 0.752*\text{motorcycle (passenger)} + 0.576*\text{bus} + 0.558*\text{bicycle} + 0.803*\text{taxi}$$

The results are also in accordance with the ones already described: (a) even though the cities slowly recover from the lockdown, still, car driving and walking are the main means of transport (here motorcycle driving has been added) (b) although there was a rise in bus commutes (larger load w.r.t 1st factor) this increase was insignificant (Fig. 3).

### 3.1.2. Travel time

a. Phase 1

For most participants, *the travel time for commuting to the workplace* is up to 30 min (Table 4). During the week of the restrictive measures, although no significant difference was observed for the longer commutes, that is to say for trips longer than half an hour, a decline was detected for the journeys between 15-30 min. Moreover, an even higher decrease in travel time was noticed for the shorter commutes, that is, for trips <15 min. Similarly, equivalent decreases were observed in travel time for university commute for both trips less than 15 min and those between 15-30 min.

A similar trend was noticed in both cities, Rethymno and Chania, regarding transportation to the workplace. More precisely, while 70.3% of participants in Rethymno travelled <15 min for commuting to work during January–February, the week 16/3–22/3, the proportion was 77.4% (Fig. 4). As for the city of Chania, the equivalent numbers were 59.7% versus 70.0%.

These differences might be attributed to the reduced traffic congestion since many people limited their daily transportation significantly and stayed at home with a remarkable decline in public transport.

Finally, it is notable that most citizens of Chania need more time to commute to their workplace. That might be correlated with the size of the city and the higher density of the population.

b. Phase 2

Undoubtedly, the easing of the lockdown measures affected travel time (Table 5). Regarding transport to the workplace, commute time for short commutes (<15 min) was increased by 5%. Furthermore, an almost equal rise (5.4%) was observed for the trips

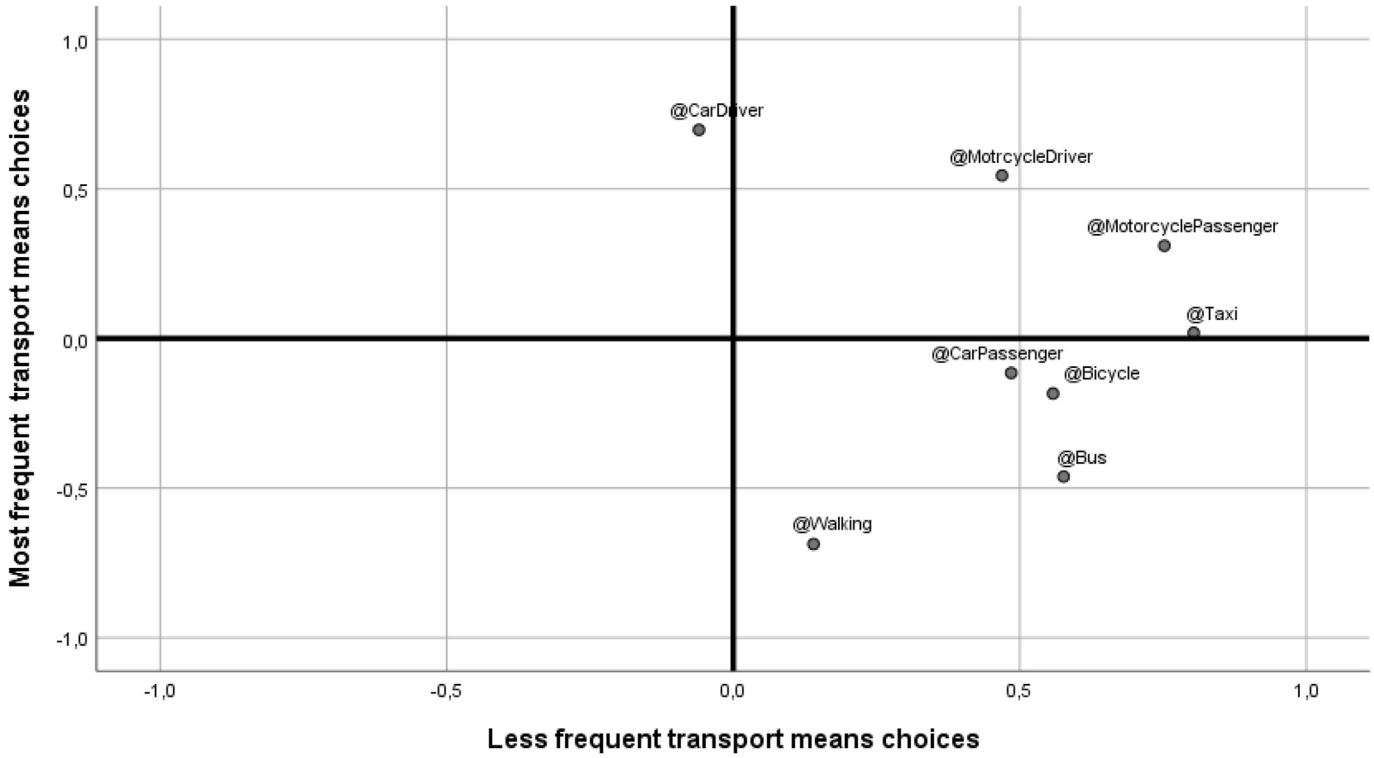


**Fig. 3.** Coordinates of the variables (means of transport) in factors' space.

**Table 4**
Travel time for commuting to the workplace/university (%) (Phase 1).

| | Workplace | | University | |
|---|---|---|---|---|
| | January–February | 16/3–22/3 | January–February | 16/3–22/3 |
| **<15'** | 61.1 | 73.1 | 40.4 | 52.1 |
| **15′-30'** | 29.7 | 20.7 | 45.8 | 37.0 |
| **31–45'** | 7.0 | 5.9 | 10.2 | 9.6 |
| **46′-60'** | 0.9 | 1.6 | 1.8 | 1.4 |
| **>60'** | 0.9 | 0.5 | 1.8 | – |

**Table 5**
Travel time for commuting to the workplace/university (%) (phase 2).

| | Workplace | | University | |
|---|---|---|---|---|
| | April | 1/6–7/6 | April | 1/6–7/6 |
| **<15'** | 67.3 | 62.3 | 48.9 | 44.0 |
| **15′-30'** | 23.5 | 28.9 | 35.6 | 37.1 |
| **31′-45'** | 3.1 | 3.5 | 6.7 | 9.5 |
| **46–60'** | 4.1 | 3.5 | 4.4 | 6.9 |
| **>60'** | 2.0 | 1.8 | 4.4 | 2.6 |

between 15-30 min. However, no significant impact was identified on longer commutes, that is, for journeys longer than half an hour.

A similar trend was detected in travel time for commuting to the university.

Concerning time spend on home-to-work travel in Rethymno (Fig. 5), during curfew, 78% of the participants travelled for <15 min. However, during the week 1/6–7/6, that proportion decreased by 10.2%. At the same time, almost 10% increased travellers for journeys between 15-30 min. A somewhat unanticipated outcome is the fact that we cannot observe the same for the city of Chania. In other words, regarding Chania, no significant changes in commute time were detected between April and early June.

During the post-quarantine period, the reappearance of private car use that we mentioned in the above section generates traffic congestion and, therefore, impacts commute time (rebound effect).

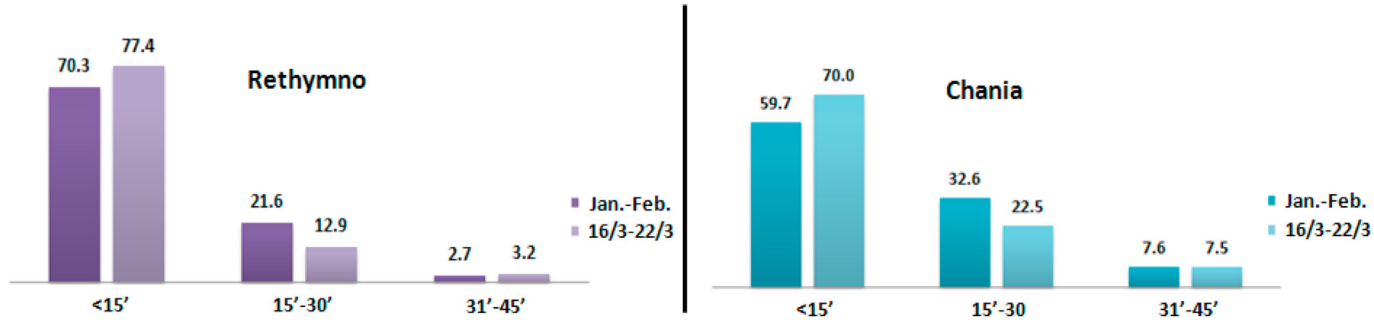


**Fig. 4.** Travel time for commuting to the workplace in the cities of Rethymno and Chania (%).

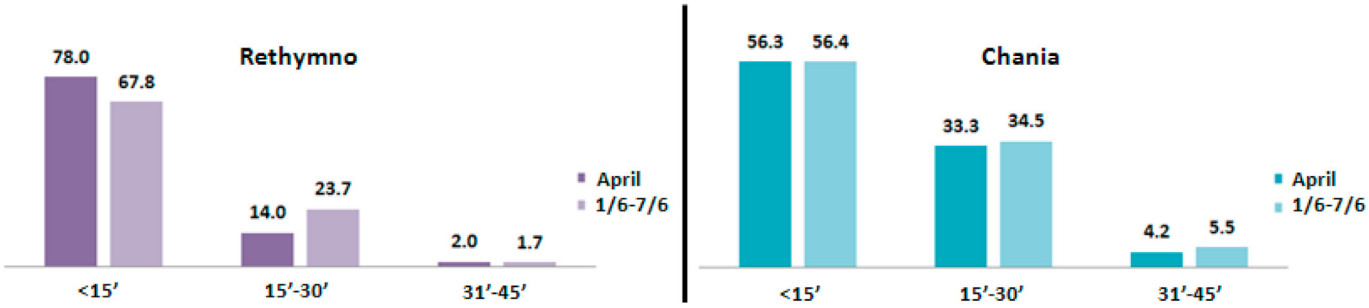


**Fig. 5.** Travel time for commuting to the workplace in the cities of Rethymno and Chania (%) (phase 2).

Even so, by comparing travel time between January–February and the week 1/6–7/6, it can be seen that in June, citizens needed less time for commuting either to the workplace or the university. This observation may be attributed on the one hand to the decrease in daily car journeys, on the other, to the fact that the 'new normality' has not been reached yet, and share of the population still limits its transportation (e.g., teleworking, e-learning, etc).

### 3.2. Travel mode choice determinants

a. Phase 1

A crucial question is *which factors influence individual travel mode choice*? According to data, road safety is of paramount importance for 8/10 of the participants. Equally, 8/10 declared that personal safety is a key driver regarding travel mode choice. Furthermore, travel time plays a predominant role for almost 3/4 of the interviewees, while approximately 58% consider the travel cost very important. Interestingly enough, the flexible departure time was classified as "very important" by 73.4% of the respondents, whereas weather conditions and ecological footprint were listed as factors of high priority by almost half of the study population (Fig. 6).

Nevertheless, most factors affect men and women differently; it is apparent that personal safety and road safety are significantly more important for women (Table 6). More specifically, 6/10 women reported them as "extremely important", as well as almost 4/10 of men. Furthermore, flexible departure time, weather conditions, and travel cost are the determinants with a higher impact on the female population. Even though flexible travel time seems more important to women, the difference is not (statistically) significant. Finally, the ecological footprint is a less essential parameter for travel mode choice for men. Here, we must mention that: in the case of chi-square tests, the requirement (i) of at least 80% of cell frequencies being five or more, of the two-way tables used, is satisfied and also (ii) the independence of all the members of the sample is being fulfilled.

b. Phase 2

An emerging question is, "*did the quarantine affected people's opinion regarding travel mode choice determinants*?". Unlike the 1st phase of the survey, personal and road safety, although they are quite significant factors for modal choice, do not come first on the list. In the research's 2nd stage, 79.3% of those interviewed consider flexibility in departure time is the key driver for choosing transport mode. On the other hand, travel time plays a crucial role for 77.7% of the participants, while approximately 76% declared that personal safety is principal (Fig. 7).

An entirely unexpected result is that road safety comes 5th on the list (74.1%), whereas travel cost is substantially vital for almost 7/10 individuals. Furthermore, as in the previous phase of the research, weather conditions and ecological footprint are not

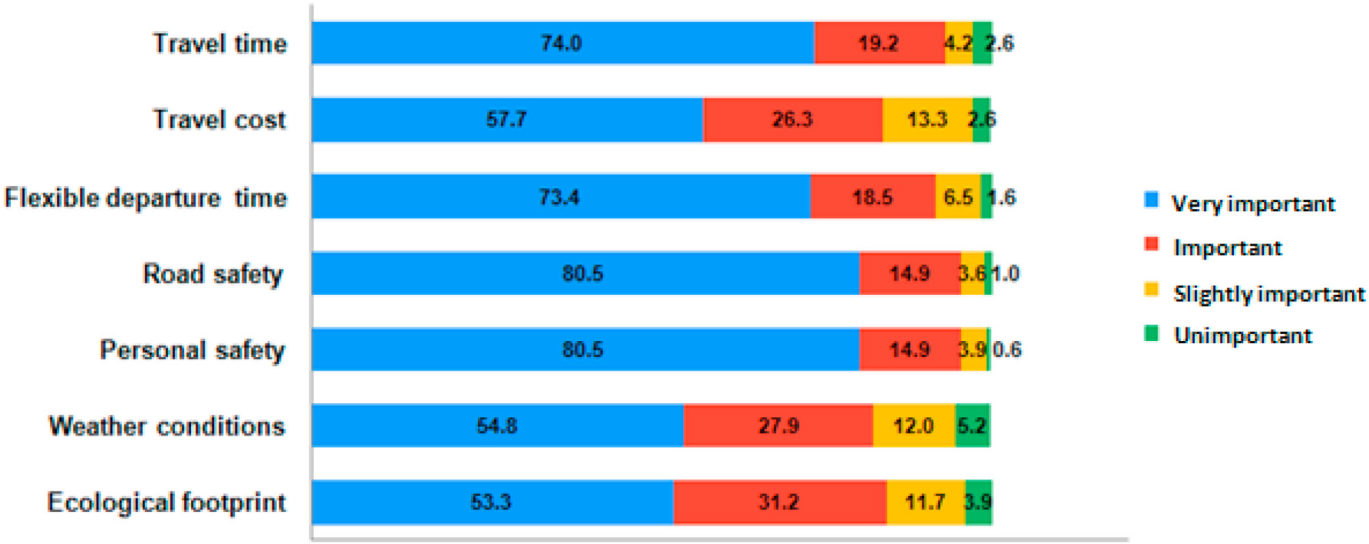


**Fig. 6.** Travel mode choice determinants (%).

**Table 6**
Travel mode choice determinants (%) concerning gender (Phase 1).

| | Travel time | | Travel cost | | Flexible departure time | | Road safety | | Personal safety | | Weather conditions | | Ecological footprint | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ |
| **Extremely important** | 38.1 | **46.0** | 23.9 | **31.6** | 31.3 | **36.2** | 42.5 | **58.6** | 41.8 | **59.2** | 21.6 | **28.2** | 14.9 | **27.0** |
| **Very important** | **34.4** | 29.3 | 23.1 | **34.5** | 35.1 | **42.5** | **32.8** | 25.9 | **32.1** | 26.4 | 25.4 | **32.8** | 28.4 | **33.9** |
| **Important** | 17.9 | **20.1** | **34.3** | 20.1 | **23.1** | 14.9 | **19.4** | 11.5 | **19.4** | 11.5 | **30.6** | 25.9 | **32.8** | 29.9 |
| **Slightly Important** | **6.0** | 2.9 | **15.7** | 11.5 | **9.0** | 4.6 | **3.7** | **3.4** | **6.0** | 2.3 | **12.7** | 11.5 | **17.9** | 6.9 |
| **Unimportant** | **3.7** | 1.7 | **3.0** | 2.3 | 1.5 | **1.7** | **1.5** | 0.6 | **0.7** | 0.6 | **9.7** | 1.7 | **6.0** | 2.3 |
| **$x^2$ test of independence** | non significant | | $x^2 = 11.845$, p-value = 0.019 | | non significant | | non significant | | $x^2 = 11.103$, p-value = 0.025 | | $x^2 = 12.639$, p-value = 0.013 | | $x^2 = 16.511$, p-value = 0.002 | |

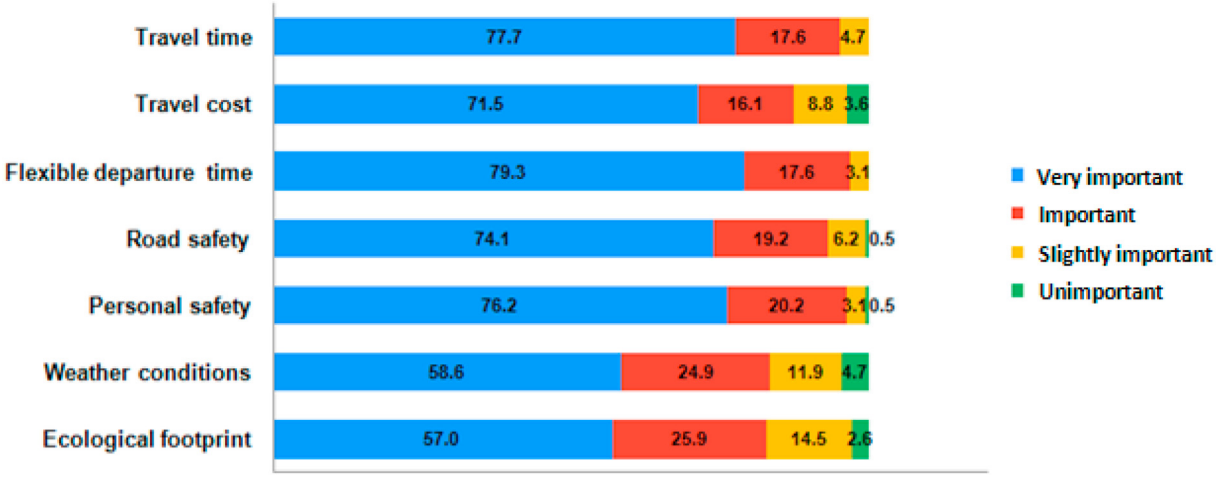


**Fig. 7.** Travel mode choice determinants (%) (phase 2).

**Table 7**
Travel mode choice determinants (%) concerning gender (phase 2).

| | Travel time | | Travel cost | | Flexible departure time | | Road safety | | Personal safety | | Weather conditions | | Ecological footprint | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ |
| **Extremely important** | 38.1 | **57.8** | 28.6 | **35.8** | 33.3 | **47.7** | 46.4 | **50.5** | 42.9 | **50.5** | 16.7 | **31.2** | 19.0 | **22.0** |
| **Very important** | **32.1** | 25.7 | **40.5** | 37.6 | 36.9 | **38.5** | 23.8 | **26.6** | 25.0 | **32.1** | 31.0 | **35.8** | 34.5 | **37.6** |
| **Important** | **23.8** | 12.8 | 15.5 | **16.5** | 23.8 | 12.8 | **20.2** | 18.3 | **25.0** | 16.5 | **32.1** | 19.3 | 28.6 | **23.9** |
| **Slightly Important** | **6.0** | 3.7 | 8.3 | **9.2** | **6.0** | 0.9 | **8.3** | 4.6 | **6.0** | 0.9 | **17.9** | 7.3 | **15.5** | 13.8 |
| **Unimportant** | – | – | **7.1** | 0.9 | – | – | **1.2** | – | **1.2** | – | 2.4 | **6.4** | 2.4 | **2.8** |

factors of paramount importance, provided that a significantly lower percentage of respondents classified them as "very important" (58.6% and 57.0%, respectively).

Travel mode choice priorities differ to some extent between the two phases of the survey. The most significant difference was identified for travel cost, provided that 13.8% more participants consider it as a significant determinant for modal choice (57.7% in phase 1, versus 71.5% in phase 2). The reason for that change is not completely clear, but it may be correlated with the economic challenges that several people are experiencing due to the lockdown.

Although personal safety lost significance for 4.3% of those questioned, the impact factor that has on the female population remains the same as previously (Table 7). Additionally, flexible departure time concerns more women, alongside with travel time. On the other hand, travel cost appeared to be a less essential parameter for males, while weather conditions and ecological footprint also have a minor impact on them. Finally, regarding road safety, no significant differences were detected between men and women.

### 3.3. Travel behaviour

To better predict future transportation requirements, *knowledge about travel behaviour across transportation modes* is considered as vital, since it forms the basis for transport models used in transport

**Table 8**
Citizens' travel behaviour.

| | Phase 1 | Phase 2 |
|---|---|---|
| No intention of reducing car use | **35.4** | 24.4 |
| Thinking about reducing car use | 7.1 | **9.3** |
| I have already reduced car use | 23.7 | **29.5** |
| Thinking about reducing public transport use and walk or cycle instead | 10.4 | **12.4** |
| Thinking about reducing public transport use and travel by car instead | 1.9 | **4.7** |

planning. At the same time, data on travel behaviour and trends is equally valuable for policymakers, provided that it enables them to make significant progress in encouraging sustainable urban mobility.

The single most conspicuous observation to emerge from the data comparison is the trend of reduced car use. In the post-lockdown period, approximately 6% more citizens reported having decreased private vehicle use, while the percentage of interviewees that are thinking about performing so increased by 2.2%. In the same vein, 11% fewer participants appeared reluctant to limit automobile use and opt for other transport modes (Table 8).

Furthermore, it is fundamental to note that there might be a decline in public transit ridership since 2% more people consider limiting the use of public transport and walk or cycle instead. Moreover, the fact that 2.8% more commuters prefer to travel by car rather than ride the bus reinforces the previously mentioned speculation.

### 3.4. Participants' attitudes on restricted movement measures

a. Phase 1

An under-investigation topic was *the consequences that had restrictive measures on citizens' commute*. According to data, 22.1% of the study population did not travel at all and stayed at home. Furthermore, half of the participants reduced their weekly transportation by 75%, while a smaller number, 17.5%, limited commuting by half. Approximately 8% of those interviewed reported limiting travelling by only 25%, whereas very few respondents (1.9%) maintained their usual travel schedule, and they did not restrict their daily commutes at all (Table 9).

Nonetheless, according to findings, the overwhelming majority of the participants abide by the novel regulations since 7/10 persons limited their daily trips by 75% or more.

Nevertheless, *are there noticeable variances between the cities of Rethymno and Chania*? The graph below (Fig. 8) indicates that overall there are no significant differences between the two populations concerning commuting reduction by 100% and 75%. However, a difference of 7.5% is visible between the persons who reduced their transportation by half. More precisely, in Rethymno, fewer citizens limited commuting by 50% than in Chania. Also, a slighter difference of almost 6% can be detected for the transportations that were cut down by one-quarter. In that case, residents of Rethymno restricted travelling more as opposed to citizens of Chania.

Another interesting finding is associated with a *different attitude on the restricted movement measures* according to age. Which age group limited more its' daily commuting? Although all age groups are at risk of the virus, experts underscore the fact that older people face the most threats and challenges. Hence, they must stay at home for as long as possible. On the other hand, sometimes the younger generation has a lower risk perception on a given situation, and further young people are used to commute and socialise a lot; thus, it might be more challenging for them to stay indoors.

Notwithstanding, unexpectedly, the age group 18–24 showed the highest rates of 100% and 75% decrease in commuting with percentages 32.3% and 56.2%, respectively (Table 9). This finding is linked with the fact that universities and educational institutions have been closed since March 10, 2020, in an attempt to contain the spread of the pandemic. Still, it is notable that youngsters followed the regulations strictly and kept social-distancing.

Furthermore, at least half of the participants of almost all age groups limited their commuting by 75% (Fig. 9). Regarding older people, the data revealed that only 12% of those aged 55–64 did not transport at all, a percentage that is considerably lower than that of the age group 18–24 (32.3%). Moreover, 1/3 of the oldest age group, ≥65 years old, restricted daily travelling by half.

There is a different *adoption of the measures* between men and women; women generally abided more by the rules (Table 10). More precisely, the rate for non-transportation was almost 7% higher for women (25.3% women, versus 17.9% men). In addition, while 53.4% of the female study population reduced its daily commute by 75%, the equivalent figure for men was 47%. On the contrary, the percentage of men who limited their transportation by half was double compared to that of women (23.9% versus 12.6%).

Moreover, in the framework of social-distancing, remote working policies were implemented. Consequently, almost one-quarter of those surveyed reported that they ceased daily commuting to the workplace, taking advantage of teleworking. Notwithstanding, the above-mentioned practice is not feasible for various professions, and for that reason, 22.1% of the participants limited in general their transportation, except the trips to and from the workplace. Moreover, 25.6% of the study population stated that their daily travelling was restricted considerably due to university closure and general lockdown. Furthermore, a minority (8.4%) commented that limited its daily commute to work due to reduced workload/service demand. Finally, very few participants (4.2%) indicated that they would like to reduce commuting, but at this moment, it is not feasible due to professional, family, and other obligations.

**Table 9**
Decrease in commuting (%) during the week 16/3–22/3 concerning age.

| | 18–24 years old | 25–34 years old | 35–44 years old | 45–54 years old | 55–64 years old | >=65 years old |
|---|---|---|---|---|---|---|
| 100% | 32.3 | 21.8 | 16.0 | 17.6 | 12 | 16.7 |
| 75% | 56.2 | 43.7 | 50.6 | 47.1 | 52 | 50 |
| 50% | 8.3 | 21.8 | 22.7 | 21.6 | 16 | 33.3 |
| 25% | 1.1 | 10.9 | 8.0 | 11.8 | 20 | – |
| Not at all | 2.1 | 1.8 | 2.7 | 1.9 | – | – |

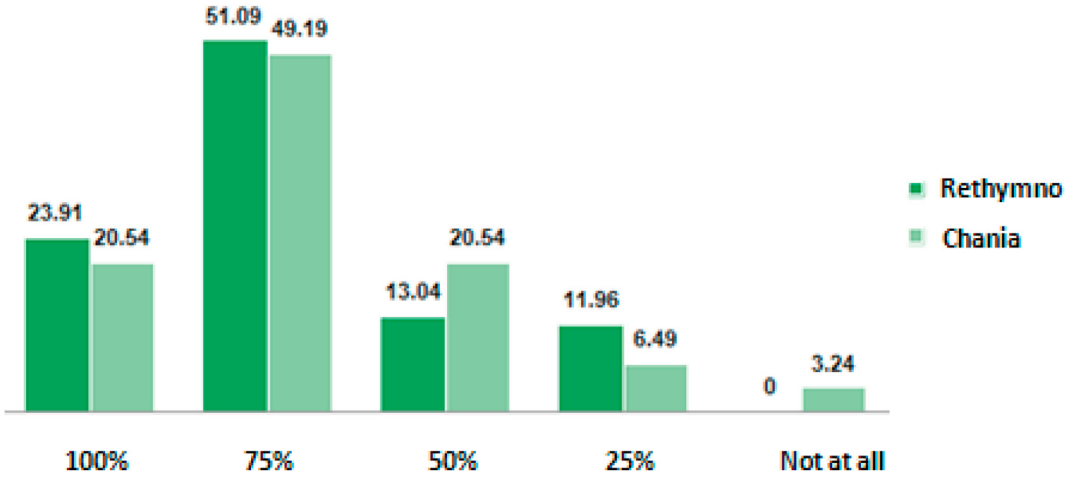


**Fig. 8.** Decrease in commuting (%) during the week 16/3–22/3 in the cities of Rethymno and Chania.

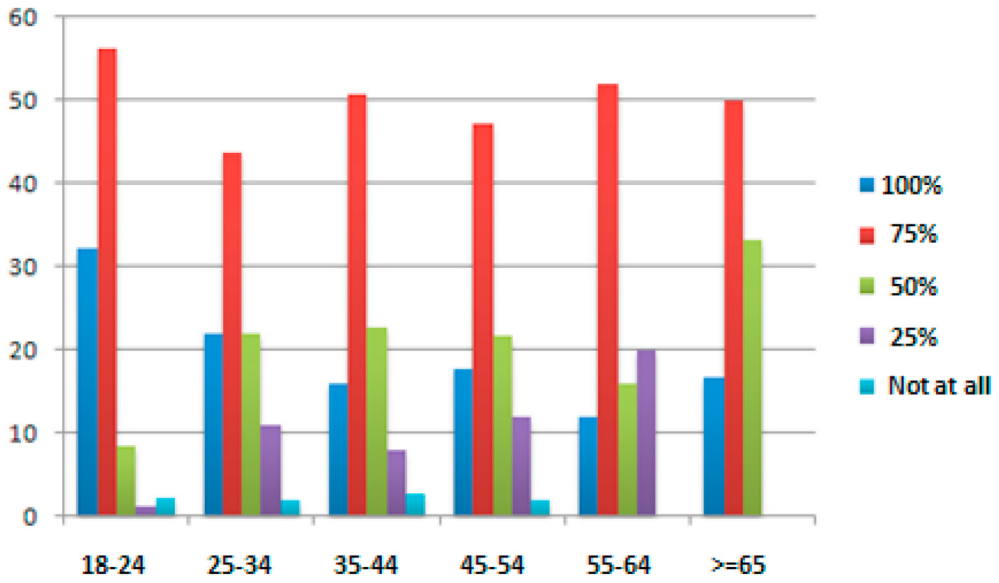


**Fig. 9.** Decrease in commuting (%) during the week 16/3–22/3 concerning age.

**Table 10**
Decrease in commuting during the week 16/3–22/3 concerning gender.

| % | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | | | 100 | 75 | 50 | 25 | Not at all | |
| Gender | Male | Count | 24 | 63 | 32 | 12 | 3 | 134 |
| | | % within Gender | 17.9 | 47.0 | 23.9 | 9.0 | 2.2 | 100.0 |
| | Female | Count | 44 | 93 | 22 | 12 | 3 | 174 |
| | | % within Gender | 25.3 | 53.4 | 12.6 | 6.9 | 1.7 | 100.0 |
| Total | | Count | 68 | 156 | 54 | 24 | 6 | 308 |
| | | % within Gender | 22.1 | 50.6 | 17.5 | 7.8 | 1.9 | 100.0 |

b. Phase 2

One month after the lifting of the strict quarantine and while the lockdown measures lessen continuously, *have the citizens returned to their regular travel schedule*?

Data analysis revealed that 22.8% of the respondents increased their weekly transportation by 100%, while almost 27% declared that the week 1/6–7/6 travelled 75% more than in April (Fig. 10). Furthermore, approximately 1/4 of the study population increased their transportation by half. On the other hand, 17.6% of the participants reported no substantial alteration in their urban travelling, provided that they transported only 25% more than in the curfew period (April). Nonetheless, a small percentage of interviewees, 8.8, stated no change in their travel patterns between the two periods.

Thus, we can conclude that 3/4 of the citizens travel significantly more in the post-lockdown period since they at least doubled their urban transportation.

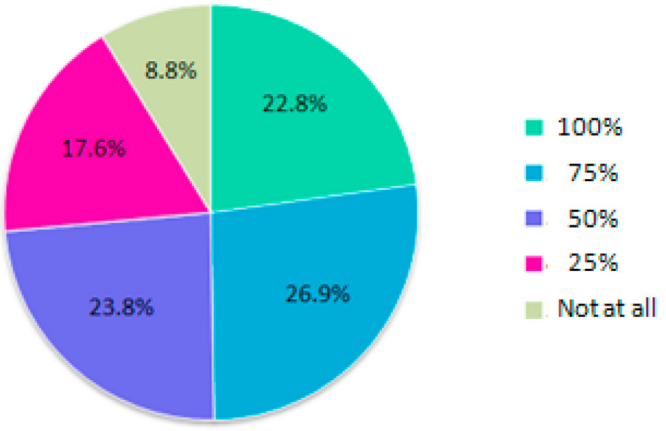


**Fig. 10.** Increase in commuting (comparison between April and the week 1/6–7/6).

Almost ¼ of the study population stated that commutes only to the workplace/university or basic needs and avoided unessential transportation. On the contrary, 34.2% of the participants have returned to their regular travel schedule and transport as much for the necessary activities as for entertainment. Notwithstanding, a small minority, 8.8%, suggested that their transportation remains limited due to teleworking/e-learning. Last, it is critical to note that 15.5% opted for travelling by private car, while 12.4% preferred active transportation (walking, cycling).

### 3.5. Shared mobility and safety

In shared mobility (e.g., carpooling, public transport, taxi), safety plays a predominant role, given that it is a primary concern for travellers and frequently a deterrent factor for opting for this transport mode. *How safe do people feel to share a car ride or take the bus*?

a. Phase 1

The survey's results indicate that 62.3% and 45.5% of the study population feel safe to share a car ride as a driver and as a passenger, respectively. On the contrary, 8.1% expressed safety concerns regarding carsharing as a driver, percentage that doubles for the passenger role. Furthermore, two-thirds of the respondents reported feeling safe using public transport (bus), and a minority, 12%, stated the opposite. Finally, 42.9% appeared to have no safety concerns for commuting by taxi, and only 17.9% mentioned feeling unsafe to travel by that means of transport.

Nonetheless, (statistically) significant differences can be observed according to gender. A notable yet expected finding is that women feel less secure to carshare. More specifically, while 16.8% of female travellers feel unsafe to share a car ride as a driver, only a small share of men (2.6%) feel the same (Table 6). The equivalent rates for carsharing as a passenger are 19.3% (women) versus 13.7% (men) (difference not statistically significant).

Notwithstanding, it is notable that the degree of safety feeling decreases considerably for both males and females commuters for carsharing as a passenger than as a driver. More precisely, regarding men, a decline of 37% can be observed between the driver and the passenger role (86.1% versus 49.2%). As for women, the reduction is lower (23.4%), given that while 71% feel safe to share a car ride as a passenger, 47.6% expressed the opposite.

Furthermore, the safety feeling as a passenger seems to decrease with age. From 63.5% for the age group of 18–24, it declines to 40.5% for the age group 55–64.

Concerning public transport, females also feel less safe than males; 78.4% of men suggested feeling safe to commute by bus versus 72.6% of women (Table 11). In contrast, 11.2% of the male population declared a sense of insecurity using public transit, whereas the equivalent figure for women was 15.3%. Regarding opting for a taxi for transportation, almost 6/10 men stated feeling secure, versus 46.5% of women (differences not statistically significant in both cases). Hence, it is apparent that men feel safer than women about shared mobility. Besides, the safety feeling for the taxi seems to increase with age, from 46.6% for the 18–24 group to 80% for the ≤65 group.

Furthermore, the results obtained showed that 73% of the study population feels safe to share a car ride as a driver with persons they already know (Fig. 11a).

Nevertheless, only 19.5% declared feeling safe to carshare as a driver with a stranger, and the percentage is even lower, 11.4%, for car commute with strangers as a passenger (Fig. 11b). Moreover, just over half of those surveyed and 6/10 persons reported feeling unsafe to share a car ride with unknown persons as a driver and as a passenger, respectively.

Enlightening was the analysis of the data safety concerning gender. As expected, generally, female travellers feel less safe than men sharing a car trip either as a driver or as a passenger with persons they know (e.g., 63.2% women versus 85.8% men, feel safe as a driver, difference statistically significant). Moreover, their safety concerns are even more severe when travelling with unknown persons. For instance, while safety reasons deter 16.1% of women from driving a vehicle with someone they know, that percentage increases significantly, reaching 59.8% when the passenger is a stranger ($x^2 = 13.794$, p-value = 0.001).

Nevertheless, surprisingly, while the vast majority of the male population, 85.8%, feels safe to drive a car with familiar persons, only 3/10 men feel the same in case the fellow traveller is unknown. In other words, men also appeared considerably concerned about their safety and unwilling to travel by car with unknown individuals. It is noteworthy that just over half of the male participants expressed feeling insecure about sharing a car ride with strangers as a passenger.

Notably are the differences between the driver and the passenger roles. Men feel safer driving than being a passenger in a car ride, either when travelling with familiar persons or unknown ones (Fig. 12). More precisely, while 85.8% and 29.9% of men declared feeling safe when driving a car with familiar persons or strangers, respectively, the equivalent percentages for the passenger role are 71.6% and 17.2%. On the one hand, that difference can be attributed to the fact that men prefer driving. On the other, they do not easily trust the driving skills of others easily, and sometimes they perceive women as bad drivers.

On the contrary, female travellers expressed a higher sense of security when being passengers and knowing the driver. Nevertheless, safety concerns increase when the driver is a stranger. Consequently, women, in the case of travelling by car with unknown persons, prefer driving to being a passenger.

**Table 11**
Feeling safe of shared mobility (%) concerning gender.

| | Car with others as a driver | | Car with others as a passenger | | Bus | | Taxi | |
|---|---|---|---|---|---|---|---|---|
| | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ |
| **Yes** | 86.1 | 71.0 | 49.2 | 47.6 | 78.4 | 72.6 | 57.0 | 46.5 |
| **No** | 2.6 | 16.8 | 13.7 | 19.3 | 11.2 | 15.3 | 21.9 | 20.8 |
| **I am not sure** | 11.3 | 12.2 | 37.1 | 33.1 | 10.3 | 12.1 | 21.1 | 32.6 |

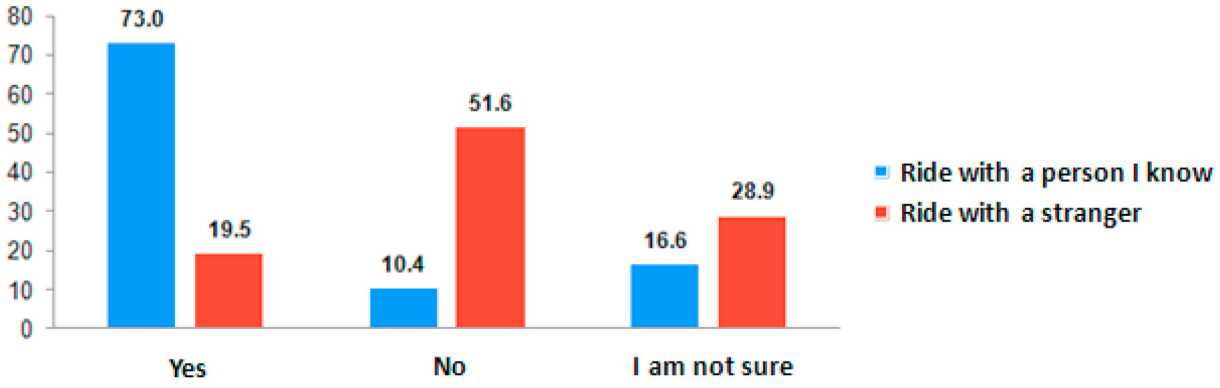


**Fig. 11a.** Feeling safe to share a car ride as a driver (%).

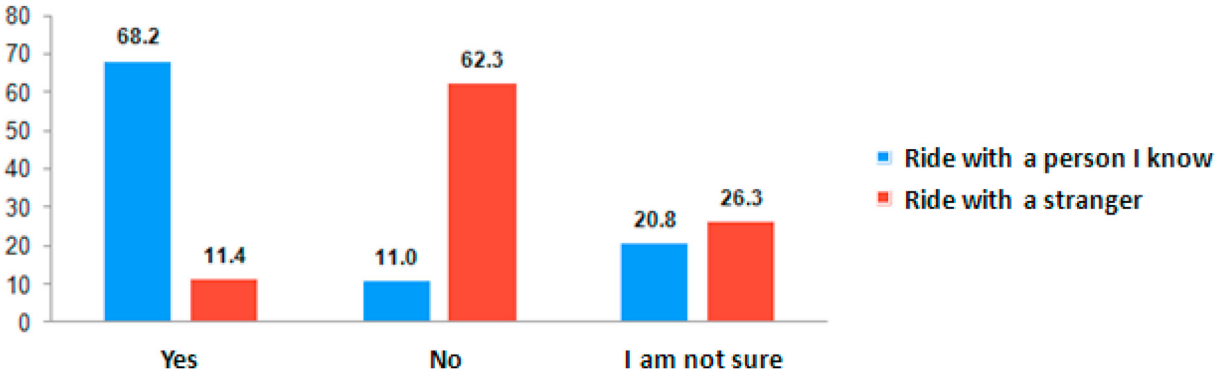


**Fig. 11b.** Feeling safe to share a car ride as a passenger (%).

Finally, the safety feeling both as a driver and passenger is of more serious concern for the age group $\geq$ 65.

a. Phase 2

The results of the 2nd phase support the previous findings (stage 1). The majority of the population feels safe to carshare either as a driver (59.1%) or as a passenger (50.8%). Compared with phase 1, the 5.3% increase regarding the passenger role may be linked to the rise in the number of car passengers that we mentioned earlier (Table 12). Also, 8.3% and 13.5% of the participants appeared to have safety concerns about sharing a car ride as a driver and as a passenger, respectively.

Furthermore, 6/10 persons reported feeling safe commuting by public transport (bus), and just a small number, 12.4%, seemed unwilling due to safety reasons. Surprisingly, those percentages differ slightly from the ones of phase 1, which implies that the impact of COVID-19 on people's notion towards public transit was not profound. Nevertheless, the sharp decline in the regular public transport ridership suggests otherwise.

Finally, 42.5% mentioned feeling secure to use a taxi, while a minority, 18.1%, stated the opposite. (no significant differences between the two phases of the survey).

Hopefully, more women than in phase 1 expressed feeling safe to carshare as a passenger (increase 8.3%). The number of female travellers that appeared to have no safety concerns for commuting as a car passenger decreased by 6.6% (Table 12). Hence, almost 15% more women feel secure to carshare as a passenger. This finding seems to be consistent with the previous comments on the increased share of car passengers.

Moreover, another interesting observation is that the percentage of the male population that declared a sense of insecurity sharing a car ride as a driver increased by 7%. Last, the proportion of females that feel secure to use public transport decreased by 12.8%.

Comparing Fig. 13a and b, the number of participants who stated feeling unsafe to carshare as a driver with a person they already know increased by approximately 3%. Moreover, the equivalent proportion when the passenger is unknown decreased by 3.4%. However, there are no significant differences between the two phases.

Regarding sharing a car ride as a passenger, an increase of 4.3% was observed for travelling with a familiar person (72.5% in phase 2, versus 68.2% in phase 1.

As in phase 1, men tend to feel safer than women to carshare, either as a driver or as a passenger. Comparing the two phases, it was shown that in stage 2, females were notably less concerned about their safety (for passenger role). More precisely, almost 10% more women declared feeling safe to commute by automobile with persons they know, while a decrease of 9.2% regarding the feeling of insecurity when the driver is a stranger was identified as well (Fig. 14).

By contrast, the sense of insecurity in carsharing increased for the male population. According to data, men who feel safe sharing a car ride as a passenger with an unknown driver decreased by approximately 7% (17.2% in phase 1, versus 10.7% in phase 2). Nevertheless, even when a driver is a familiar person, the proportion of males that expressed safety concerns increased almost by 4%. Furthermore, 10% more men feel unsafe driving their car with unknown fellow travellers.

Last, contrary to expectations, the proportion of males that feel safe to share a car journey as a driver with a stranger increased by 7%.

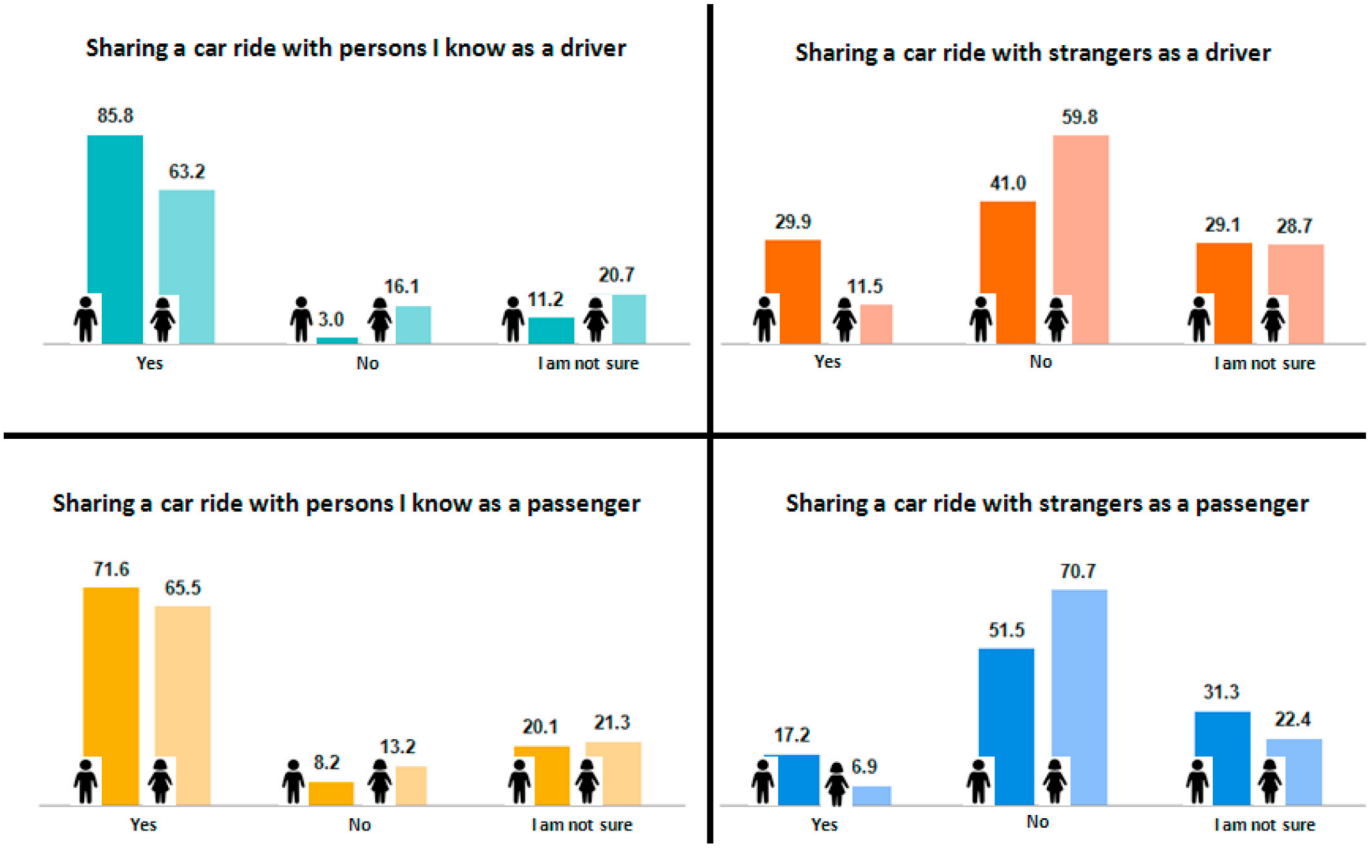


**Fig. 12.** Feeling safe to share a car ride as a driver and as a passenger (%) concerning gender.

**Table 12**
Feeling safe of shared mobility (%) concerning gender (phase 2).

| | Carshare as a driver | | Carshare as a passenger | | Bus | | Taxi | |
|---|---|---|---|---|---|---|---|---|
| | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ |
| **Yes** | 85.1 | 68.0 | 51.9 | 55.9 | 75.6 | 59.8 | 53.4 | 46.5 |
| **No** | 9.5 | 12.0 | 16.5 | 12.7 | 7.7 | 17.6 | 16.4 | 20.8 |
| **I am not sure** | 5.4 | 20.0 | 31.6 | 31.4 | 16.7 | 22.5 | 30.1 | 32.6 |

## 4. Conclusion

This study focused on the impacts of the COVID-19 pandemic on urban mobility, and concurrently, endeavoured to shed light on people's behavioural changes regarding their travel patterns.

The research revealed that both cities, Chania and Rethymno, are car-centric since almost 40% of the study population uses a private vehicle daily. Nevertheless, the cities' small size encourages green transportation, and almost 50% of the citizens choose walking for their daily commuting. On the contrary, cycling is not a preferred transport mode. The *lack of proper infrastructure* combined with the altitude differences, especially in Chania, and *cultural barriers*, probably contribute to the limited use of a bicycle within the city.

It is encouraging that a significant share (almost 30%) of citizens have already decreased car usage and opt for alternative and sustainable transport modes (walking, cycling, public transport). In addition, it is equally essential that in the post-curfew period the daily car journeys decreased. However, this is not sufficient as *one-third of the study population is unwilling to alter their travel habits*

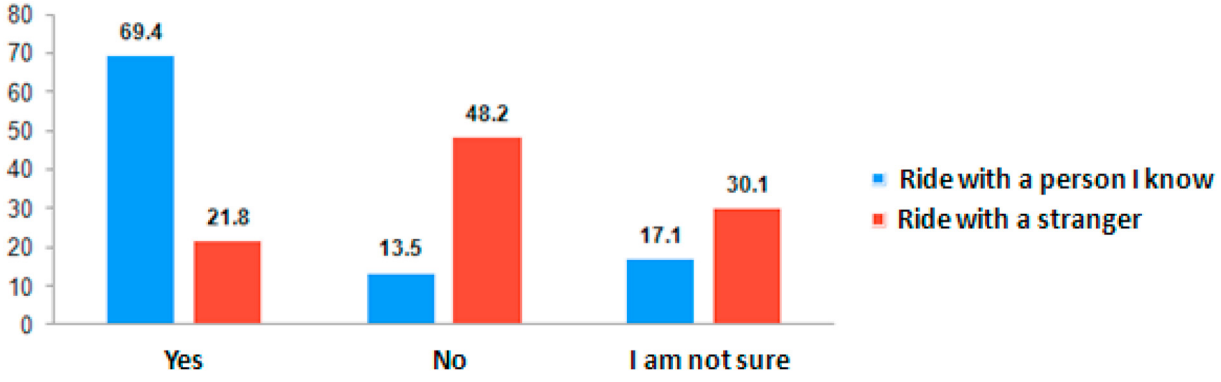


**Fig. 13a.** Feeling safe to share a car ride as a driver (%) (phase 2).

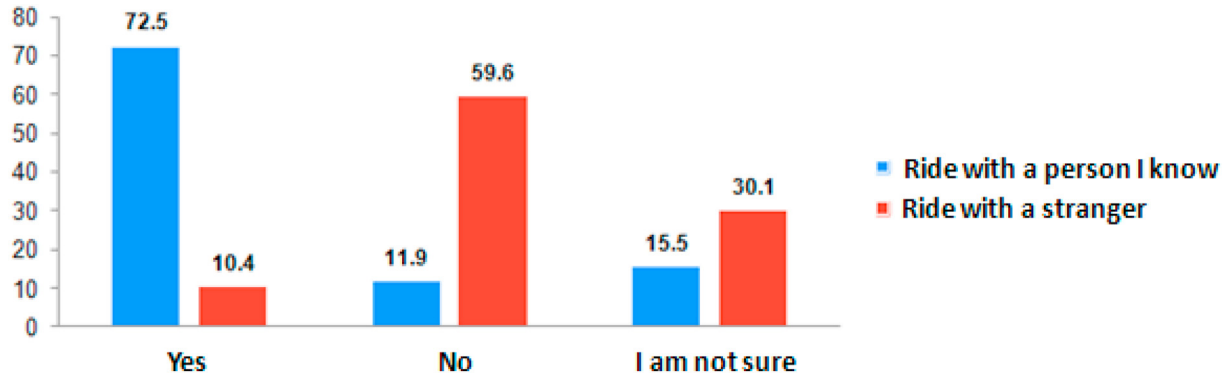


**Fig. 13b.** Feeling safe to share a car ride as a passenger (%) (phase 2).

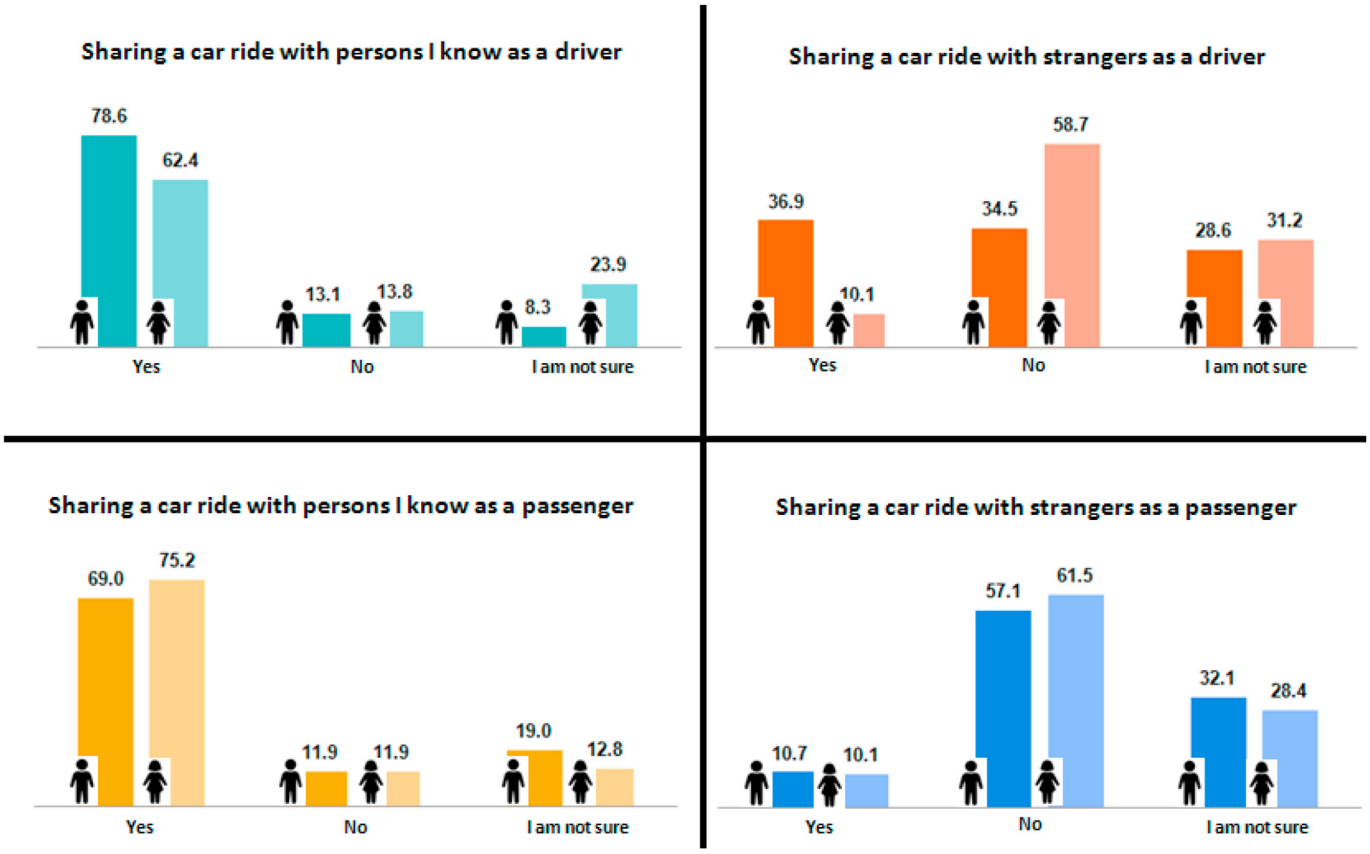


**Fig. 14.** Feeling safe to share a car ride as a driver and as a passenger (%) concerning gender (phase 2).

and limit car use, which underlines the domination of private automobiles in these cities.

A challenging finding that correlates with car dominance is that *ecological footprint is last* in the list of travel mode choice determinants. This illustrates low environmental awareness, which is a significant constraint for changing peoples' travel habits. On the contrary, safety is of paramount importance when choosing transport mode for the vast majority of travellers, especially for places with a high number of accidents like Crete. Nevertheless, how can we ensure health and safety during a pandemic? Are shared mobility and safety compatible?

Undoubtedly, it is quite challenging to combine mass transit with physical distancing, given that human interaction is innate in public transport. Furthermore, the sharp decline in public transit ridership demonstrates that passengers are *sceptical or even reluctant to use the bus*. Consequently, transportation planners and decision-makers have to unravel not only how to entice citizens back to mass transit but also how to serve public health interests. Returning back to the normality, it is critical that measures are taken to rebuild people's confidence in public transport and discourage car use, or traffic congestion will exacerbate. Frequent cleaning and disinfection of the public transport fleet, hand sanitizers, floor stickers to mark adequate spacing, are some measures that could minimize the risk of contagion and safeguard riders and employees.

Notwithstanding, besides the adverse impacts of the pandemic, there are also some positive effects. Lockdown due to COVID-19 reduced traffic congestion and consequently travel time. As stated

earlier, *travel time* not only affects peoples' well-being and overall health but also, according to respondents, it is a significant travel mode choice factor. Therefore, policymakers and transportation officials should place more emphasis on commute time.

Although it was not observed an overall uptake in cycling the reduced traffic caused *cyclists to feel safer* on the road. Several participants declared that a car-free city was ideal for commuting by bicycle safely. This underscores the need for bike lanes as the collision risk is a significant deterrent from cycling [25]. Furthermore, participants commented on the city's cleaner air and reduced frustration while travelling, additional benefits of limited motorised transport that cannot be disregarded.

The transport sector has been affected by the COVID-19 outbreak and the post-pandemic era is still obscure. The current mobility system proved unready to assimilate the impact of this unprecedented crisis, and defaults regarding the network's integration and public health were also unveiled. Nevertheless, the citizens' health and safety should be the priority of urban planning and transportation schemes, and technological advancements could play a pivotal role in that direction.

On the one hand, digital innovation facilitates the collection and analysis of real-time big data, providing useful insights on the constant and quickly changing mobility patterns [26]. By monitoring commuting patterns, transit providers and policymakers can identify and quantify passenger demand changes, track travellers volume, and adjust mobility services accordingly. For example, they can increase the frequency of services during rush hours to reduce rider density or redesign bus routes for more efficient transportation.

On the other hand, new mobile applications can provide public transit users real-time crowd-density data and enable them to choose the least occupied vehicles/stations. Moreover, trip-planning apps allow travellers to make smarter decisions on their commutes and suggest alternative mobility solutions during peak hours. Further, online transport booking not only prevents people's agglomeration at stations and bus stops but also provides contract tracing. When commuters arrange their journey via a mobile application, they can be easily informed in case of exposure to the virus. Finally, contactless payment via cards, smartphones, or wearable devices enhances commuters' safety by minimising physical contact [26].

Nonetheless, public health campaigns and strategies that encourage protective behaviours, such as wearing a mask and social distancing, are of utmost importance. A critical component of resilient cities is a "well-informed and self-motivated population" [27]. Hence, health education should be a priority and social media, billboards, and electronic screens should be used for promoting health protection guidelines. Furthermore [28], concluded that interventions focusing on the importance of general health rather than the risk of getting COVID-19 might persuade people to abide by the regulations and follow experts' recommendations. In the aftermath of the pandemic, cities should be reshaped in favour of active transport (walking, cycling), since returning to pre-COVID-19 traffic and air pollution levels is not a sustainable option. Already, several cities around the globe have been reallocating road space temporarily from cars to cyclists and pedestrians, while others, like Milan, have set in action ambitious plans to make these changes permanent [29]. In addition, as city officials are trying to fend off a resurgence in car use, they encourage cycling by providing economic incentives for the purchase/repair of bicycles [30].

Nonetheless, establishing the 'green shift' in mobility habits requires not only infrastructures but also a coordinated and integrated urban transportation system. Citizens should be able to safely navigate the city and have easy access to local and regional public transit. Furthermore, this is the opportune moment to overcome the cultural barriers and redirect people towards eco-friendly modal choices. As lockdowns ease and people start slowly commuting again, it is easier to encourage them to adopt active transport modes and adhere to them, given that due to curfews, they drifted apart from their previous mobility behaviours. Moreover, 'soft interventions' such as environmental awareness campaigns are regarded as crucial to promoting sustainable urban mobility. Nowadays, we are in a transition period. Life as we knew it has altered dramatically, and we are obliged to start fresh. As we are trying to enter in the post-COVID-19 era and cities are trying to build the 'new normality', it is remarkable to investigate further the consequences of the pandemic on urban transport. Future studies could investigate whether people perceive the long-term benefits of limiting private car use and are willing to shift towards active transportation. Furthermore, as urban commuting gradually re-starts, it would be useful to register the alterations in citizens' mobility patterns and compare them with pre-pandemic and quarantine ones, in order to identify the mobility trends. The data analysis and modelling would be useful in the future design of more flexible, sustainable, and resilient mobility strategies.

## CRediT authorship contribution statement

**Dimitra Tarasi:** Investigation, Writing - original draft, Visualization. **Tryfon Daras:** Formal analysis, Methodology, Validation, Writing - original draft, Writing - review & editing. **Stavroula Tournaki:** Conceptualization, Methodology. **Theocharis Tsoutsos:** Conceptualization, Methodology, Supervision, Writing - original draft, Writing - review & editing.

## Declaration of competing interest

None.

## Acknowledgements

This publication is supported by the European Commission by the European Union's Horizon 2020 research and innovation programme, within the framework of the project CIVITAS DESTINATIONS (Project ID: 689031). The sole responsibility for the content of this paper lies with the authors. It does not necessarily reflect the opinion of the European Union. Neither the INEA nor the European Commission is responsible for any use that may be made of the information contained therein.

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