Impact of the COVID-19 Pandemic on Citizen Travel Rules Related to Intelligent Mobility Use in Algeria:

The Influence of Personal Factors and Health Restrictions

Yasmine Keltoum Mekhtoub, Ecole Polytechnique d'Architecture et d'Urbanisme, Algeria*
Tahar Baouni, Ecole Polytechnique d'Architecture et d'Urbanisme, Algeria

ABSTRACT

The study focuses on the impact of the COVID-19 pandemic on ICT-related travel policy, based on a statistical analysis of the uptake and use of smart mobility services by the Algerian population before and during the crisis. A questionnaire distributed via the internet on social networks was used to assess ICT use and evaluate the influence of personal factors on the choice and frequency of use of technologies in mobility. The sample consisted of 368 valid individuals. Several parametric and non-parametric tests were performed to address the hypotheses posed. The results suggest that the diffusion of COVID-19 would influence Algerian citizens' mobility, which differs by gender, age group, location, and status. This work also examines the effectiveness of restrictions and tests ICT services in the face of the COVID-19 pandemic. Although mobility changes according to need, some modes of transport adapt to circumstances and others do not. Policymakers should therefore consider these changes in travel policy to develop adequate services for future disasters.

KEYWORDS

COVID-19, ICT, Impact, Mobility, Restrictions

INTRODUCTION

In the past, cities were built in a hygienic way. The hygienist movement appeared in the 19th century with the first anal proposed by Baud (1981). It remains the only current that linked urban planning and medicine, considered "a new way of rethinking the city from the point of view of hygiene and health" (Costa, 2012). Over the centuries, architecture and urban planning have lost their sense of hygiene by referring to culture, traditions, symbolism or, more recently, prestige and luxury, with relying on medical progress, which alone has been able to cope with past epidemics, thanks to vaccines, remedies, and medicines (Rahm, 2020). A few years ago, health was considered an essential and founding factor of urban planning. Whenever medicine failed in the face of a health crisis, space and urban planning reacted preventively (Levy 2012, cited by Nader, 2013). Several social utopias have left traces in this sense, where the organisation of society depended on the organisation of space itself (Ghorayeb, 2019).

In December 2019, at the time of its outbreak with the first case reported in Wuhan, COVID-19 was considered an epidemic. Still, since March 11, 2020, the WHO (World Health Organization), with an

DOI: 10.4018/IJEPR.299548 *Corresponding Author

This article published as an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0/) which permits unrestricted use, distribution, and production in any medium, provided the author of the original work and original publication source are properly credited.

unprecedented rapid spread on all continents, has considered it a global pandemic. It is considered a public health emergency of world-renowned (WHO, January 30, 2020), which has unexpectedly and dramatically disrupted human life. According to the Swiss architect Rahm (2020), this phenomenon would be a return to normal about the epidemics and natural disasters that humanity has already faced. The architecture of cities is still a witness. This idea is also supported by Kanda and Kivimaa (2020). The authors consider the global phenomenon an opportunity for humanity to witness it, study it closely for a better consideration of sustainability, and prepare for this type of chaos in the future. As for mobility, recognised as being the main factor responsible for the virus's transmissibility, massive population displacements and the role of transport have facilitated the spread (Zhang et al., 2020). Wilson (1995) argued, "given the unprecedented volume, speed, and range, global travel is a major factor in the rapid spread of today's diseases".

Intelligent mobility alone affects all the technological advances that optimise travel and those that reduce or eliminate it; it is the key to the intelligent transformation of cities (Audenhove et al., 2013). It uses ICT in modern transport technologies to improve urban traffic (Albino et al., 2015).

After joining the SD (sustainable development) wagon, Algeria is getting into the bath and joining the smart cities wagon. The chaotic development of these cities over the last two decades leaves it little choice and encourages it to do so. Algiers has long suffered from inconsistencies of order: socio-spatial, socio-economic and environmental. The depletion of natural resources has only made things worse. Algiers has been confronted for years with unprecedented population growth, a dazzling urban sprawl consuming space, and generating displacements. It has become a city spread out to see even burst, its road network now saturated and associated with hazardous urbanism, many problems have been raised: conurbation, an imbalance between centre and periphery, pollution, and especially an alarming situation of congestion CTTP (*Organisme National du Contrôle Technique des Travaux Publics*, 2006), etc.

Algiers is then immersed in the "magic circle" (Bakour et al., 2018), described by Orfeuil (2001) as the dependence of a population on the personal vehicle, where Dupuy (2002) points out that the dependence reflects the difference between the accessibility of motorists and non-motorists, causing this increase: An antiquated public transportation system, an increase in motorised households RGPH (General Census of Population and Housing, 1998-2008), and an increase in the number of cars ONS (National Statistics Office, 2011), this dependence generates more infrastructure, which in turn generates more services for motorists, which attracts more motorists (Orfeuil, 2001). Several initiatives have been taken to address this situation.

The "Algiers Smart City" project, a hopeful project led by the Wilaya of Algiers, was exhibited at the International Summit. Over two days, on 27 and 28 June 2018, it brought together more than 4,000 participants of different nationalities. The participants discussed and proposed technological solutions for Algiers, affecting the different sectors that make it up, mainly mobility. Following this summit, several agreements were signed. The "Fablab" was created to test the technological solutions envisaged. Several startups were developed and launched. New ICT mobility services enhance and facilitate travel, such as taxi apps, carpooling, and e-commerce (buying, selling, and delivering). Other services that erase and eliminate travel include telecommuting, video conferencing, e-learning, and remote medical consultation.

Although the Algiers Smart City project offers innovative solutions for the capital, the authors find its insertion and integration abrupt and brutal, both at the planning level and with the citizens. They point out that the opinion of citizens on the issue remains divided, some finding the project itself a myth while others find it innovative but not a priority. However, in times of health crisis, the authors wonder if it is necessary to ensure, accompany, and secure people's movements or suppress them by privileging remote services. They also wonder whether the pandemic may have impacted the use of ICT services. Hence, in this study, the following question is asked: *What is the Impact of the COVID-19 pandemic on citizens travel rules related to the intelligent use of mobility: the influence of personal factors and health restrictions in Algiers?*

With this in mind, this study aims to:

1. evaluate the impact of the COVID-19 pandemic on the travel policy of the citizens of Algiers to ICT mobility services;

2. evaluate the influence of personal factors on the choice of use;
3. evaluate the influence and effectiveness of mobility restrictions on the choice of use;
4. assess the effectiveness of ICT services;
5. highlight the virtues of ICT mobility services and the drawbacks.

LITERATURE REVIEW

WHO has pointed out that COVID-19 infection will grow exponentially due to the migration and export of the virus from China to other continents (Center for Disease and Prevention, 2020). Scientifically speaking, to face the disaster, two paths exist: the first, medical, concerns the vaccine as a cure, and the second is spatial related to the study of the spread of the disease (Aleta & Moreno, 2020). The Chinese government has implemented drastic measures in terms of mobility to counter the spread of the virus, which led to the suspension of all modes of transport, starting with the city of Wuhan (BBC News, 2020). Transport interconnectivity and global hypermobility have also played a central role in spreading the virus (Musselwhite et al., 2020), making the measure crucial on a global scale. Bonaccorsi et al. (2020) evoked containment to reduce the infection rate and compared the change in mobility to an exogenous shock similar to a natural disaster. The measures taken included travel restrictions (Gostin & Wiley, 2020) and total or partial closure of country and city borders (Stevis-Gridneff & Pérez-Peña, 2020; Connor, 2020). Zhang et al. (2020) even stipulated that the ban on international travel is insufficient. Traffic within each country should be controlled by prohibiting gatherings and closing schools from measuring social distancing. These measures, including prohibiting citizens from leaving their homes, should help limit the spread of infectious diseases to eradicate (The Straits Times, 2020).

Several research studies have been carried out concerning mobility during the COVID-19 pandemic, such as a study of the impact of locking on mobility (Saha et al., 2020), the effect of human mobility, and control measures on the COVID-19 (Kraemer et al., 2020). Also, the evolution of mobility is considered in response to COVID-19 (Warren & Skillman, 2020; Klein et al., 2020; Kramer & Kramer, 2020), the impact of displacement on propagation (Zhang et al., 2020; Cartenì et al., 2020; Oztig & Askin, 2020), the impact of reduced displacement on the spread of the virus (Anzai et al., 2020; Hadjidemetriou et al., 2020; Jiang & Luo, 2020; Chinazzi et al., 2020; De Vos, 2020), the challenge of ICTs in the face of COVID-19 (Abusaada & Elshater, 2020) and the effects of COVID-19 on air quality related to mobility measures (Sasidharan et al., 2020; Zhu et al., 2020; Monks, 2020). Several researchers even concluded that containment has been successful, i.e., a 12% reduction in pollution (Liu et al., 2020). However, there is a lack of research on the use of ICTs related to mobility and on the user preferences of the population in times of crisis.

Based on these studies, the authors can argue that the COVID-19 has a profound impact on mobility (Wellenius et al., 2020). Moreover, the long-term consequences may affect the mobility system and its needs and the general consumption of fossil fuels (Kanda & Kivimaa 2020). Today, many countries face economic decline (Gopinath, 2020) with the closure of borders and the complete cessation of tourism (Coven & Gupta, 2020). International mobility is affected, and chaotic predictions state that there will not be as many travellers as 2019 until around 2022 or even 2023 (Jolly, 2020). These measures have reduced human mobility (De Vos, 2020; Klein et al., 2020; Warren & Skillman, 2020), probably delaying coronavirus transmission (Chinazzi et al., 2020). Algeria followed the pace of border closures and health restrictions, such as the internal closure of borders between Wilayas and the complete stoppage of public transport to assess the impact of health restrictions and their effectiveness.

In intelligent mobility, several advances have been made to improve road safety. This happens in the dominance of GPS and onboard sensors (Liu et al., 2017), simulation software (Michau et al., 2017), cognitive radio (Daniel et al., 2016), and Traffic View applications (Nadeem et al., 2004). In addition, other means are available to reduce economic and environmental impact through data processing. We may refer to TIME as a platform for environmental monitoring of transportation information (Bacon et al., 2008), intelligent parking via E-parking and automated parking (Hafezi et al., 2012;

Trigona et al., 2016; Lee et al., 2016; Shaikh et al., 2016, Khanna & Anand, 2016; Pham et al., 2015; Nawaz et al., 2016). Traffic Signal Synchronization (Faria et al., 2017), sensors and communication technologies also calculate time and detect traffic flows and density (Ghazal et al., 2016; Jagadeesh et al., 2015; Moller et al., 2015). Nevertheless, other alternatives were proposed by Smith, Sochor & Karlsson (2018) to promote MaaS (Mobility as a Service) using the latest mobility technologies such as peer-to-peer carpooling. Carpooling applications are also available in Algiers and other Wilayas in particular. The leader of carpooling in Algeria is MelyaGo (MelyaGo, 2019), M3aya, 2019 followed by Karos launched by TemTem (TemTem), (nroho, 2013), Adini, lahaqni, taxi reservation via an app. The Yourcab platform gathers the most used taxi apps in Algiers (YourCab, 2022): (Yassir), (Temtem), Careem, owned by Uber, (Heetch), (Amir), (Coursa). Other applications have already been launched, and others are being launched: Tymo, Wesselni, OuiGo, Harbin, YallaGo, etc.

In addition, there are remote services that eliminate the need to travel, such as e-commerce (websites and apps for internet shopping and home delivery). COVID-19, in its early days, caused panic. As the number of cases increased, this panic was replaced by the use of technology as a response. Online shopping, home delivery, or even online ordering of horticultural products for self-sufficiency (Ungoed-Thomas, 2020) were used to eliminate the need to travel (Hanbury, 2020). In Algeria, the panic following the pandemic also caused stockouts of food products of first necessity. We find the applications and websites par excellence in e-commerce in Algeria grouped in a comparison site (Comparili, 2019), The purchase/sale: Ouedkniss, MarketPlace of Facebook, for shopping and various purchases Jumia and Jumia Food, temtem One, Yassir Market, Batolis, Alger Bazar, Algerie store, Naqdilek Amir Market and AchaGo.

Furthermore, Schools and universities focus on eLearning (Peters, 2020; Salama, 2020). Reference eLearning platform in Algeria (e-Learning platform), as well as (beeform e-Learning), a multitude of e-learning platforms of universities (all specialities) available to Algerian citizens, (Université d'Alger 2), (Ecole Nationale Polytechnique (ENP), (Université de Bejaïa), (Université Alger 1), (Université de Blida), (Université de Boumerdes), (Université de Chlef), (Université d'Oran 2), (Université de Skikda), etc.

Several sectors impose telework because of health measures. Hence, telework and conference visions are increasingly used (Batty, 2020). In Algeria, telework is positive for 71.2% of the workers interviewed during the COVID-19 pandemic (survey of the Centre of Research in Applied Economics for Development, (CREAD, aps, 2021). Thanks to video conferencing technology, or better still, thanks to new technologies, it is possible to book a taxi on the Internet via mobile applications or to work remotely from home without having to travel. People can also benefit from a free and effortless remote medical consultation.

Remote medical consultations were already available in Algeria since 2016 (etabib, 2016). This platform includes more than 20,000 doctors in 25 specialities. The platform has even received an African telemedicine award (etabib award, 2020), the mobile application (etabib mobile application). The cab application Yassir has developed a platform, to provide for the medical needs of users and these paid drivers by providing them with volunteer doctors. Another example is the application Amir (Amir medical application).

It is difficult to judge and understand the mobility needs of citizens from a safety perspective. The scientific literature reveals a scarcity of studies related to mobility, particularly intelligent mobility. Therefore, this study aims to understand the travel behaviour of citizens in the face of the pandemic. In addition, we evaluate adherence to new technologies and their frequency of use.

METHODS

Research Design

This study used a causal research design, based on a sample survey, aimed at developing and understanding the impact of COVID-19 on use, usage choice and evaluating the relevance of ICT services in mobility. A self-administered questionnaire was distributed via the Internet, targeting citizens of Algiers users of knowledge technologies. This distribution method was chosen because

of the current health emergency. This study concerns the use of technology in mobility, the idea of using technology to collect data from the Algiers population.

Survey Instrument

To study the impact of COVID-19, the author's choice to evaluate the ICT services was made following the scientific literature. The authors chose six items according to the studied context (city of Algiers) and by evaluating the need: cab applications, carpooling, e-commerce (Smith et al., 2018); teleworking (Batty, 2020), vision conferences, eLearning (Peters, 2020; Salama, 2020). Remote medical consultation is a variable that authors added to their study, essential because of the health crisis. The use of ICT services is evaluated before and during COVID-19 under the influence of personal factors of each user (gender, age, residence, status) and context-related mobility restrictions (restriction of public transport suspension, restriction of border closure between departments). The authors chose to test the relevance of the services as standard evaluation factors: 5 elements: ease of use, time-saving, money-saving, and frequency of use, to which is added a factor related to health in times of pandemic, namely "security".

Investigation Procedure

The Algerian connection is preceded by a reputation, weak connection, repeated disruptions and maintenance cuts, political blocking of social networks. It is quite different today. 'Algérie Télécom' provides the Internet connection. The operators 'Djezzy' and 'Ooredoo' ensure coverage throughout the country (Carte de couverture 3G/ 4G/ 5G, 2021). An improved and doubled optical fibre from 10 Mbps to 20 Mbps ensures high-speed services as well as very high speed for individuals and companies (Algérie Télécom Catalogue, 2021/2022). In addition, the latest test of 5G with the Chinese company Huawei is underway (Huawei 5G, 2021) and will be launched very soon.

Before releasing the research instrument, it was tested with 10 people to assess its clarity and content and improve it to finalise it. An authentication question for potential respondents was added to identify intent errors and detect erroneous responses not to be included in the study. In addition to an automated response block that allows only one response per person, the dissemination of the instrument was done on different social networks in two languages (Arabic and French) to reach more people. The questionnaire consisted of four sections. The first described the context of the study and its objective. The second section collected the personal characteristics of respondents. The third section asked respondents about their travel behavioural habits before and during COVID-19. It also asked them about their apprehensions about ICTs for mobility (based on the Likert scale), while the fourth section aimed to assess the effectiveness of the travel restrictions (Appendix A).

The sample is representative, counting 368 of the 538 respondents to their questionnaire (elimination of questionnaires that failed the logical response test), confirming its viability and the representativeness of the results obtained at a confidence level of 95% and a calculated margin of error of 5%. The authors collected data relating to the movements of the inhabitants of Algiers before and during the COVID-19 pandemic and their use of ICTs to support their movements and eliminate them. The survey was extended from July 1 to August 15, when the number of contaminated people in Algiers was 100 per day out of the approximately 600 contaminated people throughout Algeria. The sample includes women (60.1%), men (39.9%), young people between 18 and 35 years old (46.7%), people between 35 and 55 years old (41.8%), people over 55 years old (11.5%), mainly workers (72.8%), students (10.6%), unemployed (9.5%) and retirees (7.1%). Residents were mainly located between 0 and 30 km from Algiers city centre (69.8%), 18.5% were located in the city centre, and 11.7% were located more than 30 km from the city centre (Table 18, Appendix B).

Data Analysis

Table 1 summarises several validity tests to assess the reliability of the items. Cronbach's Alpha measures the coherence of items (Thiolliere et al., 2016). The CR is the composite reliability

Table 1. Indicators of questionnaire validity

Coefficient	Value	Sig	Decision
Alpha de Cronbach	0.705	α>0.700	Very good
Coefficient Omega (CR)	0.941	ω>0.600	Excellent
Average Variance Extracted (AVE)	0.740	AVE>0.500	Excellent
Kaiser-Meyer-Olkin (KMO)	0.803	KMO>0.500	Very good
Bartlett Sphericity Test	0.000	P<0.05	Excellent

coefficient (Peterson & Kim, 2013). The AVE is the discriminant validity of the measure, with the item coefficients evaluated according to the grid of Fornell and Larcker (1981). The KMO measures the adequacy of the data sampling (Andale, 2017). Bartlett's test measures the overall independence of the components (correlation matrix) (Anastassakos & d Aubigny, 1984). The indicators are significant; allow considering the data obtained as variables.

A descriptive analysis of each variable was then carried out, with several parametric, non-parametric and cross-tabulation tests, to study the relationship between several variables (SPSS V25 for Windows). Hypothesis tests were conducted to study the impact of the pandemic on human mobility by evaluating the influence of personal characteristics (1) on ICT use choices: gender (Levene test, one-way ANOVA test), age (Kruskul Wallis test), status (Pearson x2) and residence (Kruskul Wallis test). Cross-tabulations were carried out to study the effectiveness and impact of restrictions on the travel policy of Algerians and their use of new mobility technologies: (1) Suspension of public transport and the use of private cars (correlation, test x2), (2) prohibition of travel between the departments and its repercussions on the lives of citizens (correlation, test x2); ICT evaluation: (2), (3) To test the evaluation of Algerians to ICT services of mobility according to (Safety, Ease of use, Time-saving, Money-saving, Frequency of use and suppression of trips), (Likert scale). (5) Regression to measure the effectiveness of ICT as a dependent variable of other independent variables (Safety, Ease of use, Time-saving, Money-saving and Frequency of use) (Pearson's correlation, R-two, t Student, Fisher, Significance). The hypothetical model in Figure 9 (Appendix B) reflects the methodology applied (Table 21, Appendix B).

RESULTS AND DISCUSSIONS

Hypothesis Testing, the Influence of Personal Factor

Age Factor

The Kruskul Wallis test was used to test the existence of a relationship between age factor and choice of services used during COVID-19. The test concerns samples from more than two categories: C_1= 18 to 35 years, C_2= 35 to 55 years, C_3= 55 to 65 years, C_4= 65 years, and more. Therefore, there are two hypotheses:

H0= No relationship between age and choice of ICT mobility services used during the epidemic;
H1= Existence of a link between age and the use of ICT mobility services during the epidemic.

For e-commerce (H=10,956 and p-value=0.012), teleworking (H=8,829 and p-value=0.032), vision conference (H=12,504 and p-value=0.006), taxi applications (H=12,424 and p-value=0.006), carpooling (H=7,227 and p-value=0.065), the p-value obtained is well below 5%, the null hypothesis is therefore rejected in favor of the alternative hypothesis confirmed. The results presented in Table 2 indicate that age influences ICT mobility services in the COVID-19 period except for medical consultation. The very high p-value=0.986 proves that age has no influence. Thus, the authors

Table 2. Kruskul Wallis age test results

Variables	H	Df	Asymptotic Significance
E-commerce	10.956	3	.012
Teleworking Vision Conference	8.829 12.504	3 3	.032 .006
Cab application	12.424	3	.006
Carpooling	7.227	3	.065
Medical consultation	.148	3	.986

deduce that the crisis affected all age groups concerning remote medical consultation from a safety and health point of view. The authors assumed that each age group has its preferences for services, so a test was conducted to demonstrate this hypothesis (Multiple factor analysis of correspondences).

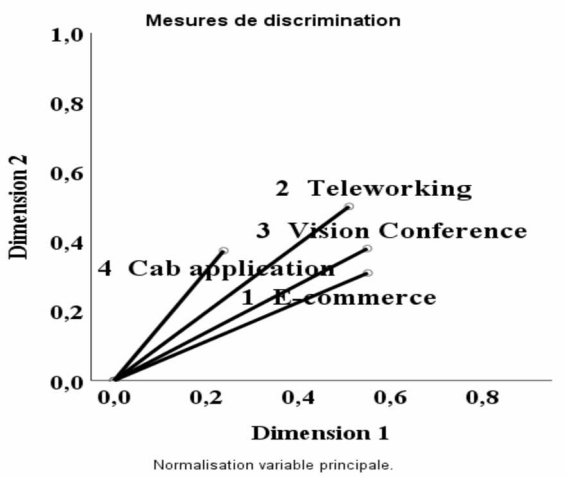
Cronbach's Alpha value is satisfactory (α= 0.56). It has a recovery capacity of 62% inertia by the two dimensions of information storage (1, 2), making the factorial analysis of multiple coding optimal and relevant. The most discriminating variables in choosing the use of mobility ICT services during the COVID-19 are teleworking and conference vision (Figure 1). The dimensions (1, 2) show that when age increases, use decreases. The remote services without human contact are finally the most influenced by age during the crisis period of the COVID-19.

Based on Figure 1 and Table 3, it can be noted that citizens of Algiers were strongly influenced by the exogenous factor COVID-19 dividing the four age categories into two parts:

Table 3. AFCM analysis based on age groups

Dimension	Alpha de Cronbach	Total (equity value)	Inertia
1	.582	1.943	.324
2	.536	1.808	.301
Total		3.751	.625
Average	.560	1.875	.313

Figure 1. Most discriminating variables for age



C_1 (18-35) and C_2 (35-55) and C_3 (55-65) and C_4 (£65). For C_1 and C_2, the use of taxi and e-commerce applications mainly, while in the COVID-19 period, conversion to telework and vision conferencing can be noted. For C_3 and C_4, the use of e-commerce and taxi applications increased, while conversion to medical consultation can be observed (Table 20, Appendix B). E-commerce was a preferred practice of the four categories before and during COVID-19 proving its efficiency, while taxi applications experienced great success compared to e-commerce. This result may be related to the fact that they carry a higher risk of contagion. A hybrid age model of use before/during COVID-19 was designed following the results obtained (Figure 5, Appendix B).

Gender Factor: Levene's Non-Parametric Test

Levene's test allowed us to assess a relationship between the gender factor and the choice of services used during the COVID-19 period. This test concerns the hypothesis of variance equality. In general, a normality test is imposed beforehand, but the obtained sample is large (368 people), making it possible to claim normality.

H_o Lack of gender influences the choice to use ICT services in the COVID-19 period.
H_1 At least the choice of a service is influenced by the gender factor in the COVID-19 period.

Levene's test verified the equality of the variances except one, namely remote medical consultation. With a p-value = 0.031, it is considered to be very satisfactory. The test proves that the absence of influence is erroneous, so gender is an influential factor in using ICT services (Martin & Bridgmon, 2012). Therefore, the null hypothesis is rejected, favouring the alternative hypothesis. Table 5 confirms the results obtained with the ANOVA test, with p and F values identical to those of the Levene's test in Table 4.

Table 4. Levene's test for gender (variance homogeneity by gender)

Service	Levene	Df_1	Df_2	Sig.
E-commerce	0.076	1	307	.783
Teleworking	1.145	1	307	.285
Vision Conference	0.106	1	307	.745
Cab application	0.055	1	307	.814
Carpooling	1.183	1	307	.278
Medical consultation	4.674	1	307	.031

The authors assumed that each gender has his/her own preferences for services, so a test was conducted to demonstrate this hypothesis (cross-tabulation). Before COVID-19, men and women preferred cab applications and e-commerce. The current disparities concern other services in second place; women's use is higher than men s; whereas, in the COVID-19 period, the order of preferences is almost the same for both genders, dominated by teleworking, e-commerce, and visual conferencing, where women's use remains higher. COVID-19 has greatly impacted the choice of ICT services (favouring those remotely) for both men and women. However, the Frequency of use is dominated by the female gender and, therefore, a greater awareness of the danger. *(Table 20, Appendix B).*

Table 5. One Way ANOVA test for gender

Service		Sum of squares	Df	Average square	F	Sig.
Medical consultation		4.161	1	4.161	4.674	.031

Residence Factor: Levene's Test (Non-Parametric)

Levene's test was used to determine the existence of a relationship between the location factor and the choice of services used during COVID-19. This test concerns the hypothesis of equality of variances, based on the unidirectional test of Kruskal Wallis. Therefore, two hypotheses are highlighted:

H_o Residence does not influence the type of ICT services used in the COVID-19 period.
H_1 Residence influences the type of services used during the COVID-19 period.

Table 6. ANOVA test for location

	Sum of squares	Df	Average square	F	Sig.
Intergroups	257178.439	3	85726.146	4.489	.004

The p-value is always referred to as "sig". There is only equality of variance Ho if the p-value is above the fixed threshold of 5%. The p-value is well below 5% (p-value = 0.004), which means that the test is satisfactory. It rejects the null hypothesis in favour of the alternative (retained) hypothesis: individuals' residence places influence their choice of ICT mobility services (Nordstokke & Zumbo, 2010; Nordstokke et al., 2011). The authors assumed that each residence category has its preferences for services, so a test was conducted to demonstrate this hypothesis (Table 20, Appendix B).

Disparities in the use of ICT mobility services according to the place of residence were observed. Before the pandemic, the further away a person was from downtown Algiers, the less use of taxi applications and e-commerce. While during the pandemic, this criterion is no longer valid because it is no longer a question of distancing oneself when using ICT services, but rather of favouring "remote" services and therefore no longer having to travel.

Status Factor: Pearson Chi-Square

A measure of association between the qualitative variables was chosen, namely cross-tabulation. It consists in crossing a variable (Status) with the variables of intelligent mobility services. The Pearson's chi-square value determined whether there is a relationship between the choice of service used and the status in times of health crisis. Thus, two hypotheses were formulated:

H_0 Absence of influence of COVID-19 on the choice of service use relating to the Status.
H_1 COVID-19 influences at least the use of one or more services (in particular) by Status.

Table 7. Cross-tabulation of Items with the status factor (Pearson Chi-square)

Service	Chi-square	Df	Asymptotic significance
E-Commerce	11.217	9	.121
Cab application	13.273	9	.119
Vision Conference	24.092	9	.002
Teleworking	30.414	9	.000
Carpooling	12.362	9	.191
Medical consultation	16.343	9	.031

For COVID-19 to not influence the choice of using ICT services over status, the Sig value (p-value) would have to be greater than the 5% value. Table 7 indicates that three ICT services are influenced by status during the COVID-19 period, namely teleworking (X2=30.414 and p-value=0.000), vision conferencing (X2=24.092 and p-value=0.002), and remote medical consultation (X2=16.343 and p-value=0.031). The null hypothesis H_0 is thus rejected, favouring the alternative hypothesis $H_{1,}$ which states that Status influences the choice to use ICT services during the COVID-19 crisis.

The authors assumed that each status group has preferences for services used before and during COVID-19. After the begging of the COVID-19 period, the authors note: the stable use of e-commerce in the G_1 (Student), G_2 (Worker), G_4 (Unemployed) groups, subscription of G_3 retirees (26.7% to 46.7%); teleworking, a preferred service by the G_1 (12.2% to 53.7%) and the G_2 (18% to 50,2%); vision conferencing, a service preferred by G_1 (7.7% to 59%) and G_4 (13% to 30.4%), G_2 (22.8% to 34.7%); remote medical consultation increased in all groups: G_1 (10% to 37.5%), G_2 (14.9% to 19.0%), G_3 (0% to 26.7%) and G_4 (20.8% to 37.5%).

Other services experienced a significant decrease in utilization, with Cab applications for all groups in G_1 (51.1% to 26.7%), G_2 (51.1% to 26.7%), G_3 (33.3% to 6.7%) and G_4 (65.2% to 8.7%); carpooling G_2 (16.7% to 7.3%) and G_3 (6.7 to 0%). COVID-19 had a double influence on the choice of services used by the statuses, positive by favouring teleworking for workers, conference viewing for students, e-commerce for the retired and unemployed, and negative for cabin applications. On the other hand, it did not affect the e-commerce service, whose use remains stable in times of crisis (Table 20, Appendix B).

Cross-Tabulations, Assessing the Impact of Mobility Restrictions During the Covid-19

Cross-Tabulation 1: Use of ICTs and Restriction on the Suppression of PT

Table 8. Crossover ICT Services (taxi application, carpooling) and public transport restriction

	Never used (%)		**Before COV19 (%)**		**During COV19 (%)**	
	No	Yes	No	Yes	No	Yes
Cab application	37.8	10.2	53.7	54.1	8.5	35.7
Carpooling	79.1	68.4	15.8	13.2	5.1	18.4

The authors crossed two ICT travel services with the public transport restriction variable to test their efficiency and see their influence on private car use. According to Table 8, 75.2% of individuals remain attached to their personal car. They reduced their application use (-45.2%) and carpooling (-10.7%) following COVID-19. While 24.8% of individuals who rely on public transportation reduced their use of the application (-18.4%) and increased their use of carpooling.

Restricting the suspension of public transport was effective but did not have the desired effect, as the displacements were not suppressed. The Algerians remain attached to their personal car, which is less risky than public transport in these times of crisis. The alternative of ICT was able to meet the needs of the Algiers population despite the circumstances and was able to minimise the propagation of the coronavirus.

*Cross-Tabulation 2: Intercity Travel Ban Restriction*PT Users*PV Users During COVID-19*

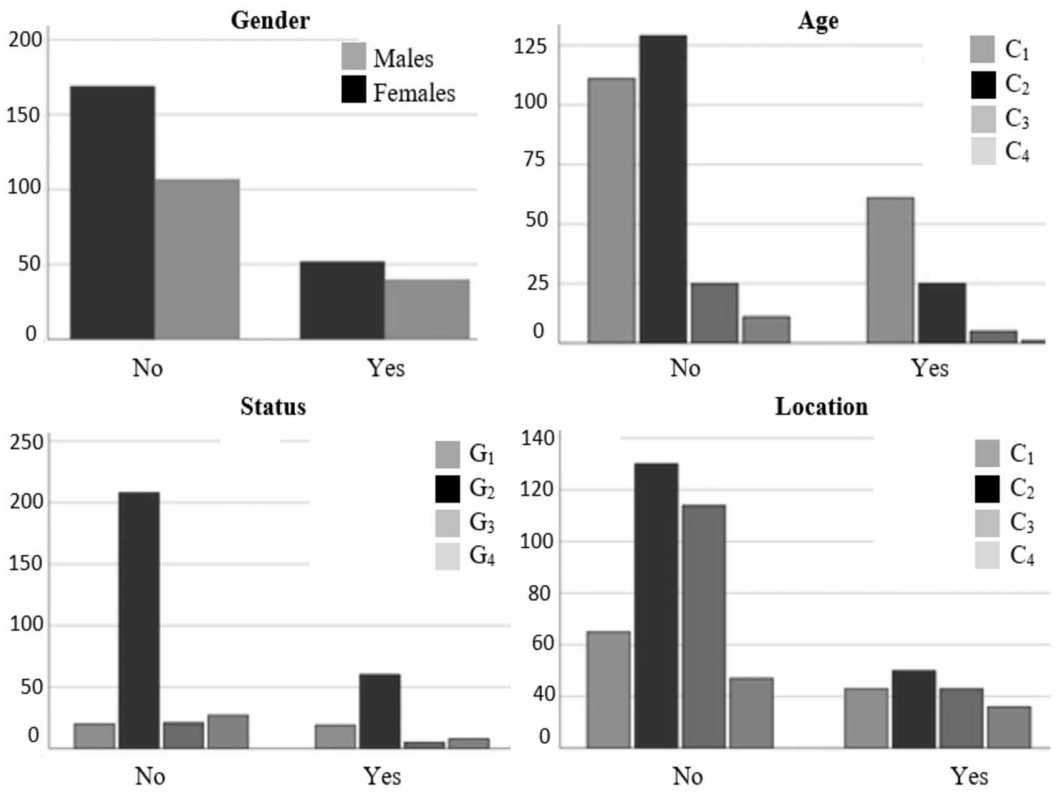
The authors affected a cross-tabulation to evaluate the effectiveness of the inter-city displacement restriction. It aims to understand citizens' of Algiers presumed and desired displacement motives during the period of confinement, to compare the effect of the restriction on people attached to their personal vehicle (PV) and those who depend on public transport (PT).

Among private car users, 61.9% were not affected by the inter-city restriction, compared with 36% of those who rely on public transport. Thus, the inter-city restriction was effective because if it had not been implemented, 63.2% of public transport users and 38.1% of private car users would have travelled and would have aggravated the number of cases, spreading the virus from city to city. Figure 2 indicates that the attachment to the private car during COVID-19 concerns more women than men, young people than older people, workers than other statuses and people living from 0 to 30 km from the centre of Algiers.

Table 9. Reasons for Desire to travel in restricted times inter-cities

	No %	Yes (reasons) %				Total %
		Professional	Medical	Family	Other	
PV%	61.9	15.6	0.9	17.3	4.3	100.0
PT%	36.8	22.4	2.6	35.5	2.6	100.0

Figure 2. Addiction to PV and dependence on PT (according to personal factors)



ICT EVALUATION

Influence of ICTs on the Travels (Displacements) of Algiers Population Before and During COVID-19

The T Paired test is appropriate to compare the same sample and the same services evaluated in two different periods (Table 19, Appendix B). The T-test shows that 83.4% of the respondents have used one or more of these means, while 16.6% have never used them. The use of many services increased during the COVID-19 survey: teleworking (16.8% to 46.3%), vision conferences (20.5% to 36%), and remote medical consultations (14% to 23.1%). The use of other services decreased, such as e-commerce (47.1% to 41%), taxi applications (53.8% to 16.3%), and carpooling (15.1% to 8.7%). Increased use of telecommuting, visual conferencing, and remote medical consultation is synonymous with safety and efficiency in times of crisis. In contrast to taxi and carpooling applications, which have experienced a significant decline, e-commerce, with a slight decrease, remains effective in all circumstances. Therefore, it can be noticed that the Algiers population prefers remote services in times of crisis.

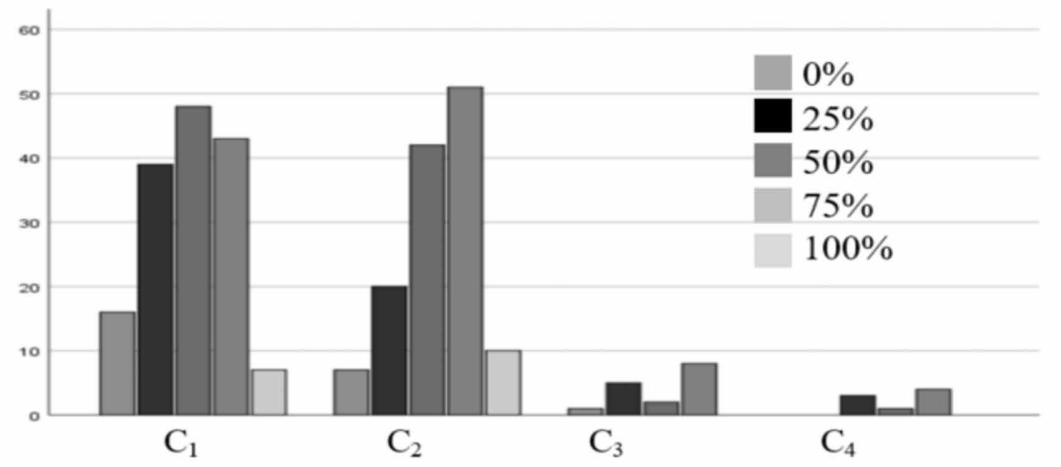
Cross-Tabulation 3: Likert Scale ICT Service Use and Percentage of Travel Suppression

Table 10. Travel reduction through ICT mobility services

	0%	25%	50%	75%	100%
N	24	67	93	106	17
%	7.8	21.8	30.3	34.5	5.5
Cumulative %	7.8	29.6	59.9	94.5	100

The effectiveness of intelligent mobility services was studied using the Likert scale (Table 10). Algiers' population has reduced its displacements between 50% and 75%. A cross-tabulation (Figure 3) was carried out between the Satisfaction and Age t variables to determine the age groups most satisfied with ICT services. The categories C_1=18/35 and C_2=35/55 have much more suppressed their displacements thanks to ICT, contrary to C_3 and C_4 (over 55). Therefore, young people use remote ICT services (without displacement) more frequently than older people.

Figure 3. Reduction and elimination of travel by Age



Likert Scale: Scoring ICT Mobility Services

An ordinal question using the Likert scale was used to rate qualitative data on intelligent mobility services according to Efficiency, Safety, Ease of use, Time-saving, Money-saving, Frequency of use, based on a numerical annotation ranging from 1=Not at all to 5=Excellent, ascending order scale.

Through the percentages and the weighted average of the answers, Algerians find the use of ICT services, Efficient (x = 3.31), Safe (x = 3.29), Easy to use (x = 3.49), and profitable over time (x = 3.49), on the other hand, not profitable in money (x = 2.26) and little-used (x = 2.62).

Table 11. Likert scale for scoring ICT mobility services

Class	1	2	3	4	5	Total	X±ET	Level
Efficiency	6.8	17.3	31.6	28.3	16.0	100.0	3.31±1.08	high
Security	6.8	17.3	31.6	28.3	16.0	100.0	3.29±1.13	high
Ease of use	5.9	12.1	28.0	35.2	18.9	100.0	3.49±1.11	high
Time-saving	7.5	10.7	26.4	35.8	19.5	100.0	3.49±1.14	high
Saving money	35.5	25.1	23.1	10.1	6.2	100.0	2.26±1.22	low
Frequency of use	17.6	29.6	31.6	15.3	5.9	100.0	2.62±1.12	low

Multiple Regression: Annotation of the Efficiency of ICT Services Among Algerians

A regression analysis was performed to analyse the association between the dependent variable used in this study (effectiveness of the ICT services) and several variables that can influence it (Security, Ease of use, Time-saving, Money-saving, and Frequency of use). Two hypotheses were formulated:

H_0 There is no relationship between the efficiency of ICT services and the independent variables.
H_1 There is a relationship between the efficiency of ICT services and the independent variables.

Table 12. Pearson correlation coefficient

	Security	Ease of use	Time-saving	Money-saving	Frequency use
Pearson Corr	.767	.762	.671	.403	.464
Sig	.000	.000	.000	.000	.000

A strong and highly significant Pearson's correlation exists between the dependent variable (Efficiency) and the three independent variables: Safety (0.767), Ease of use (0.762), and Time-saving (0.671). The other two, Money-saving (0.403) and Frequency of use (0.464), are moderately correlated but significant. All variables have a p-value = 0.00 £ 0.05. Then, the multicollinearity was verified between the variables (Tolerance and VIF) (Table 13).

There is multicollinearity between the variables only if the VIF value is higher than 10 (VIF Security = 2.467; $VIF_{Ease\ of\ use}$ = 2.661; $VIF_{Time\text{-}saving}$ = 2.309; $VIF_{Money\text{-}saving}$ = 1.233; $VIF_{Frequency\ of\ use}$ = 1.398), All the variables have a VIF lower than 10 which means that there is no multicollinearity between the variables, i.e., this allows to continue the analysis.

Two important measurements were made in the regression model. The correlation coefficient (R= 0.834) is very close to 1, which clearly indicates that the dependent variable is significantly related to the independent variables, and R^2 (coefficient of determination), which ranges from 0 to 1 at a minimum validation of 0.3, measures the quality of prediction of linear regression. The obtained R^2 (= 0.695) is well above the threshold, indicating a significant value for the independent variables

Table 13. VIF / Standardized Coefficients Beta, Student Test, and Significance Test

Model	B	Error	Bêta	t	Sig.	simple	Tolerance	VIF
Constant	.232	.126		1.839	.067			
Security	.364	.048	.381	7.616	.000	.767	.405	2.467
Ease of use	.349	.051	.357	6.863	.000	.762	.376	2.661
Time-saving	.104	.046	.110	2.268	.024	.671	.433	2.309
Saving money	.074	.032	.083	2.358	.019	.403	.811	1.233
Frequency	.049	.037	.051	1.349	.178	.464	.715	1.398

Table 14. Test of the R / R^2 and F of the file

R	R^2		R-square	Variation F	Df_1	Df_2	Sig. Variation F	Durbin-Watson
.834	.695	.60421	.695	137.011	5	301	.000	1.876

explain the efficiency at 69.5%. The variation in F is highly significant and equal to Fisher's F = 137.011 (Table 15), with a significance level of 0.000 (Excellent). Thus, the regression equation is very good, indicating that the five independent explanatory variables contribute very significantly to the scores of the dependent variable.

Table 15 summarizes the results of the analysis of the Beta standardized regression coefficients, the Student's test and the significance test. The results translate into: Security (β= 0.381^{3}0.3; t= 7,616; p-value= 0.000£ 0.05), Ease of use (β= 0.357^{3}0.3; t= 6,863; p-value= 0.000 £0.05), Time-saving (β= 0.110^{3}0.3; t= 2.268; p-value=0.024£0.05), Saving money (β=0.083^{3}0.3; t=2.385; p-value= 0.019£0.05), Frequency of use (β= 0.051 £ 0.3; t=1.349; p-value= 0.178^{3}0.05). Thus, it can be noted that Security and Ease of use have a significant positive effect on the effectiveness of the ICT services. H0 is therefore rejected in favor of H1. There is a strong relationship between the effectiveness of services and the variables (Security and Ease of use).

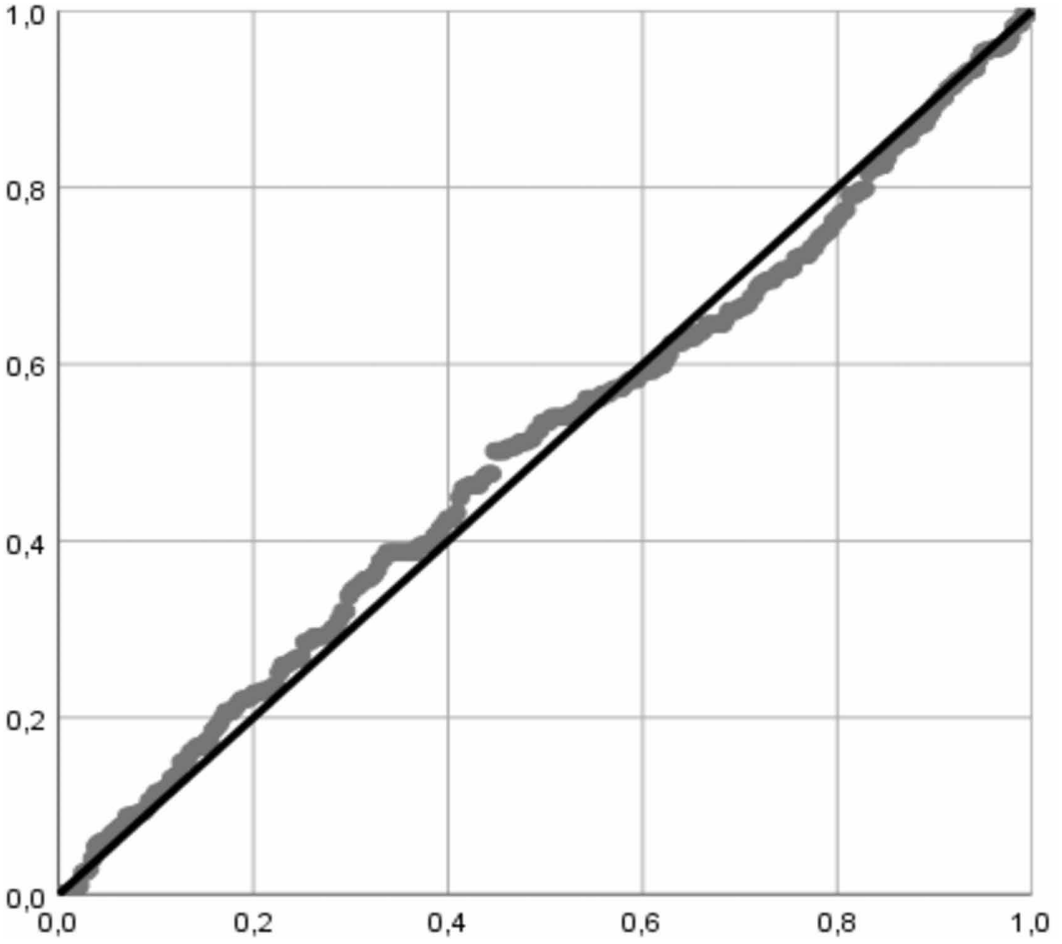
Table 15. Fisher's Test/ ANOVA

Model		Sum of squares	Df	Average square	F	Sig.
1	Regression	250.094	5	50.019	137.011	.000

As for the other variables, Time-saving and Money-saving have a small positive effect on the effectiveness of the ICT services. However, the value remains significant thanks to the p-value of (0.024&0.019). The Frequency of use does not seem to affect the effectiveness of the ICT services with a p-value higher than 5%. Thus, the effectiveness of the ICT services is completely independent of their Frequency of use.

Based on Table 14, the last Durbin-Watson box is examined to evaluate the correlation between residuals and errors; it varies between 0 and 4. This test invalidates or confirms the hypothesis of independence between residuals. In the best case, it will be between 1.5 and 2.5. In this case, it is 1.5£1.876£ 2.5 (excellent), but a graphical analysis must always confirm this result. The examination of the residuals shows a normal distribution without statistically too high values; thus, the prediction is valid and appropriate for all the answers (Figure 4).

Figure 4. Graphical analysis of residuals



CONCLUSION

This study aimed to assess the travel behaviour of the Algiers population before and during the COVID-19 period. The main objective was to highlight the influence of COVID-19 on travel and the influence on the choice of intelligent mobility services to cope with the pandemic, the latter having raised awareness of the population in terms of safety and hygiene. Several key findings emerge from the results obtained. First of all, public transportation (sustainable or not) has failed and shown its limits in the face of the COVID-19 pandemic. The latter highlighted the virtues of technology in terms of mobility; the possibility of ICTs not only accompanying and securing the journeys but also reducing or, better still, eliminating them. The authors' analysis of the travel rule in Algiers showed that personal factors such as (Gender, Age, Status, and Residence) influence the choice of ICT service used, whether before or during the COVID-19 pandemic. Differences in choice from one sex to another, from one age group to another, from one status to another, and from one location to another were observed, favouring remote services without human contact.

Next, the authors examined the restriction on public transportation and the influence of COVID-19 on travel service choice. Among the motorised means of transportation that are resistant to the pandemic, the results show that the private car, after having always been blamed, now happens to be the second safest means after ICT in terms of pandemic security. In Great Britain, walking,

cycling, and even private cars are being encouraged at the expense of public transport. Searching for a personal vehicle has increased dramatically, raising concerns about sustainability. In addition, from a safety point of view, it was assumed that people would avoid MaaS (Mobility as a Service), such as carpooling and booking cabs by application. Still, it turns out that only people attached to their personal car avoid this service. Unlike those affected by the CT suspension, this service is proving to be a solution in times of crisis, when it was thought that the sector would experience a difficult period. This has proven the effectiveness of the measures taken, such as abolishing public transport.

The pandemic has challenged everyone, young and old, men and women, to agree on the awareness and importance of reducing travel and the choice of ICT services used, given their effectiveness. This choice was related to Safety, Ease of use, Time and Money-Saving, and was independent of the Frequency of use. The influence of COVID-19 allowed varying the choices of Algiers population, from Cab applications to remote ICT services without human contact, namely Telework, Vision Conference, and Medical Consultation. E-commerce, on the other hand, has been able to withstand COVID-19 and remains just as used before and during the pandemic. It is considered the essential service in all circumstances to meet the primary needs of the Algerian population. It can be concluded that the restriction of the closure of businesses has been doubly beneficial. Not only has it reduced travel, but it has also mitigated the spread of the disease and has not handicapped the Algiers population. On the contrary, it has allowed testing e-commerce and its effectiveness with all age groups.

Moreover, as the epidemic has challenged the transport sector, the "Post-COVID-19 transport program" proposes new practices adapted to current conditions but, more importantly, are sustainable and capable of coping with future disasters. It would be more appropriate, like the Corona, to anticipate and consider a new transport rule that is resilient, studied, and adapted to past and future risks, and that should be an opportunity for progress toward sustainable development, supporting alternatives to the personal vehicle for development (bicycles, electric scooters, various ICT services up to walking with maps, and others; this could serve future employment opportunities. The document showed a way to analyse the impact of COVID-19 and the resulting change in the daily travel habits of Algerians and their use of ICT. Its influence is extreme, favouring ICT, a greater use of habituated people (mainly the young population), and adherence to the use of the senior category.

However, this study remains limited to the results obtained concerning the scale of the city of Algiers. The same study can have other results according to the location, the types of technologies available, and the population questioned. Furthermore, this study only considers personal factors and restrictions imposed by the State. Therefore other factors could serve as complementary research, such as psychological or economic factors, in an ideal world of gathering all the factors likely to influence the choice to use new mobility technologies. It would be more meaningful to study the post-COVID-19 period to assess the impact of travel changes (future contribution), complement the current research before and during COVID-19, and finally, make recommendations and proposals to leaders to improve the current transportation rule towards intelligence and resilience.

CONFLICT OF INTEREST

All the authors have no conflict of interest with the funding entity and any organisation mentioned in this article in the past three years that may have influenced the conduct of this research and the findings.

FUNDING AGENCY

The publisher has waived the Open Access Processing fee for this article.

REFERENCES

Abusaada, H., & Elshater, A. (2020). COVID-19 Challenge, information technologies, and smart cities: Considerations for well-being. *International Journal of Community Well-Being*. 10.1007/s42413-020-00068-5

Albino, V., Berardi, U., & Dangelico, R. M. (2015). Smart Cities: Definitions, Dimensions, Performance, and Initiatives. *Journal of Urban Technology*, *22*(1), 3–21. doi:10.1080/10630732.2014.942092

Aleta, A., & Moreno, Y. (2020). Evaluation of the potential incidence of COVID-19 and effectiveness of containment measures in Spain: A data-driven approach. *BMC Medicine*, *18*(1), 157. Advance online publication. doi:10.1186/s12916-020-01619-5 PMID:32456689

Anastassakos, I., & d'Aubigny, G. (1984). L'utilisation des tests de sphéricité pour la recherche de la dimension de l'espace latent en analyse factorielle classique et en analyse en composantes principales. *Revue de Statistique Appliquee*, *32*(2), 45–57.

Andale, S. (2017). *Kaiser-Meyer-Olkin (KMO) test for sampling adequacy*. Statistics How To.

Anzai, A., Kobayashi, T., Linton, N. M., Kinoshita, R., Hayashi, K., Suzuki, A., & Nishiura, H. (2020). Assessing the Impact of Reduced Travel on Exportation Dynamics of Novel Coronavirus Infection (COVID-19). *Journal of Clinical Medicine*, *9*(2), 601. doi:10.3390/jcm9020601 PMID:32102279

Audenhove, V., Korniichuk, F-J. O., Dauby, L., & Pourbaix, J. (2013). *The future of urban mobility 2.0*. Arthur D. Little.

Bacon, J., Beresford, A. R., Evans, D., Ingram, D., Trigoni, N., Guitton, A., & Skordylis, A. (2008). TIME: An Open Platform for Capturing, Processing and Delivering Transport-Related Data. *5th IEEE Consumer Communications and Networking Conference*, 687–691. doi:10.1109/ccnc08.2007.158

Bakour, M., Baouni, T., & Thevenin, T. (2018) La dépendance automobile à Alger: entre efficacité du système automobile et précarité du système de transport. RTS - Recherche Transports Sécurité, IFSTTAR, 2018,

Batty, M. (2020). The coronavirus crisis: What will the post-pandemic city look like? *Environment and Planning. B, Urban Analytics and City Science*, *47*(4), 547–552. doi:10.1177/2399808320926912

Baud, J.-P. (1981). Les hygiénistes face aux nuisances industrielles dans la première moitié du XIXe siècle. Revue Juridique de l'Environnement, 3, 205-220. doi:10.3406/rjenv.1981.1644

BBC NEWS. (2020). *Coronavirus: Wuhan Shuts Public Transport over Outbreak*. https://www.bbc.com/news/world-asia-china-51215348

Bonaccorsi, G., Pierri, F., Cinelli, M., Flori, A., Galeazzi, A., Porcelli, F., Schmidt, L., Valensise, C.-M., Scala, A., Quattrociocchi, W., & Pammolli, F. (2020). Economic and social consequences of human mobility restrictions under COVID-19. *Proceedings of the National Academy of Sciences of the United States of America*, *117*(27), 15530–15535. Advance online publication. doi:10.1073/pnas.2007658117 PMID:32554604

Careem. (2019). *Cab application*. https://www.android-dz.com/uber-careem-algerie/

Carroll, R. J., & Schneider, H. (1985). A note on levene's tests for equality of variances. *Statistics & Probability Letters*, *3*(4), 191–194. doi:10.1016/0167-7152(85)90016-1

Carte de couverture 3G/ 4G/ 5G. (2021). https://www.nperf.com/fr/map/DZ/-/32.Algrie-Telecom/signal/?ll=31.31610138349565&lg=3.6914062500000004&zoom=6

Cartenì, A., Di Francesco, L., & Martino, M. (2020). How mobility habits influenced the spread of the COVID-19 pandemic: Results from the Italian case study. *The Science of the Total Environment*, *741*, 140489. doi:10.1016/j.scitotenv.2020.140489 PMID:32599395

Center for Disease and Prevention. (2020). *2019 Novel Coronavirus, Wuhan, China*. https://covid.cdc.gov/covid-data-tracker/

Chicco, D., Warrens, M. J., & Jurman, G. (2021). The coefficient of determination R-squared is more informative than SMAPE, MAE, MAPE, MSE and RMSE in regression analysis evaluation. *Peer J. Computer Science, 7*, e623. <ALIGNMENT.qj></ALIGNMENT>10.7717/peerj-cs.623

Chinazzi, M., Davis, J.-T., Ajelli, M., Gioannini, C., Litvinova, M., Merler, S., Piotti, A. P. Y., Mu, K., Rossi, L., Sun, K., Viboud, C., Xiong, X., Yu, H., Halloran, M. E., Longini, I. M. Jr, & Vespignani, A. (2020). The effect of travel restrictions on the spread of the 2019 novel coronavirus (COVID-19) outbreak. *Science*, *368*(6489), 395–400. doi:10.1126/science.aba9757 PMID:32144116

Chun, B. T., & Lee, S. H. (2015). Review on ITS in smart city. *Advanced Science and Technology Letters*, *98*, 52–54. doi:10.14257/astl.2015.98.14

Colas, J. (2020). *Analyse de la regression: Comment interpreter le R-carré et évaluer l'adéquation de l'ajustement?* Comparili. https://comparili.net/

Connor, P. (2020). *More than nine-in-ten people worldwide live in countries with travel restrictions amid COVID-19*. https://www.pewresearch.org/fact-tank/2020/04/01/more-than-nine-in-ten-people-worldwide/

Costa, M. C. L. (2012). *Le discours hygiéniste et la mise en ordre de l'espace urbain de Fort- aleza, au Brésil. Histoire* (Ph.D. Thesis). Université de la Sorbonne Nouvelle - Paris III.

Coven, J., & Gupta, A. (2020). *Disparities in mobility responses to COVID-19*. Academic Press.

CREAD. (2021). *Covid-19: Plus de 10% des salariés estiment l'experience du télétravail "positive", on aps*. https://www.aps.dz/economie/124082-covid-19-plus-de-70-des-salaries-estiment-l-experience-du-travail-a-distance-positive

Daniel, A., Paul, A., Ahmad, A., & Rho, S. (2016). Cooperative Intelligence of Vehicles for Intelligent Transportation Systems (ITS). *Wireless Personal Communications*, *87*(2), 461–484. doi:10.1007/s11277-015-3078-7

De Vos, J. (2020). *The effect of COVID-19 and subsequent social distancing on travel behavior. Transp*. Res. Interdisciplinary Perspectives., doi:10.1016/j.trip.2020.100121

Dupuy, G. (2002). Cities and automobile dependence revisité: Les contrariétés de la densité. *Revue d'Economie Regionale et Urbaine*, *1*(février), 141–156. doi:10.3917/reru.021.0141

Etabib Award. (2020). https://etabib.dz/etabib-telemedecine/service-pro/

Faria, R., Brito, L., Baras, K., & Silva, J. (2017).Smart mobility: A survey. *International Conference on Internet of Things for the Global Community (IoTGC)*. doi: doi:10.1109/IoTGC.2017.8008972

Fornell, C., & Larcker, D.-F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *JMR, Journal of Marketing Research*, *18*(1), 39–50.

Ghazal, B., ElKhatib, K., Chahine, K., & Kherfan, M. (2016). Smart traffic light control system. *Third International Conference on Electrical, Electronics, Computer Engineering and their Applications (EECEA),* 140–145. doi: doi:10.1109/EECEA.2016.7470780

Ghorayeb, M. (2019). *La loi Cornudet, un urbanisme hygiéniste et social*. Droit et Ville.

Gopinath, G. (2020). *The great lockdown: Worst economic downturn since the great depression*. https://blogs.imf.org/2020/04/14/the-great-lockdown-worst

Gostin, L.O., & Wiley L. F. (2020). *Governmental public health powers during the COVID-19 pandemic: stay-at-home orders, business closures, and travel restrictions*. doi:10.1001/jama.2020.5460

Hadjidemetriou, G. M., Sasidharan, M., Kouyialis, G., & Parlikad, A. K. (2020). The impact of government measures and human mobility trend on COVID-19 related deaths in the UK. *Transportation Research Interdisciplinary Perspectives*, *6*, 100167. doi:10.1016/j.trip.2020.100167

Hafezi, M. H., Ismail, A., & Shariff, A. A. (2012). Comparative Analysis of Fare Collection System on Bus Operations. *Journal of Applied Sciences (Faisalabad)*, *12*(4), 393–397. doi:10.3923/jas.2012.393.397

Hanbury, M. (2020). *UK Grocery Chains Add Hundreds Of Thousands Of Delivery Slots For Online Orders But Admit That They Still Can't Keep Up With Demand.* Business Insider. https://www.businessinsider.com/tesco-ocado-sainsburys-cant-keep-up-with-surging-demand-amid-coronavirus-4?r=US&IR=T

Huawei 5G. (2021). https://www.gsma.com/spectrum/wp-content/uploads/2020/10/Roadmaps-for-awarding-5G-spectrum-in-the-MENA-region-French.pdf

Jagadeesh, Y. M., Suba, G. M., Karthik, S., & Yokesh, K. (2015). Smart autonomous traffic light switching by traffic density measurement through sensors. *International Conference on Computers, Communications, and Systems (ICCCS),* 123–126. doi: doi:10.1109/CCOMS.2015.7562885

Jiang, J., & Luo, L. (2020). Influence of population mobility on the novel coronavirus disease (COVID-19) epidemic: Based on panel data from Hubei, China. *Global Health Research and Policy*, *5*(1). Advance online publication. doi:10.1186/s41256-020-00151-6

Jolly, J. (2020). Airlines May Not Recover From COVID-19 Crisis For Five Years, Airbus. *The Guardian*. https://www.theguardian.com/business/2020/apr/29/airlines-may-not-recover-from-COVID-19-crisis-for-five-years-says-airbus

Kanda, W., & Kivimaa, P. (2020). What opportunities could the COVID-19 outbreak offer for sustainability transitions research on electricity and mobility? *Energy Research and Social Science, 68.*

Khanna, A., & Anand, R. 2016. IoT based smart parking system. *International Conference on Internet of Things and Applications (IOTA)*, 266–270. doi: doi:10.1109/IOTA.2016.7562735

Kim, H. Y. (2017). Statistical notes for clinical researchers: Chi-squared test and Fisher's exact test. *Restorative Dentistry & Endodontics*, *42*(2), 152–155. https://doi.org/10.5395/rde.2017.42.2.152

Klein, B., LaRocky, T., McCabey, S., Torresy, L., Privitera, F., Lake, B., Kraemer, M. U. G., Brownstein, J. S., Lazer, D., Eliassi-Rad, T., Scarpino, S. V., Chinazzi, M., & Vespignani, A. (2020). *Assessing changes in commuting and individual mobility in major metropolitan areas in the United States during the COVID-19 outbreak*. Paper Network Science Institute.

Kraemer, M. U. G., Yang, C., Gutierrez, B., Wu, C., Klein, B., Pigott, D. M., du Plessis, L., Faria, N., Li, R., Hanage, W. P., Brownstein, J. S., Layan, M., Vespignani, A., Tian, H., Dye, C., Pybus, O. G., & Scarpino, S. V. (2020). The effect of human mobility and control measures on the COVID-19 epidemic in China. *Science*, *368*, 493–497. doi:10.1126/science.abb4218

Kramer, A., & Kramer, K. Z. (2020). The potential impact of the COVID-19 pandemic on occupational status, work from home, and occupational mobility. *Journal of Vocational Behavior*, *103442*. Advance online publication. doi:10.1016/j.jvb.2020.103442

Lee, C., Han, Y., Jeon, S., Seo, D., & Jung, I. (2016). Smart parking system for Internet of Things. *IEEE International Conference on Consumer Electronics (ICCE)*, 263–264. doi: doi:10.1109/ICCE.2016.7430607

Liu, B., Jia, D., Lu, K., Chen, H., Yang, R., Wang, J., Barnard, Y., & Wu, L. (2017). Infrastructure-Assisted Message Dissemination for Supporting Heterogeneous Driving Patterns. *IEEE Trans. Intell. Transp. Syst., 18*(10), 2865-2876. doi: 10.1109/INFCOMW.2017.8116389

Liu, S., Kong, G., & Kong, D. (2020). Effects of the COVID-19 on air quality: Human mobility, spillover effects, and city connections. *Environmental and Resource Economics*. Advance online publication. doi:10.1007/s10640-020-00492-3

M3aya. (2019). *M3aya carpooling application*. https://m3aya.com/dz

Martin, W. E., & Bridgmon, K. D. (2012). Quantitative and statistical research methods: From hypothesis to results. Wiley.

MelyaGo. (2019). https://www.melyago.com/#/

Michau, G., Nantes, A., Bhaskar, A., Chung, E., Abry, P., & Borgnat, P. (2017). Bluetooth Data in an Urban Context: Retrieving Vehicle Trajectories. *IEEE Trans. Intell. Transp. Syst*. doi: 10.1109/TITS.2016.2642304

Mishra, P., Singh, U., Pandey, C. M., Mishra, P., & Pandey, G. (2019). Application of student's *t*-test, analysis of variance, and covariance. *Annals of Cardiac Anaesthesia*, *22*(4), 407–411. https://doi.org/10.4103/aca.ACA_94_19

Möller, D. P. F., Fidencio, A. X., Cota, E., Jehle, I. A., & Vakilzadian, H. (2015). Cyber-physical smart traffic light system. *IEEE International Conference on Electro/Information Technology (EIT)*, 546–551. doi: doi:10.1109/EIT.2015.7293395

Monks, P. (2020*). Coronavirus: Lockdown's effect on air pollution provides rare glimpse of lowcarbon future*. https://theconversation.com/coronavirus-lockdowns-effect-on-air-pollution-provides-rare-glimpse-of-low-carbon-future-134685

Musselwhite, C., Avineri, E., & Susilo, Y. (2020). Editorial JTH 16 the Coronavirus Disease COVID-19 and implications for transport and health. *Journal of Transport & Health*, *16*, 100853.

Nadeem, T., Dashtinezhad, S., Liao, C., & Iftode, L. (2004). TrafficView: Traffic data dissemination using car-to-car communication. *ACM SIGMOBILE Mob. Comput. Commun. Rev.*, *8*(3), 6–19.

Nader, B. (2013). Levy. A. Ville, urbanisme et santé: les trois révolutions. *Pollution atmosphérique, 219.* http://lodel.irevues.inist.fr/pollutionatmospherique/index.php?id=2376

Nawaz, S., Efstratiou, C., & Mascolo, C. (2016). Smart Sensing Systems for the Daily Drive. *IEEE Pervasive Computing*, *15*(1), 39–43.

Nordstokke, D. W., & Zumbo, B. D. (2010). A new nonparametric Levene test for equal variances. *Psicológica, 31*(2), 401-430.

Nordstokke, D. W., Zumbo, B. D., Cairns, S. L., & Saklofske, D. H. (2011). The operating characteristics of the non-parametric Levene test for equal variances with assessment and evaluation data. *Practical Assessment, Research & Evaluation*, *1*(5). Advance online publication. doi:10.7275/5t99-zv93

Nroho. (2013). https://nroho.com/

ONS (Office National des Statistique). (2011). *Parc national automobile. Bulletin statistique N°618.*

Orfeuil, J. P. (2001). *Problèmes politiques et sociaux: dossiers d'actualité mondiale. N°851-852 février*. Documentation Française.

Organisme National du Contrôle Technique des Travaux Publics. (2006). Étude de trafic sur les 110 carrefours stratégiques d'Alger. Author.

Oztig, L. I., & Askin, O. E. (2020). Human mobility and COVID-19: A negative binomial regression analysis. *Public Health*. Advance online publication. doi:10.1016/j.puhe.2020.07.002

Peters, A. (2020). *This tool is helping cities find the neighborhoods most vulnerable to coronavirus.* From Fast Company. https://www.fastcompany.com/90481120/this-tool-is-helping-cities-find-the-neighborhoods

Peterson, R. A., & Kim, Y. (2013). On the relationship between coefficient alpha and composite reliability. *The Journal of Applied Psychology*, *98*(1), 194–198.

Pham, T. N., Tsai, M. F. D., Nguyen, D. B., Dow, C. R., & Deng, D. J. (2015). A Cloud-Based Smart-Parking System Based on Internet-of-Things Technologies. *IEEE Access: Practical Innovations, Open Solutions*, *3*, 1581–1591. doi:10.1109/ACCESS.2015.2477299

Rahm, P. (2020). *Corona virus ou le retour à la normale.* AOC. https://aoc.media/opinion/2020/03/09/coronavirus/

Saha, J., Barman, B., & Chouhan, P. (2020). Lockdown for COVID-19 and its impact on pupil mobility in India: An analysis of the COVID-19 Community Mobility Reports. *Children and Youth Services Review*, *105160*. Advance online publication. doi:10.1016/j.childyouth.2020.105160

Salama, S. M. (2020). Coronavirus questions that will not go away: Interrogating urban and socio-spatial implications of COVID-19 measures. *Emerald Open Research, 2*(14). doi:10.35241/emeraldopenres.13561.1

Sasidharan, M., Singh, A., Torbaghan, M. E., & Parlikad, A. K. (2020). A vulnerability-based approach to human-mobility reduction for countering COVID-19 transmission in London while considering local air quality. *The Science of the Total Environment*, *140515*. Advance online publication. doi:10.1016/j.scitotenv.2020.140515

Schober, P., Boer, C., & Schwarte, L. A. (2018). Correlation Coefficients. *Anesthesia and Analgesia*, *126*(5), 1763–1768. doi:10.1213/ane.0000000000002864

Shaikh, F. i., Jadhav, P. N., Bandarkar, S. P., Kulkarni, O. P., & Shardoor, N. B. (2016). Smart Parking System Based on Embedded System and Sensor Network. *International Journal of Computers and Applications*, *140*(12). Advance online publication. doi:10.5120/IJCA2016909532

Smith, G., Sochor, J., & Karlsson, I. C. M. (2018). Mobility as a Service: Development scenarios and implications for public transport. *Research in Transportation Economics*. Advance online publication. doi:10.1016/j.retrec.2018.04.00

Stevis-Gridneff, M., & Pérez-Peña, R. (2020). Europe Barricades Borders to Slow Coronavirus. *New York Times.* https://www.nytimes.com/2020/03/17/world/europe/EU-closes borders-virus.html

TemTem. (2019). *Cab application*. https://temtem.taxi/business.html

The Straits Times. (2020). *Coronavirus: How Some Countries Are Keeping-Or Not Keeping-People Indoors*. https://www.straitstimes.com/world/coronavirus-how-some-countries-are-keeping-or-not-keeping-people-indoors

Thiolliere, F., Ledochowski, S., Reynaud, B., Wallet, F., Schaff, B., Bohe, J., Piriou, V., & Lepape, A. (2016). Mesure de la culture sécurité: Utilisation du Safety Attitudes Questionnaire en réanimation (SAQ-ICU). *Anesthésie and Réanimation.*, *2*(3), 146–154.

Trigona, C., Andò, B., Sinatra, V., Vacirca, C., Rossino, E., & Palermo, L., kurukunda, S., & Baglio, S. (2016). Implementation and characterisation of a smart parking system based on 3-axis magnetic sensors. *IEEE International Instrumentation and Measurement Technology Conference Proceedings*. doi: doi:10.1109/I2MTC.2016.7520379

Ungoed-Thomas, J. (2020). Vegetable Seed Sales Shoot Up As The Nation Digs For Victory During The Coronavirus Crisis. *The Times.* https://www.thetimes.co.uk/article/vegetable-seed-sales-shoot-up-as-the-nation-digs-for-victory-during-the-coronavirus-crisis-39kzgtdnc

Warren, M. S., & Skillman, S. W. (2020). *Mobility changes in response to COVID-19*. https://arxiv.org/abs/2003.14228

Wellenius, G., Vispute, S., Espinosa, V., Fabrikant, A., Tsai, T., Hennessy, J., Williams, B., Gadepalli, K., Boulanger, A., Pearce, A., Kamath, C., Schlosberg, A., Bendebury, C., Stanton, C., Bavadekar, S., Pluntke, C., Desfontaines, D., Jacobson, B., Armstrong, Z., … Gabrilovich, E. (2020). *Impacts Of State-Level Policies On Social Distancing In The United States Using Aggregated Mobility Data During The COVID-19 Pandemic.* https://arxiv.org/abs/2004.10172

Wilson, M. (1995). Travel and the emergence of infectious diseases. *Emerging Infectious Diseases*, *1*, 39–46.

World Health Organization. (2020). *Novel Coronavirus China*. https://www.who.int/csr/don/12-january-2020-novel-coronavirus-china/en/

Yassir. (2019). *Cab application*. https://yassir.com/en/home/

Zhang, C., Chen, C., Shen, W., Tang, F., Lei, H., Xie, Y., Cao, Z., Tang, T., Bai, J., Xiao, L., Xu, Y., Song, Y., Chen, J., Guo, Z., Guo, Y., Wang, X., Xu, M., & Zou, H. (2020). Impact of population movement on the spread of 2019-nCoV in China. *Emerging Microbes & Infections*, 1–28. doi:10.1080/22221751.2020.1760143

Zhu, Y., Xie, J., Huang, F., & Cao, L. (2020). The mediating effect of air quality on the association between human mobility and COVID-19 infection in China. *Environmental Research*, *189*. Advance online publication. doi:10.1016/j.envres.2020.109911

APPENDIX A - QUESTIONNAIRE

Opinion survey on the theme of smart mobility during the COVID-19 period, city of Algiers. The survey targets all the age groups of people living in Algiers, working there or going there for various reasons.

I. Individual interviewee data

1. Gender:
Female
Male
2. *Age*:
18/35 years old
35/55 years old
55/65 years old
£65 years old
3. Place of residence:
Algiers downtown 0-10 km from downtown
10-30 km from downtown £ 30 km from downtown
4. Status:
*S*tudent
Worker
Retired
Unemployed

II. COVID-19, Practices to improve or even avoid travel through new (ICT)

5. Have you ever used these practices (online shopping, delivery, telecommuting, video conferencing, carpooling, Cab application, remote medical consultation)?
Yes
No
6. How do you deal with these new practices?

Table 16. How do you deal with these new practices?

	Never used	Before COVID-19	During COVID-19
E-commerce			
Teleworking			
Vision Conference			
Cab Application			
Carpooling			
Medical consultation			

7. Record your experience using new ICT-related practices (1 to 5).
8. As a result of the new ICT, to what extent have you reduced your travel during COVID-19?
0% 25% 50% 75% 100%
9. Were you among those affected by the elimination of public transport services
No, I've always been attached to my car Yes

Table 17. Record your experience using new ICT-related practices (1 to 5)

	Security	Ease of use	Time-saving	Money-saving	Frequency use
Note					

10. Are you affected by the new restriction on travel between cities? If so, on what grounds?
No Yes, professional reason
Yes, medical reason Yes, family reason

APPENDIX B - TABLES AND COMPARISONS OF FACTORS INFLUENCING THE CHOICE OF ICT SERVICE USE

Age: C_1=18-35 years old, C_2=35-55 years old, C_3=55-65 years old, C_4=More than 65 years old
Gender: Females, Males.
Location: C_1=Downtown of Algiers, C_2=0-10 km from Downtown of Algiers, C_3= 10-30 km from Downtown of Algiers, C_4= More than 30 km from Downtown of Algiers.

Table 18. Sample distribution by personal characteristics (gender, age, location, status)

Topic	Class	Frequencies	(%)	Total
Gender	Females	221	60.1	100%
	Males	147	39.9	368
Age	C_1= 18/35 years	172	46.7	100%
	C_2= 35/55 years	154	41.8	
	C_3= 55/65 years	30	8.2	368
	C_4= More than 65 years	12	3.3	
Status	C_1= Student	39	10.6	
	C_2= Worker	268	72.8	100%
	C_3= Retired	26	7.1	368
	C_4= Unemployed	35	9.5	
Residence	G_1= City centre of Algiers	68	18.5	
	G_2= 0-10 km of centre of Algiers	140	38.0	100%
	G_3= 10-30 km of centre of Algiers	117	31.8	368
	G_4= More than 30 km of centre of Algiers	43	11.7	

Table 19. ICT use in mobility before and during the COVID-19 period (cross-tabulation)

	Yes %		No %		Total %	
	83.4		**16.6**		**100.0**	
	E-commerce	Tele working	Vision Conference	Cab Application	Carpooling	Medical consultation
Never used	11.9	36.9	43.5	29.9	76.2	62.9
Before C19	47.1	16.8	20.5	53.8	15.1	14.0
During C19	41.0	46.3	36.0	16.3	8.7	23.1

Table 20. Distribution of Items (cross-tabulation) for determining user preferences in relation to personal

	Before C19 (%)				During C19 (%)				P
1. Services / Age	**C_1**	**C_2**	**C_3**	**C_4**	**C_1**	**C_2**	**C_3**	**C_4**	
E-commerce	46.2	48.8	50	25.0	39.8	43.5	37.5	25.0	.000
Teleworking	13.3	20.8	12.5	25.0	49.1	47.2	25	12.5	.000
Vision Conference	17.4	24.8	6.25	37.5	44.3	31.0	12.5	0.0	.000
Cab Application	54.5	55.6	43.7	25.0	21.9	10.6	6.25	12.5	.000
Carpooling	16.8	15.2	6.25	0.0	12.3	4.5	0.0	14.3	.000
Medical consultation	13.8	15.3	6.25	12.5	22.5	22.6	31.3	25.0	.000
2. Services / Gender	**Female**		**Male**		**Female**		**Male**		
E-commerce	47.5		46.6		42.2		39.0		.000
Teleworking	17.3		16.0		49.0		42.0		.000
Vision Conference	20.1		21.2		38.7		31.8		.000
Cab Application	54.8		52.2		16.2		16.4		.000
Carpooling	10.6		22.3		9.0		7.4		.000
Medical consultation	16.0		11.0		26.8		17.3		.000
3. Services/Location	**C_1**	**C_2**	**C_3**	**C_4**	**C_1**	**C_2**	**C_3**	**C_4**	
E-commerce	49.2	47.1	47.2	43.6	42.4	43.1	39.4	35.9	.000
Teleworking	11.3	17.2	18.0	20.0	50.9	44.0	45.9	48.6	.000
Vision Conference	17.5	20.3	21.4	23.5	49.1	35.3	32.1	29.4	.000
Cab Application	59.7	59.7	7.2	40.0	22.6	15.1	13.0	20.0	.000
Carpooling	19.2	10.6	7.3	19.4	3.8	11.4	5.8	12.9	.000
Medical consultation	18.5	16.4	10.4	9.1	24.1	21.1	23.6	27.3	.000
4. Services / Status	**G_1**	**G_2**	**G_3**	**G_4**	**G_1**	**G_2**	**G_3**	**G_4**	
E-commerce	40.0	49.3	26.7	46.4	42.2	40.0	46.7	46.4	.000
Teleworking	12.2	18.0	20.0	9.1	53.7	50.2	6.7	13.6	.000
Vision Conference	7.7	22.8	26.7	13.0	59.0	34.7	6.7	30.4	.000
Cab Application	51.1	54.4	33.3	65.2	26.7	15.7	6.7	8.7	.000
Carpooling	13.2	16.7	6.7	8.7	18.4	7.3	0.0	8.7	.000
Medical consultation	10.0	14.9	0.0	20.8	37.5	19.0	26.7	37.5	.000

Status: G_1= Student, G_2= Workers, G_3= Unemployed, G_4= Retired.

HYBRID FIGURES AND COMPARISONS OF FACTORS INFLUENCING THE CHOICE OF ICT SERVICE USE

Table 21. Definition of tests

Tests	Explanation
Levene	Levene's Test of Equality of Variances is used in SPSS to assess meeting the statistical assumption of **homogeneity of variance** in between-subjects designs. Levene's Test of Equality of Variances is a simple statistical test to interpret. If the ***p***-value associated with Levene's test is **LESS THAN .05**. (Carroll & Schneider, 1985).
One Way Anova	Analysis of variance (ANOVA) can determine whether the means of three or more groups are different. ANOVA uses F-tests to statistically test for equality of means (Colas, 2020)
R/R^2	The Pearson linear coefficient of determination, noted R2 or r2, measures the quality of linear regression prediction (Chicco, Warrens & Jurman., 2021).
Pearson correlation	Use the Pearson correlation coefficient to examine the strength and direction of the linear relationship between two continuous variables. The correlation coefficient can range in value from −1 to +1. The larger the absolute value of the coefficient, the stronger the relationship between the variables. An absolute value of 1 indicates a perfect linear relationship for the Pearson correlation. A correlation close to 0 indicates no linear relationship between the variables (Schober, MedStat; Boer, Schwarte &Lothar, 2018).
Beta Coefficient	The beta coefficients are the regression coefficients obtained if you first center-reduce all the variables to obtain for each one a mean equal to 0 and a standard deviation equal to 1. Thus the advantage of the beta coefficients (as opposed to the B coefficients, which are not center-reduced) is that the magnitude of these beta coefficients allows you to directly compare the relative contribution of each independent variable to the prediction of the dependent variable (Riou, Landaisz, 1998).
Student Test	It is one of the most popular statistical techniques used to test whether the mean difference between two groups is statistically significant. The null hypothesis stated that both means are statistically equal, whereas the alternative hypothesis stated that both means are not statistically equal. They are statistically different from each other. (Mishra, Singh, Pandey, Mishra, & Pandey, 2019).
Fisher Test	Fisher's exact test is practically applied only in analyzing small samples, but it is valid for all sample sizes. While the chi-squared test relies on an approximation, Fisher's exact test is one of the exact tests. Especially when more than 20% of cells have expected frequencies < 5, we need to use Fisher's exact test because applying the approximation method is inadequate (Kim, 2017).

Figure 5. Hybrid age model of ICT use before and during COVID-19

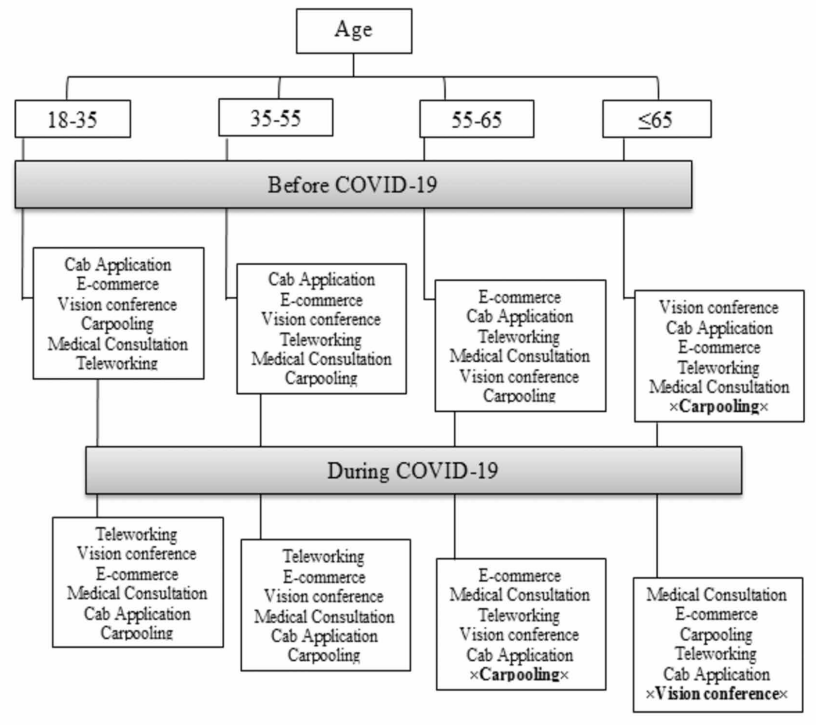


Figure 6. Hybrid gender model of ICT use before and during COVID-19

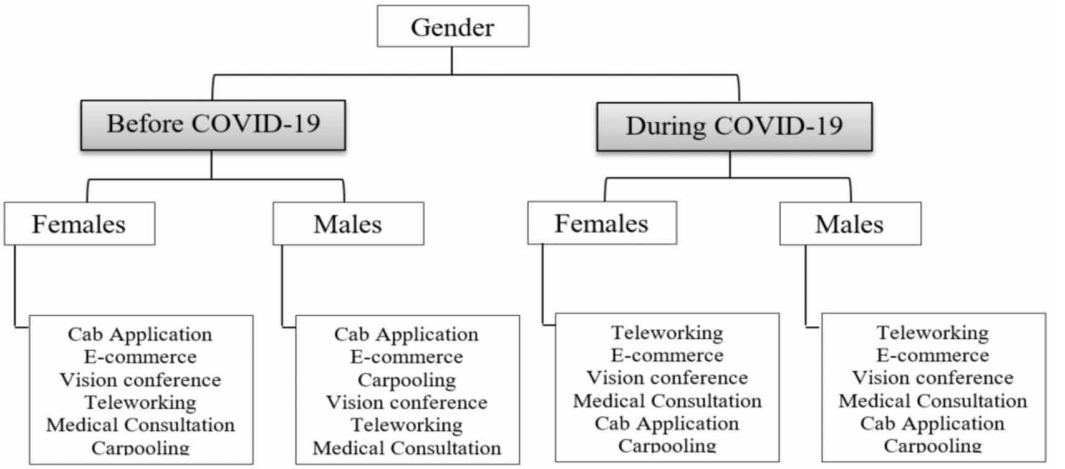


Figure 7. Hybrid location model of ICT use before and during COVID-19

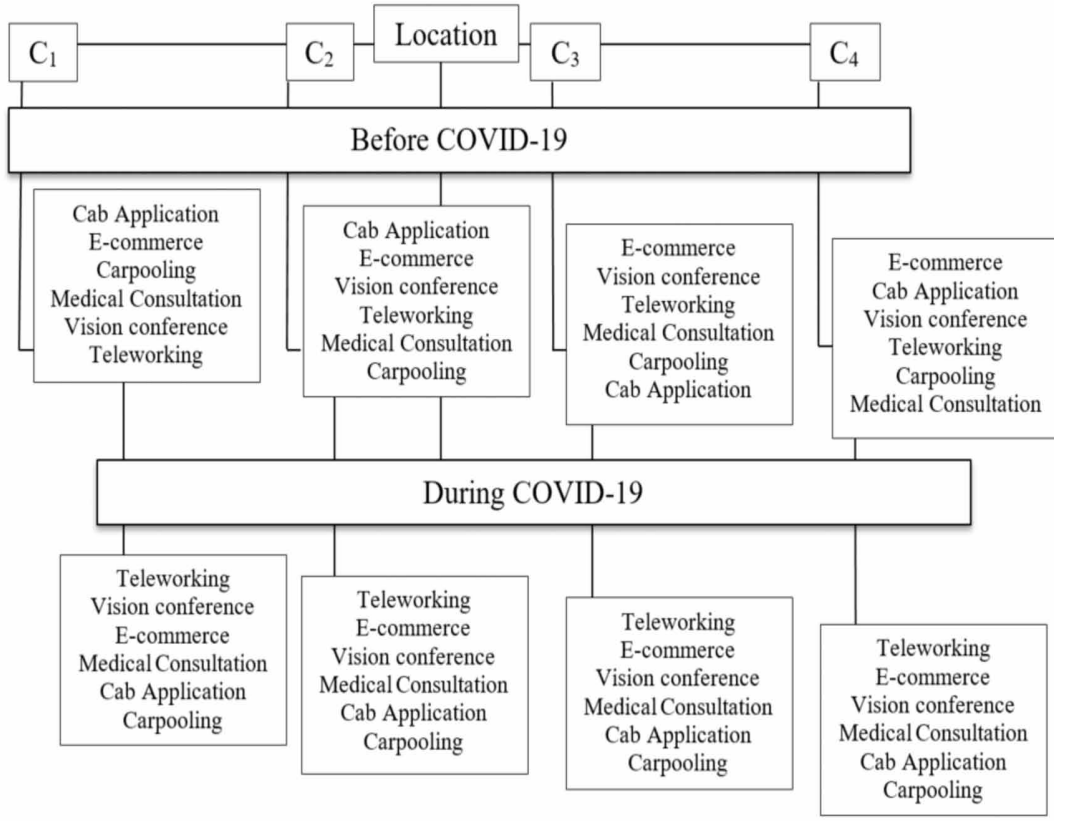


Figure 8. Hybrid status model of ICT use before and during COVID-19

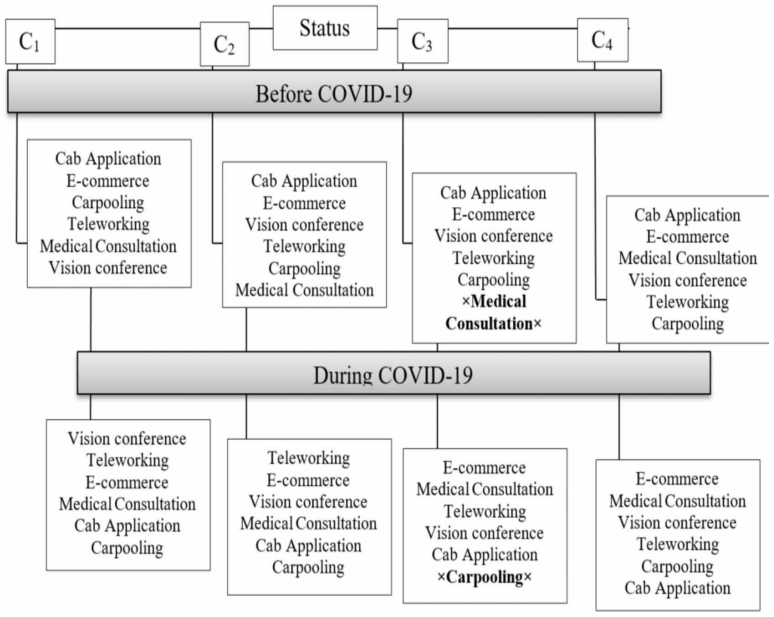


Figure 9. A hypothetical search model