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Could Technology and Intelligent Transport Systems Help Improve Mobility in an Emerging Country? Challenges, Opportunities, Gaps and Other Evidence from the Caribbean

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Abstract: Apart from constituting a topic of high relevance for transport planners and policymakers, support technologies for traffic have the potential to bring significant benefits to mobility. In addition, there are groups of "high potential" users, such as young adults, who constitute an essential part of the current market. Notwithstanding, and especially in low and middle-income countries (LMICs), their knowledge and acceptance remain understudied. This study aimed to assess the appraisal of intelligent transport systems (ITS) and other technological developments applicable to mobility among Dominican young adults. Methods: In this study, we used the data gathered from 1414 Dominicans aged between 18 and 40, responding to the National Survey on Mobility in 2018 and 2019. Results: Overall, and although there is a relatively high acceptance, attributed value, and attitudinal predisposition towards both intelligent transportation systems and various support technologies applicable to mobility, the actual usage rates remain considerably low, and this is probably exacerbated by the low and middle-income status of the country. Conclusions: The findings of this study suggest the need to strengthen information and communication flows over emerging mobility-related technologies and develop further awareness of the potential benefits of technological developments for everyday transport dynamics.

Keywords: technology; mobility; intelligent transport systems; perception; low and middle-income countries; Dominican Republic

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1. Introduction

Intelligent transportation systems (ITS) can be understood as the set of applications, devices, and technological systems that facilitate traffic management, control, and monitoring [1,2]. Among their multiple advantages, ITSs contribute to improving users' safety [3], traffic flows [4], and trip-related decisions [5]. In practical terms, this means minimizing congestion, reducing pollution, and (equally important) enhancing mobility as a potentially positive and safe experience [6,7].

There is great variability of ITS systems that have been applied on roads around the world for some years [8]. Intelligent mobility enables connection between vehicles (V2V) and between vehicles and infrastructure (V2I) [9]. Thus, the number of transport means equipped with devices capable of detecting risks and facilitating driving maneuvers for drivers keeps rising [10]. In addition, many urban areas have also incorporated electronic devices, such as cameras or smart traffic lights, helping cities enforce traffic laws and protecting vulnerable road users [11,12].

In addition, ITSs are already present in the market through products, such as advanced driving assistance systems (ADAS) and autonomous cars, both useful to minimize human errors during driving and improve overall road safety [13,14]. Therefore, at the user level, a great acceptance of technologies applied to traffic among their potential consumers

could be expected. However, recent studies suggest that opinions, intentions, and usage willingness of ITSs could be rather split, especially among users who currently have minute information about them [15].

1.1. New Technologies in Traffic: A Socially Challenging Issue?

In general, emerging technologies in mobility are well-valued by most of the existing studies on traffic safety [16], with young men being the population group expressing the most positive opinions [17]. Specifically, the most highly valued aspects are safety improvements [18], reduced traffic congestion and travel time [19], amenities for the elderly and/or physically challenged [20,21], environment and fuel savings [22,23], and other miscellaneous benefits [24,25].

However, several studies have pointed out that the geographic provenance of their users could be the main factor affecting the assessment of ITS systems [26,27]. Namely, people living in highly industrialized countries with high rates of economic wealth are favorable to the inclusion of traffic-related technology. In contrast, people living in emerging countries, where the evidence is scarce, have been implied to remain more reluctant [26]. Enhanced by many social disparities, one of the factors influencing these gaps might be the current unequal penetration of information and communication technologies (ICTs) among different countries.

Precisely, one of the regions that seems more affected by these issues is the Caribbean, whose countries are in the lower-middle zone of the world ranking, which reflects the number of households with internet access [28]. In contrast, this list is headed mainly by European and Asian countries [29]. Conversely, almost all the existing studies conducted in low and middle-income countries (LMICs) show a lower predisposition to accept and use advanced support technologies in traffic [27,30]. Some of the main constraints commonly expressed by users from LMICs are the fear of potential cybersecurity issues or system failures [31], personal data treatment [32], a feeling of excessive monitoring [33,34], and environmental concerns [35].

From a theoretical point of view, different approaches have been developed to understand interpersonal differences in the degree of acceptance of technology. Initially, Schifter and Ajzen (1985) developed the theory of planned behaviour (TPB) [36], which shows that the intention to behave, modulated by attitude and subjective norm, may be the best behavioral predictor. A few years later, Davis (1989) proposed the technology acceptance model (TAM) [37], in which perceived ease of use and perceived usefulness are hypothesized to directly influence attitudes towards technology and, consequently, the intention to use it. Overall, both TPB and TAM models agree on the imperative need for users to have a positive attitude and value a certain behavior as necessary steps to increase its likelihood. However, to the best of our knowledge, these assumptions have never been tested in this region, specifically regarding support technologies for mobility.

1.2. Study Context: The Case of the Dominican Republic

In recent years, the Dominican Republic has made significant progress in the traffic and road safety sector [38]. Specifically, with the creation of the National Institute of Transit and Land Transportation (INTRANT) in 2017, multiple measures have been developed to improve traffic efficiency and reduce crash rates in the country [39]. Concretely, many advances have been observed in terms of transport policy, infrastructural advancements, road safety communication, and a progressive improvement of the automotive fleet [40,41].

Notwithstanding, crash rates continue to be among the highest in the world [42], partly due to the low adherence to policymaking outcomes and the many other social problems relatable with everyday transport dynamics [43]. In addition, the Dominican population, as in other Latin American countries, such as Brazil, Jamaica, and Colombia, tends to privilege private vehicles over massive transport, explaining an abruptly large increase in the use of motorcycles [43,44], precarious small-sized public transport means [45], and other low-cost everyday solutions [46,47].

In this regard, previous studies suggest that bringing people closer to transport-related technology (applicable to everyday mobility) would be helpful to face many of the common threats affecting the Dominican population, starting with young segments of the population, given their greater positive attitudes, experiences and capabilities to interact with ICTs and ITSs [17,38,48]. Although the current developments in this regard are still considerably scarce, it is worth mentioning that, to date, some first technology-related advances for improving transport dynamics are taking place, especially with the implementation of local mobile applications development by the government to improve the mobility of vehicles, as well as a progressive modernization of accessibility and payment methods in public transport (e.g., biometric devices and contactless payment systems) [45,49].

1.3. Study Aim

Bearing in mind the aforementioned considerations, this study aimed to assess the appraisal of intelligent transport systems and other technological developments applicable to mobility among Dominican young adults (aged between 18–40). In this regard, it was hypothesized that this segment of the population would attribute a high degree of value to ITSs and other supporting technological developments for traffic settings, even though demographic factors might modulate these appraisals.

2. Materials and Methods

2.1. Participants

This nationwide study used the information provided by 1411 young adult Dominicans between 18 and 40 years of age. These participants were divided into two samples. The first (n = 661) was gathered in the 2018 national survey on mobility, and the second (n = 753) corresponded to the national survey of 2019, allowing us to make comparisons on the state of affairs in this regard between the two different years (Table 1). As an important issue to be remarked, a sample for the year 2020 could not be gathered due to the COVID-19 pandemic.

Table 1. Sociodemographic characteristics of the two study sub-samples.

Factor	Value	2018		2019	
		n	**%**	***n***	**%**
Gender	Man	308	46.6%	375	49.8%
	Woman	353	24.1%	378	50.2%
	Total	661	100%	753	100%
Habitat	Urban	502	75.9%	611	81.1%
	Rural	159	24.1%	142	18.9%
	Total	661	100%	753	100%
Job situation	Unemployed	138	21.1%	286	38%
	Full-time job	389	56.7%	328	43.3%
	Part-time job	134	20.3%	148	19.7%
	Total	661	100%	753	100%
Driving status	Licensed	236	35.7%	311	41.3%
	Not licensed	425	64.3%	442	58.7%
	Total	661	100%	753	100%

The data used for this study were gathered using a stratified random sampling method. Therefore, distribution was proportional to the population, according to the ONE (National Statistics Office of the Dominican Republic) census, by age, sex, habitat, and province, as shown in Table 1. Regarding sample size, the minimum number of participants was determined to be n = 385 for each year, assuming a confidence level of 95%, a maximum margin of error of 5% (alpha = 0.05), and a beta of 0.20, in order to achieve statistical representativeness. In addition, the sampling characteristics are similar to those employed

by previous empirical road safety research in the country [47–49]. Personal data were managed in accordance with current data protection laws, and respondents participated voluntarily and anonymously.

2.2. Design, Procedure and Instruments

As aforementioned, the data used for this study were directly obtained from the National Mobility Survey of the Dominican Republic in 2018 [50] and 2019 [51]. The questionnaire consisted of several blocks of questions that explored citizens' perceptions of various traffic, mobility, and road safety issues. Among these addressed topics were: private and public transport, mobility on foot and by bicycle, knowledge of institutions and traffic laws, and communication campaigns developed in the Dominican Republic. In addition, there was a specific section for the knowledge and valuation of mobility-related technology, focused on ICTs and ITS systems, whose results are discussed in this paper.

The questionnaire was administered through personal interviews. The data collection process was carried out using a CAPI (computer-assisted interviewing) system on recorded and geo-referenced tablets to reduce interviewing time and avoid errors in the recording of data.

To achieve the proposed objectives, the following variables were considered:

- Sociodemographic variables and driving data: sex, age, working situation, habitat, frequency of driving.
- Knowledge of intelligent transportation systems: questions were asked using a dichotomic scale (Yes/No): "Do you know what ITS systems are?"; "Do you know what Smart Mobility is?"; and "Do you know what Smart Cities are?".
- Perceptions about technology on traffic: A Likert scale from 0 to 10 was used for the following questions: "To what extent do you consider that technology (in general) can be useful for the improvement of mobility?"; "To what extent do you consider mobile apps as useful for the improvement of mobility?"; and "To what extent do you consider ITS systems as useful for the improvement of mobility?"
- Use of mobile apps during urban trips: a generic question was asked about the use of apps with two answer options (yes/no), as well as an open question specifying which apps are used. The degree of belief that apps could encourage the use of public transport and the degree to which they could improve traffic and mobility in the Dominican Republic were also evaluated through a Likert scale from 0 to 10.
- As environmental affairs have been acquiring growing importance in mobility and technology-related improvements, a complementary question was included asking for participants' self-reported degree of environmental concern, using a scale ranging from 0 to 10 (see Figure 1).
- Individuals' willingness to use different means of transport (i.e., private means, public transport, or walking) to perform their everyday trips was assessed through a Likert scale from 0 to 10.
- Finally, the importance given to ten different features of intelligent transport systems (e.g., 'traffic information'; see Figure 2 for full list) was assessed through a scale ranging from 0 to 10.

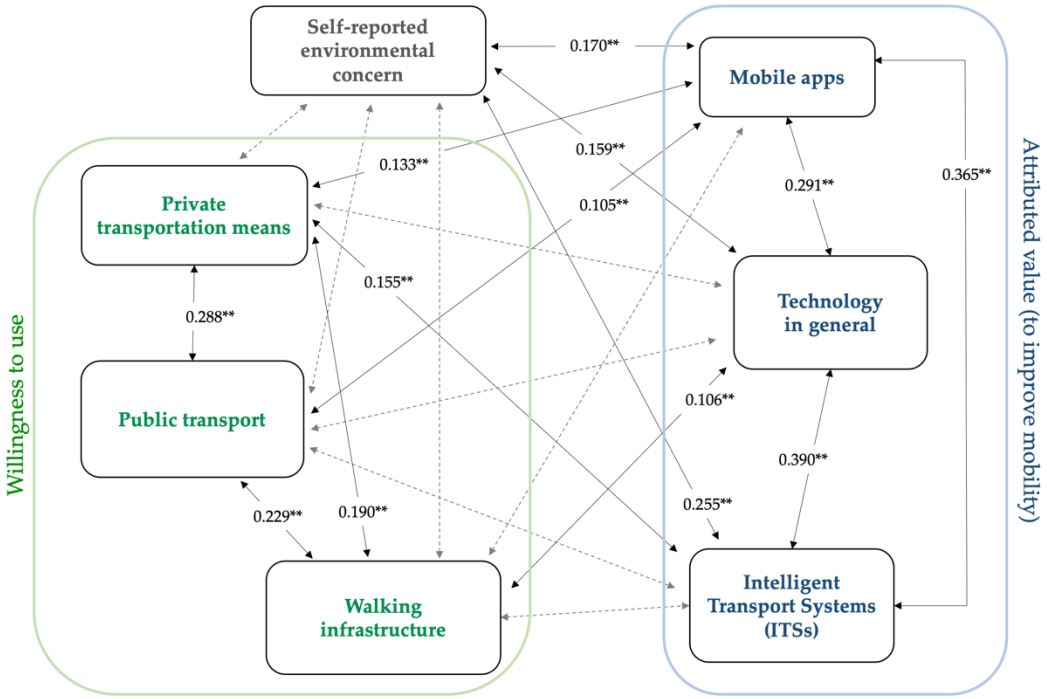

Figure 1. Correlation networks: Pearson's bivariate associations. *Notes:* ** Correlation is significant at the level $p < 0.010$.

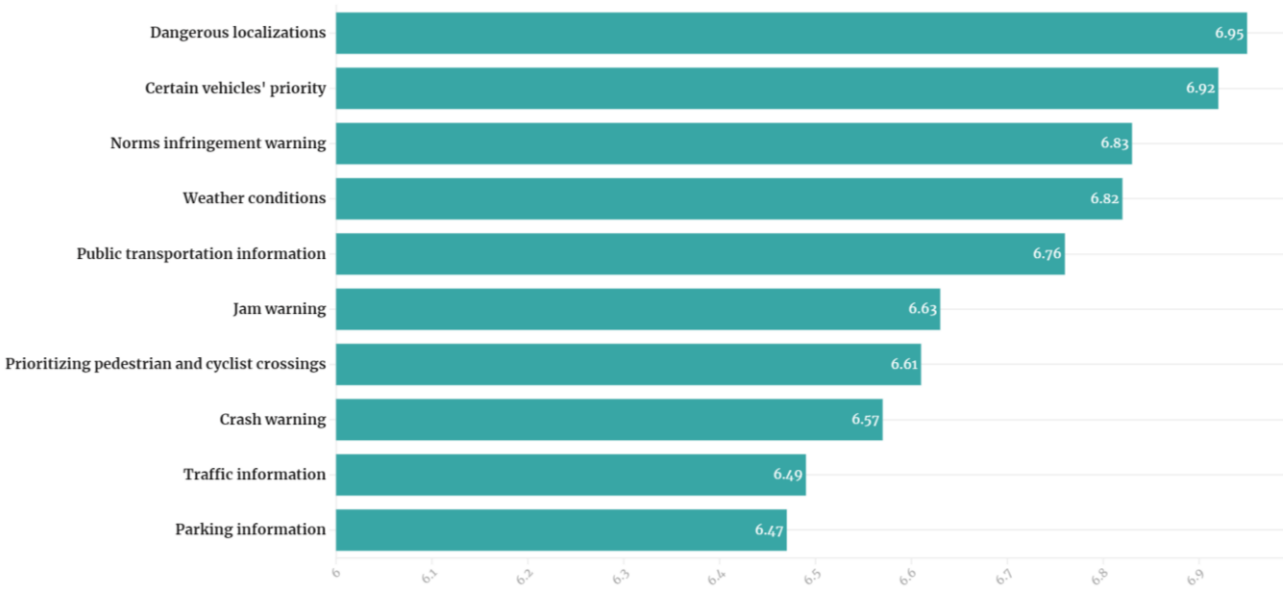

Figure 2. Priority of the use of ITS systems according to Dominican citizens.

2.3. Data Processing

This study aimed to describe and characterize the amount of knowledge of ITS systems held by Dominican individuals through descriptive analysis. ANOVA and chi-square tests were also used to determine how the variables changed over time between the two surveys. Pearson correlations and their corresponding graphical network representations have also been performed to establish possible statistical relations among the analyzed variables. All the statistical tests performed used differential significance level criteria of $p < 0.050$, $p < 0.010$, and $p < 0.001$. IBM SPSS (Statistical Package for Social Sciences) version 26.0 (Armonk, NY, USA) was used to perform all statistical analyses.

2.4. Ethics

The Ethics Committee of Research in Social Science in Health of the University of Valencia was consulted before the study. It confirmed that the research met general ethical criteria and agreed with the Declaration of Helsinki (IRB approval number: HE0001251019). After the team gave them a detailed description of the research goal and all preceding considerations, participants consented to participate in the study.

3. Results

Overall, the descriptive results of this study show how the self-reported knowledge of intelligent transport systems remained relatively scarce on the part of young Dominicans in both 2018 and 2019. Despite this, a statistically significant increase in the number of people who claim to know about ITS is observed in this short period of time, being 4.2% in 2018 and 8.2% in 2019 (Table 2).

Table 2. Level of knowledge and perception of ITS systems.

		2018		2019			
		%	*n*	%	*n*	Chi^2	*p*	Phi
ITS systems knowledge	Yes	4.2%	28	8.2%	62	$Chi^2_{(1)} = 9.439$	0.002	−0.082
	No	95.8%	633	91.8%	691			

	2018			2019				
	X	SD	*n*	X	SD	*n*	ANOVA	*p*
Valuation of technology (in general) as something useful for the improvement of traffic?	7.41	2.42	661	8.03	2.84	753	$F_{(11,412)} = 18.953$	<0.001

Another interesting finding was the fact that only 3% of participants reported having an awareness of the concept of "Smart Cities" and 4.7% of Smart Mobility. In regard to their valuation of the usefulness of technological improvements for traffic dynamics, young Dominican adults reported similar average values (M = 7.41; SD = 2.42 for 2018 and M = 8.03; SD = 2.84 for 2019), with a slight but still statistically significant increase between these two years, as also shown in Table 2.

3.1. Correlation Analyses

Another issue worth exploring was the set of associations among technological, environmental, and transport-related issues, as perceived by Dominicans. As this is a bivariate procedure, the correlation network presented in Figure 1 graphically depicts the relationships between pairs of them. In brief, some interesting outcomes stand out:

Firstly, and regarding the bivariate relationships between technology-related affairs and environmental concerns, it was found that participants' assessments on (i) technology in general; (ii) apps; and (iii) ITSs for traffic improvement are all positively (and significantly) correlated with their self-reported degree of environmental concern.

Secondly, it was found that technology-related perceptions were associated to a certain extent with participants' willingness to use different means of transportation:

(a) The value attributed to mobile apps for improving mobility was positively correlated to individuals' willingness to use public and private transport means, although not with the intention of using walking infrastructure to perform their daily trips.
(b) On the other hand, the overall valuation of technology for mobility was correlated to usage willingness only in the case of walking trips.
(c) Finally, the value attributed to intelligent transport systems for improving mobility was positively associated with the willingness of individuals to use public transportation, but not with their intention to travel either by private means of transport or walking.

3.2. Which ITS Features Are More Important for Young Dominicans?

As aforementioned, ITS systems were overall valued as positive for improving urban mobility (M = 6.49; SD = 2.76). In this sense, examining the differential level of acceptance of various of their core features seems relevant.

Overall, the most highly rated ITS features were: (i) detection of dangerous locations (M = 6.95; SD = 2.60); and (ii) priority pass for certain vehicles (ambulances, emergency vehicles, public transport, etc.) (M = 6.92; SD = 2.61). On the other hand, the lowermost rated ITS features were parking information (M = 6.47; SD = 2.40) and traffic information (M = 6.49; SD = 2.51).

3.3. Valuation and Usage Level of Mobile Apps in Urban Trips

Participants' valuation of mobile applications both in everyday life and as a tool for invigorating mobility improvement showed a relatively good assessment, as shown in Table 3. Overall, and following the aforementioned [0–10] scale, mobile apps' relevance for everyday life was scored with an M = 7.22/10 in 2018, while this mean value increased to M = 7.49/10 for the year 2019, the difference being significant, and its trend of an increasing nature.

Table 3. Level of perception and use of mobile apps for the improvement of mobility.

Value Attributed to Apps		**2018**			**2019**					
		X	**SD**	***n***	**X**	**SD**	***n***	**ANOVA**		***p***
For enhancing everyday life		7.22	2.59	661	7.49	2.94	753	$F_{(11,412)}$ = 3.370		0.067
For improving mobility		7.34	2.61	661	7.72	3.04	753	$F_{(11,412)}$ = 6.341		0.012
		2018			**2019**					
		%		***n***	**%**		***n***	**Chi^2**	***p***	**Phi**
Use of mobile apps as a support for urban trips	Yes	13.6%		86	23.0%		173	$Chi^2(1)$ = 23.359	<0.001	0.129
	No	86.4%		575	77%		580			

Secondly, a similar trend was found in regard to the value attributed to mobile apps for enhancing mobility, with a significant increase between 2018 (M = 7.34/10) and 2019 (M = 7.72/10), showing a growing appreciation and perceived usefulness among applications potentially applicable to the traffic environment.

However, and despite this relatively high rating of mobile applications on mobility, their usage level remains scarce for 2019, even though there has been a significant increase of almost 10% in the number of people using them during their urban trips (see Table 3).

Finally, it is worth depicting that the mobile apps relatable to mobility had the highest frequency of use. Figure 3 shows the most used applications, among which those related to navigation, maps, and routes stand out.

Although a very small proportion of respondents (up to 23%) reported having a minimum degree of mobility-related app usage, it is worth remarking that: (i) this trend is, in any case, rising, and (ii) there was a slight increase in the use of apps related to active transportation, from 0.3% in 2018 to 0.5% in 2019.

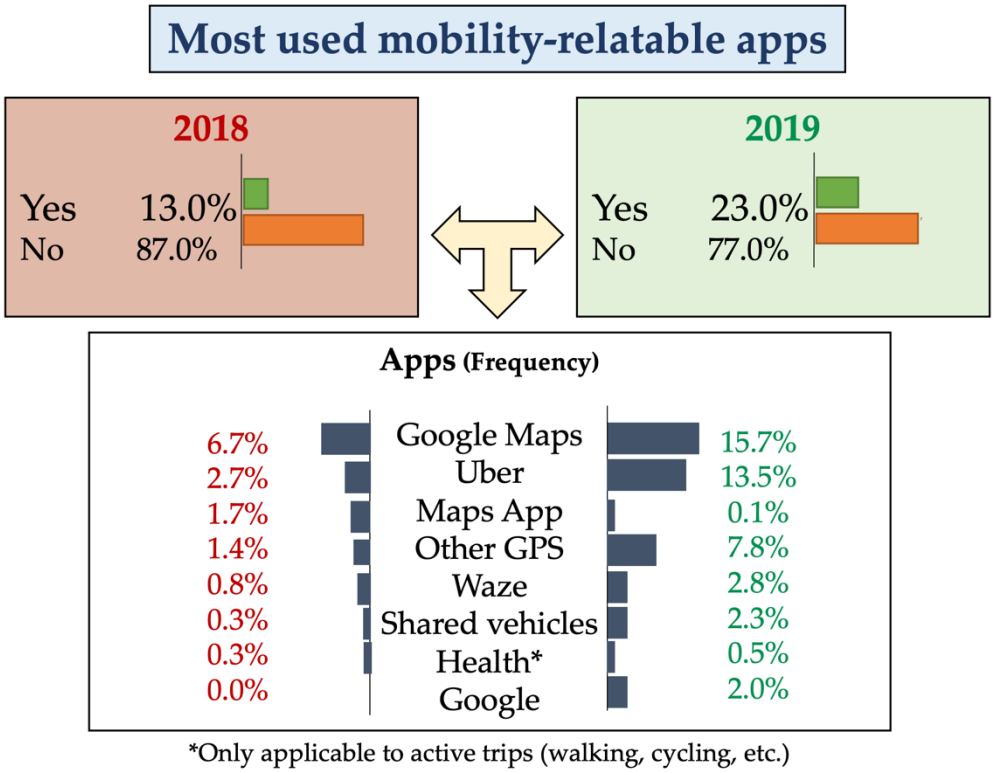

Figure 3. Most commonly used apps during urban trips (absolute frequency).

4. Discussion

The core aim of this study was to assess the appraisal of intelligent transport systems and other technological developments applicable to mobility among Dominican young adults (aged between 18–40). Overall, the findings show that there is a relatively high acceptance, attributed value, and attitudinal predisposition. However, the actual usage rates remain considerably low, probably exacerbated by the Low and Middle-Income status of the country.

Despite the relatively low knowledge and usage rates, it is remarkable how awareness of ITS is starting to increase, especially considering several benefits they may imply for both road users and transportation dynamics, ranging from the minimization of traffic jams in urban areas and the reduction of gas and waste pollutants in cities to the prevention of traffic crashes [5,6].

Further, and apart from assessing the self-reported knowledge of a key segment of the Dominican population about ITS systems, it is worth addressing their social perception of the importance of technology for mobility, as well as various potential specific spheres, including those related to mobile apps and connected devices [52].

This growing understanding of technology benefits for mobility could be hypothesized to help enhance potential ITS applications in the country. However, it seems necessary to keep strengthening relevant issues remarked by preceding literature about technology consumption on traffic, such as perceived usefulness, attitudes, safety improvements and personal data management [16,36,37,53]. Thus, the practical value of this research is contributing to the understanding of the current perceptions and beliefs of young Dominicans regarding new technologies and their application for traffic, mobility, and road safety. The conclusions obtained will serve as a starting point for the development of social awareness measures and policies.

4.1. Social Perception of the Role of Technology for Traffic and Mobility Improvement

As described before, self-reported knowledge of ITS systems was rather scarce among Dominicans, as well as other related concepts, such as ‘smart mobility’ and ‘smart cities’.

Previous studies agree on the prevalence of this panorama across several Latin American countries, despite the important role of Information and Communication Technologies (ICTs) in the growth of these territories [54].

For instance, research conducted in Colombia exposes the growing misinformation and number of misbeliefs surrounding the aforementioned concepts [55], even though government lines of action revolve around digitization and technological innovation [56]. Similar conclusions can be drawn from the implementation of some ITS systems in Brazil, where the role of users and institutions in the specific technological adaptation to the problems of each region is emphasized [57,58].

In contrast, supportive technological systems for mobility already count on a considerably high (and still increasing) acceptance in countries from other regions, principally Europe and Asia. In these contexts, a strong satisfaction with these systems is usually reported, as a good part of the population reports perceiving everyday mobility-related and quality of life improvements as a result of these advances [59]. Despite the evident contextual and income-related differences, it can be hypothesized that increasing community involvement, participation, and individual responsiveness for the correct functioning of ITS systems might increase their acceptance, valuation, and future use [60].

In this regard, differences in the degree of knowledge of ITS systems have been stated as closely linked to the digital (income-based) gap between territories [61]. While in developed countries, the majority of people have access to electronic devices, digital media and the internet, low and middle-income countries (LMICs) still tend to report a very low digitization rate. According to the data, only between 6–7 out of 10 Dominicans have an internet connection [62], placing them very far from high-income countries (HICs), where this index usually reaches 90% of people [63]. Notwithstanding, and more as a potentially positive scenario, the Digital Agenda 2030 for the Dominican Republic has been recently approved with the aim of promoting a digital, open, and participatory society in which connectivity, cybersecurity, and digital accessibility of the population could be improved in several fields, including transport and mobility [27,64].

4.2. Present and Future: Traffic Management and Environmental Sustainability

Apart from being considerably favourable, the valuation of new technologies applied to mobility, ITSs, and mobile apps has also been significantly associated with having a greater concern about environmental issues [65]. In other words, the people considering environmental issues as relevant problems for the country were the ones who best perceive the benefits that digital tools can bring to the traffic environment.

Indeed, the reality is that the Dominican Republic has concerningly high rates of pollution, and this can be an attractive opportunity to change this challenging state of affairs [66]. In recent years, the renovation of vehicles to reduce emissions has been boosted. However, currently, more than 52% of the country's vehicle fleet is composed of vehicles older than 10 years, which produce excess polluting gases [67]. This situation, together with the dynamics of Dominican commuting, does not favour the reduction of emissions produced by transportation. A large part of the population travels by private vehicle, with very few people opting for bicycles or walking for their regular trips [38,50,51]. Therefore, ITS systems that manage and regulate traffic and public transport could be very beneficial for the environment. Their implementation would reduce traffic jams in urban areas and minimize the time spent commuting, with a direct impact on the country's pollution rates [68]. To complement this measure, it would be highly recommended to improve the conditions of sidewalks and pedestrian areas to encourage travel by non-polluting means of transport.

Transport dynamics can also explain the relationships between other variables. Thus, the degree of public transport use is related to the perception of how much a traffic application can contribute to mobility. At the same time, the greater use of private transport is also related to the prioritization of ITS systems. Thus, frequent drivers consider the implementation of certain ITS services to be more urgent.

4.3. Perceived Value and Usage of Mobile Apps in Mobility

Although the use of applications while travelling is relatively low, it has grown substantially in the short, analyzed period of time. Therefore, it is expected that this positive trend will continue in the coming years, especially with the increase in the acquisition of mobile devices by the population.

The main applications used are related to maps and route settings. There is, in any case, a small percentage using active transport-related apps, especially those useful to strengthen walking and cycling trips, something that could be used in favor of public health improvements in the mid- and long-term, even though their distracting potential should also be considered [69–71].

Additionally, and significantly linked to other potentially helpful technological advances for enhancing urban mobility, the role of emerging trends in transportation should be considered, such as the globally growing use of micromobility [72]. Although its market share is still minimal (estimated to be <4%), partly as a result of the low-income status of the country and the lack of infrastructural adequation for it, the potential improvements that these trends could bring for enhancing transport dynamics in the region (as well as their 'side effects') remain to be seen.

Changes in citizens' travel habits should be promoted with concrete measures and initiatives ranging from reducing the prices to improving infrastructure and public vehicles. Once these adjustments have been made, it is more likely that citizens will be able to use the application to the fullest extent of its functionalities. In this way, the applications and other technological factors can act as enablers of change in the transportation dynamics of Dominicans.

5. Conclusions

This study shows how there is a relatively high acceptance, attributed value, and attitudinal predisposition towards both intelligent transportation systems (ITS) and various support technologies applicable to mobility. However, their actual usage rates remain considerably low, probably enhanced by the low and middle-income status of the country.

Further, these findings suggest the need to strengthen information and communication flows over emerging technologies, as several gaps remain present, even though a slight increase in knowledge, acceptance, and engagement on mobility-related applications and other technologies has been observed between the years 2018 and 2019.

In practical settings, this research can contribute to understanding technology-related perceptions, beliefs, and practices and their potential applications for traffic, mobility, and road safety. This will be particularly relevant to increasing users' awareness, knowledge, and confidence on the matter, favoring their potential application to improve transportation dynamics, quality of life, and traffic safety in the country.

Author Contributions: S.A.U., F.A. and M.F. conceived and designed the research, and performed the data collection; M.F. analyzed the data; F.A., M.T.T. and S.A.U. contributed with reagents/materials/analysis tools; M.T.T. contributed with paper revisions; M.F. and S.A.U. wrote and revised the paper. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: Both data collection phases of this study were conducted according to the guidelines provided by the Declaration of Helsinki and approved by the Ethics Committee of Research in Social Sciences in Health" from the Institute on Traffic and Road Safety at the University of Valencia, Spain (IRB numbers HE0001251018—25 October 2018, and HE0002130519—5 May 2019).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data will be available upon reasonable request to the corresponding author.

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Conflicts of Interest: The authors declare that there are no conflict of interest or potential disclosures.

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