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Article

Smartphone App Usage Patterns for Trip Planning Purposes and Their Stated Impacts in The City of Bhopal, India

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Abstract: With considerable growth in the Information & Communication Technologies, several smartphone-based mobility platforms have already sprung up and they have the potential of transforming the mobility ecosystem completely. However, mobility-based smartphone app usage pattern across various user groups in Indian cities is unknown, and this knowledge is vital for introducing new consolidated apps-based services. Therefore, using primary data from a survey carried out in Bhopal (India), this article analyses the usage pattern of smartphone apps for trip planning activities and travel outcomes across various user groups at the personal and household level. The research offers empirical indication of relationships between smartphone app usage for trip planning (like departure time, choosing a destination, choosing the mode, se-lecting route, communicating, and coordinating trips, and performing tasks online instead of visiting) and resulting travel outcomes including vehicle kilometers travelled (for purposes like work/education, shopping, and recreation), social gathering, new place visits and group trips. The chi-square test has been used to test and interpret several socioeconomic variables that could in-fluence this relationship, such as gender, age, income, etc. This study's findings provide important behavioral insights that may be useful in policy discussions.

Keywords: Smartphone Apps; Trip Planning; App Usage; Travel Outcomes

1. Introduction

The information and communication technologies (ICTs) are now becoming more widely available, most especially in the form of mobile phones. In India, there are 85 mobile phone connections for every 100 persons, according to latest statistics and the use of mobile phones has increased exponentially over the past decade [1]. Mobile phones have also transformed from essential communication tools into robust information, communication, sensing, and entertainment devices called Smartphones. Nearly 24% of Indians own smartphones [2]. Although it is slower than many emerging economies, smartphone ownership has been growing at a healthy rate [3] due to the push provided by the Government of India toward creating digital infrastructure and digital literacy through the Digital India initiative. This initiative aims to facilitate the high-paced penetration of mobile connectivity, not just in large urban centres but also in medium to smaller towns and distant villages [4] and the availability of low-cost/refurbished smartphones. Given that 81 percent of internet users in India access the internet through their smartphones, these smartphones represent a crucial means of accessing the internet [5].

One of the most significant innovations is smartphone enabled applications, or 'Apps'. These apps provide fast access to previously unavailable transportation-related information, including real-time data in some circumstances, allowing users to make better educated mobility decisions. Apps are being used more frequently by users for a variety of transportation use cases. More people are beginning their trips with their smartphones to plan out their routes, find out when the next bus, train, or metro will de-

part, get a taxi, or find a private driver using services provided by app-based cab aggregators. As a result, developed nations now have an ecosystem of smartphone-enabled mobility services known as Mobility-as-a-Service (MaaS), which is a service that incorporates many modes of transportation into a single app. An example is 'Whim' in Helsinki (Finland) which allows users to plan and pay for trips involving public transportation, bike-sharing, taxis, and car-sharing. When one starts Whim, there is no longer a need to switch between apps because everything is there to be used immediately. This single app has driven users towards multimodality, and they are shifting towards sustainable mobility patterns [6]. Since then, such platforms have either already been deployed or are under trial in many cities across the world.

The Indian government unveiled its flagship initiative, the "Smart Cities Mission," in 2015 with the goal of creating 100 sustainable and citizen friendly Indian cities. These cities are intended to bring together and incorporate the best technologies that the market has to offer for an urban infrastructure that is highly connected and technology friendly [7]. Thus, work on MaaS platforms has already started. Ministry of Housing and Urban Affairs (MoHUA), Government of India, along with other industry partners, are working on setting out a framework to introduce them in Indian Cities to integrate all forms of shared transport through a single app with multiple functions of route/mode choice and payment gateway [8]. Owing to rapidly increasing internet and smartphone penetration in all the regions of the country as a result of lowering of the costs of data and handsets, along with other flagship government projects like Digital India [9] for improving access to internet in all urban and rural areas, it is not going to be long when MaaS platforms start emerging, beginning from larger cities, and then eventually penetrating the medium size cities as well.

However, to even consider deploying such high-order services, it is essential to first investigate the usage pattern of the current smartphone apps, especially for trip planning purposes in medium size cities which would form the basis for a smartphone-enabled mobility ecosystem when these systems become available. This is especially important to be studied in a medium-sized city because the use of smartphone apps for travel needs, for most people and households in such cities, is somewhat a novel trend, and the knowledge of users' usage patterns of existing apps is unavailable. The socio-economic factors driving the app usage are also unknown, and it is unclear what kind of users are adopting them. It is also unknown whether the usage of these smartphone applications has changed users' mobility in Indian cities because the effects of these apps on the stated travel outcomes, including Vehicle Kilometres Travelled (VKT), the frequency of social gatherings, visiting new places and planning group trips by different user groups have not been studied.

So, the aim of the study is two-fold. It first aims to investigate how different user groups use smartphone apps to meet their different trip planning demands. Second, the impacts of using smartphone apps, as reported by different user groups, on travel outcomes have also been investigated.

2. Literature Review

The impact of ICT on travel has been extensively studied in the literature, especially in industrialised nations. Numerous studies investigated how sociodemographic factors affected people's use of ICT. Most internet users are young and middle-aged persons, along with students [10]. Most mobile phone users [11] and smartphone users [12] were likewise in the same age groups. Men used the internet more frequently than women [10]. However, a US survey of St. Louis Metro users found that smartphone ownership is gender neutral. [12]. Participation in online activities also rises along with income level [10]. Bhat, Sivakumar, & Axhausen (2003) [11] and Mondschein (2011) [13] found a similar pattern, demonstrating that the probability of owning a cell phone rises with income. On the other hand, income was found to be a less significant predictor of smartphone ownership [12]. According to a survey on US travellers, online planning and purchasing of travel-

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related goods and services, such as lodging and tickets, has dramatically expanded over the past few years [14]. Srinivasan & Athuru (2004) investigated the engagement in virtual activities (using the internet), such as online banking and maintenance and discretionary activities, utilising data from 4214 respondents from the San Francisco Bay Area [10]. The study found that while using the internet shortens journeys, maintenance activities and trip frequency increase.

In the case of relationships between travel outcomes and trip characteristics, Wang & Law (2007) discovered that ICT enhances recreational activities, trip frequency, and travel time [15]. The impact of using ICT-based services, such as email, the internet, video calling and conferencing, etc., on time consumption and travel behaviour in Hong Kong have been investigated by the authors. Wang and Fesenmaier (2013) investigated about how using a smartphone for entertainment, communication, convenience, and information search affected how well a trip went [16]. According to the study, a smartphone can change how travellers chose to travel, how they organise their trips, and how easily they can access information.

The contemporary literature, the majority of which were carried out in developed nations, mainly concentrated on the effects of ICT on travel. There is little evidence, even in those nations, of how ICT-based smartphone applications affect regular trip planning tasks like choosing to complete online tasks rather than travelling, communicating with travel partners or coordinating travel, and selecting travel destinations, modes of transportation, and departure times [17]. There are also limited studies on the impact of smartphone use on travel-related activities such vehicle kilometres travelled, the number of new places visited, social gathering at-tended, and planned group trips. [17]. There hasn't been any equivalent research done on Indian cities, as far as the authors are aware.

3. Materials and Methods

3.1. Case Study

The Indian city of Bhopal has been taken up as the case study for this research. It is the capital of the State (Province) of Madhya Pradesh and is in Central India. The city is a hub of knowledge with many public and private universities, culturally vibrant neighbourhoods with long histories, and various man-made and natural lakes. As per the Census of India (2011), more than 2 million people [18] live in 813 Sq.km (2,482 persons/sq.km) of Bhopal urban agglomeration (including Kolar), and as per trend-based estimation, it is expected to have grown to about 2.5 million by 2022. The per capita net income in Madhya Pradesh increased to INR 103,288 or USD 1,656.58 [19], putting it in 13th place among the other states. So relatively, it can be considered a medium-income state, and the per-capita income for Bhopal urban agglomeration has been estimated to be INR 134,982 for the year 2022 using trend-based analysis of past data [20]. The city also has an average literacy rate of 83.47%.

Bhopal has compelling reasons to be considered as a Case Study. It was picked as one of the first round's 20 lighthouse cities out of the 100 cities chosen for the Smart Cities Mission, the purpose of which is to turn the city into a smart, sustainable, and liveable city that is prepared for the future. A 186-kilometre Bus Rapid Transit System (BRTS) is operational in the city and is integrated with an app called 'Chalo' which provides real-time information about the bus service. A tap-to-pay bus card named "Chalo Card" has also been introduced, which has a prepaid wallet and the capability to store bus passes. The public Bicycle Sharing (PBS) system has been deployed on multiple stretches in the city, primarily in the catchment of BRTS. App-based shared mobility platforms like Uber, Ola and Rapido have already provided their services. Construction work on Phase 1 of the Bhopal Metro commenced in January 2019 and is expected to be completed by 2026. So, with almost all the modern forms of mobility systems (both existing and committed) and increasing smartphone penetration, the city already has the ingredients for deploying

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MaaS, and as the city grows in size and complexities, trip planning would become a critical part of everyday lives of the residents. Many such apps are already available in the city (Table 1).

Table 1. Types of Smartphone Apps for Trip Planning Purposes available in Bhopal

Trip Planning Purposes → / **Smartphone Apps available in Bhopal**	**Deciding Departure Time**	**Deciding Destination**	**Mode Choice**	**Route Selection**	**Communication & coordination**	**Online Tasks**
Map & Navigation Services (E.g., Google Maps and Apple Maps)	✓		✓	✓	✓	
Public Transport Apps (E.g., Chalo App)	✓		✓			
Shared Mobility Apps (E.g., Uber, Ola, InDriver, Rapido, Chartered Bikes, etc.)	✓		✓			
Information Apps for Recreational Activities (E.g., BookMyShow, Zomato, etc.)	✓	✓				✓
Ticketing and Payment Apps (E.g., PayTM, PhonePay, Bharat Pay, GPay, etc.)			✓			✓
Social Network Apps (Facebook, WhatsApp, Twitter, etc.)		✓		✓	✓	

3.2. Data Collection

A survey of smartphone users was conducted online to gather the primary data for this study. Interviews were conducted between September – 2021 and December – 2021, and a representative sample of 475 individuals from Bhopal was collected through a stratified random sampling technique. Topics covered in the survey included smartphone app usage for trip planning activities along with personal level details like Gender, Age Group (users below 18 years of Age have not been considered in the study due to their high mobility dependence), and Years of Smartphone use; and Household level details in-cluding household composition (with or without children below 18 years of Age), month-ly household income, four-wheeler ownership and two-wheeler ownership.

The personal and household-level socio-economic information has been recorded as categorical choices. Questions regarding respondents' smartphone apps usage for trip planning activities such as departure time, choosing a destination, choosing the mode, selecting route, communicating, and coordinating trips, and performing tasks online instead of visiting a specific location were asked. A 5-point Likert Scale was used to collect the data, with options such as Never, Rarely, Sometimes, Often, and Always. The impact on Vehicle Kilometres Travelled (VKT) for Work/Education Trips, Shopping Trips, and Recreational Trips, number of new places visited, number of group trips planned, and number of social gatherings attended were further questions asked regarding travel outcomes. Again, a 5-point Likert Scale was used to collect the data, with options such as Significantly Reduced, Slightly Reduced, No Impact, Slightly Increased, Significantly Increased.

3.3. Data Analysis

The responses were then converted into a numeric scale, with Never = 1, Rarely = 2, Sometimes = 3, Often = 4, and Always = 5. These mean scores were used to create graphical

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plots to better understand app usage patterns. A higher mean score by an app user category indicates greater reliance on smartphone apps. The relationship between the personal and household level attributes of respondents and their smartphone app usage patterns has been investigated using a Chi-Square Test to determine whether the variations in app usage patterns within the different user groups identified at the personal and household levels are caused by this relationship.

4. Results and Discussion

The results in this section have been organized into two parts. First, the smartphone app usage pattern for trip planning purposes across various user groups based on personal and household attributes has been discussed. Then, it is followed by the assessment of the reported impacts of the usage of these apps on travel outcomes.

4.1. Smartphone App Usage Pattern

The smartphone app usage pattern for trip planning purposes by various user groups based on personal level attributes is shown in Figure 1.

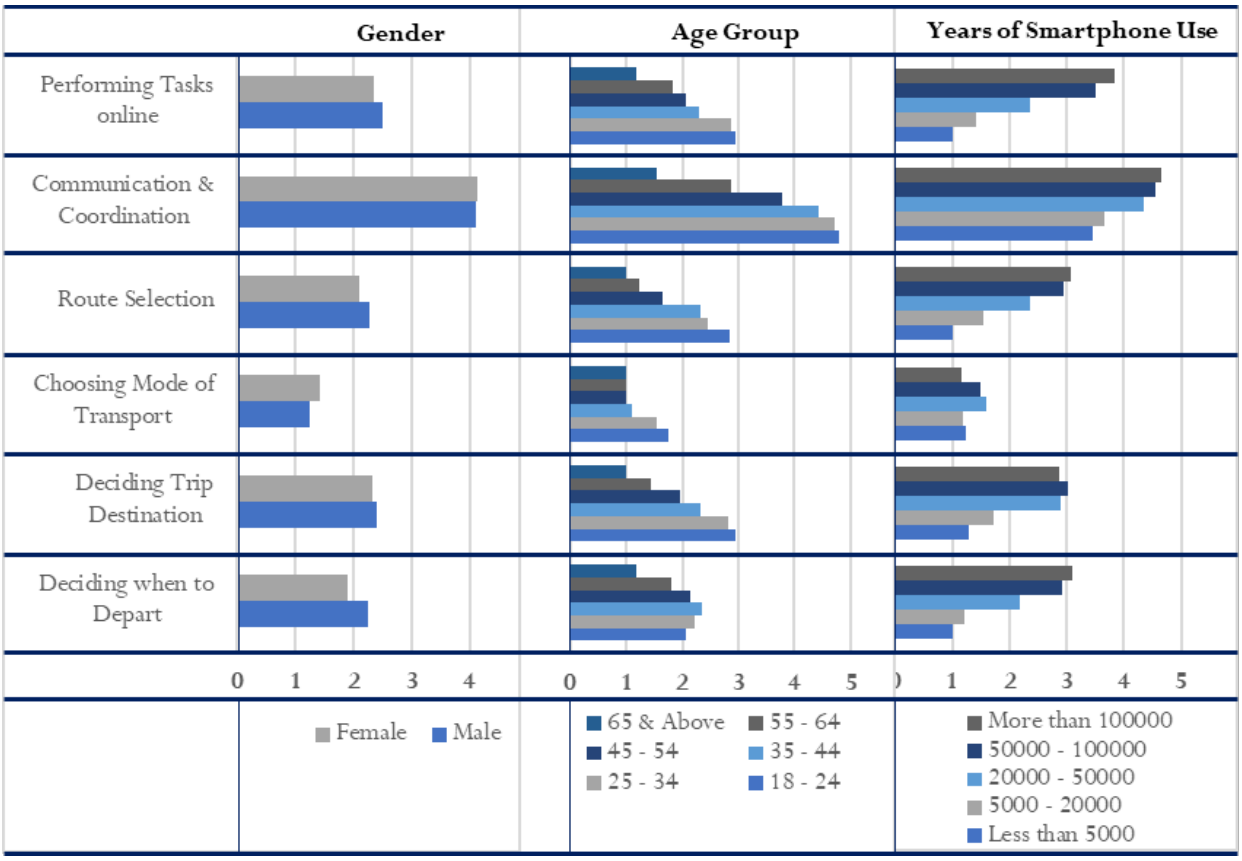

Figure 1. Personal level mean scores for smartphone app usage patterns for trip planning purposes

Overall, except for communication and coordination enabled by navigation services and social networking apps, users across Gender, Age and Years of Smartphone Usage show lower dependence on smartphone apps. Choosing the mode of transport is the least preferred use. The mean score for various trip planning purposes across Gender is relatively similar for most purposes. Young users aged 18 to 44 have a higher score than older users showing higher usage of apps for all purposes. Users experienced with more than five years of smartphone use show higher mean scores for all purposes. The Chi-Square Test has been used to investigate the association between personal level user attributes

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(Gender, Age Group and Years of Smartphone Use) and app usage patterns for trip planning purposes. For example, in the case of Gender, the test seeks to check if the difference in app usage patterns between Male and Female respondents exists due to a relationship between gender and app usage patterns. The p-values for relationships that are lesser than the chi-square critical value (5% significance level; $p < 0.05$) have been considered significant and null hypotheses for them have been rejected (Table 2), thus showing that there is a significant relationship.

Table 2 Estimated levels of significance for the relationship between personal and household level attributes and app usage

Purpose of App Use	Personal Level			Household Level			
	Gender	Age Group	Smartphone Use (Years)	Household Composition	Household income	Vehicle Ownership	
						Four-Wheeler	Two-Wheeler
1. Deciding when to Depart	0.001	0.001	0.000	0.049	0.000	0.000	0.000
2. Deciding Trip Destination	0.369	0.000	0.000	0.070	0.000	0.000	0.000
3. Choosing Mode of Transport	0.000	0.000	0.000	0.504	0.000	0.015	0.023
4. Route Selection	0.556	0.000	0.000	0.396	0.000	0.000	0.000
5. Communication & Coordination	0.844	0.000	0.000	0.966	0.000	0.000	0.000
6. Performing Tasks online	0.153	0.000	0.000	0.300	0.000	0.000	0.000

At the personal level, the test rejects the null hypothesis for Gender for trip purposes like deciding when to depart and choosing a mode of transport, where a difference in app usage pattern has been observed between the male and female respondents due to an inherent relationship between Gender and mentioned trip planning purposes. For both purposes, it can be observed that females are slightly lesser likely to use smartphone apps. For Age Group and Years of Smartphone Use for All Purposes of Trip Planning, the test also rejects the null hypothesis, demonstrating a significant relationship. Age has been negatively related to smartphone app usage, and the propensity for app usage keeps decreasing. The younger users are more likely app users for the stated purposes. However, among the younger users, app usage for deciding when to depart and route selection find relatively lesser dependence. It has also been observed that longer years of smartphone ownership and usage increases reliance on app usage. An exception to this is the purpose of communication and coordination, for which it has been observed that even relatively new users show significant reliance on smartphone app usage.

Further, the smartphone app usage pattern for trip planning purposes by various user groups based on household-level attributes is shown in Figure 2.

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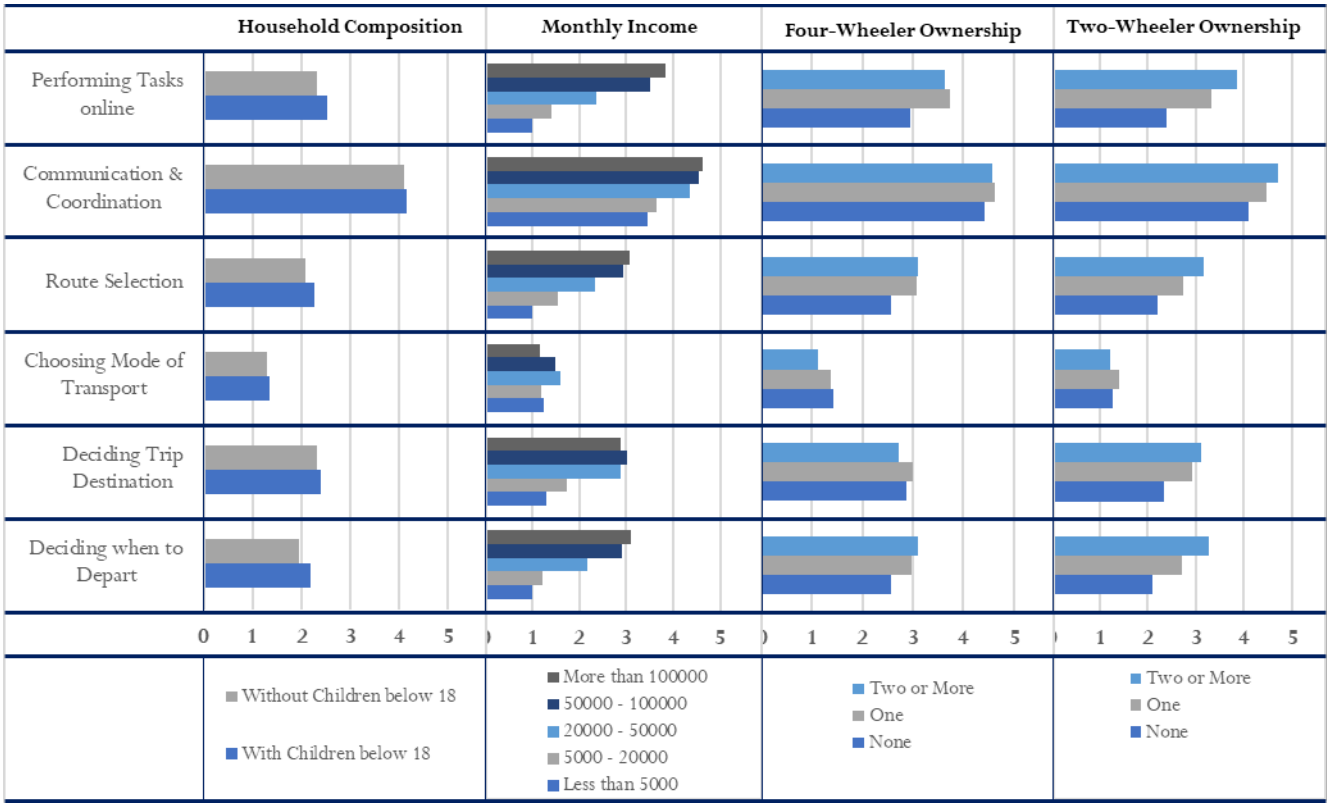

Figure 2. Household-level mean scores for smartphone app usage patterns for trip planning purposes

As observed earlier, users mainly use apps for communication and coordination across all household level attributes and choosing the mode of transport is the least preferred use. It has been observed that the mean score of app usage is not much affected by the presence of children below 18 years in the city. However, other user attributes like Monthly Income and vehicle ownership have been observed to show variations in the mean score. The mean score for app usage by high-income users has been observed to be higher for all purposes and steadily decreases for lower-income groups. Communication and coordination are the most preferred purpose for which users use apps among all income categories. Although the use of apps for choosing a mode of transport has the least mean score across all purposes, it has been observed that only the users of medium-income households have relatively higher usage. It has also been observed that the absence of a private vehicle discourages users from using smartphone apps for the mentioned purposes. Users who own a four-wheeler or a two-wheeler have higher mean scores for app usage. However, in choosing a mode of transport, households with private vehicles show relatively lesser dependence on smartphone use.

The association between user attributes at the household level (such as household composition, income, and vehicle ownership) was investigated using the Chi-Square Test and app usage patterns for trip planning. (Table 2). The chi-square test rejects the null hypothesis for household composition to decide when to depart only, thus showing that a significant difference in the app usage pattern for the mentioned purpose is due to an inherent relationship between household composition and mentioned purpose. For all other trip planning purposes, such a relationship does not exist. The test also rejects the null hypothesis for monthly household income, four-wheeler ownership and two-wheeler ownership for all trip planning purposes. For most purposes, monthly household income is positively related to app usage, and the higher income of the household encourages it. However, even low-income households rely on smartphone apps for communication and coordination. It has been observed that users who belong to families with at least one private car appear to demonstrate more reliance on smartphone applications for various

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trip planning purposes. Private ownership of four- and two-wheelers seems to encourage app usage as well.

4.2. *Impact Assessment*

The impact of using smartphone apps on the various travel outcomes for smartphone users has been investigated at both personal and household levels. Interestingly, the impact is meagre as most users across various classifications reported 'No Impact' on travel outcomes.

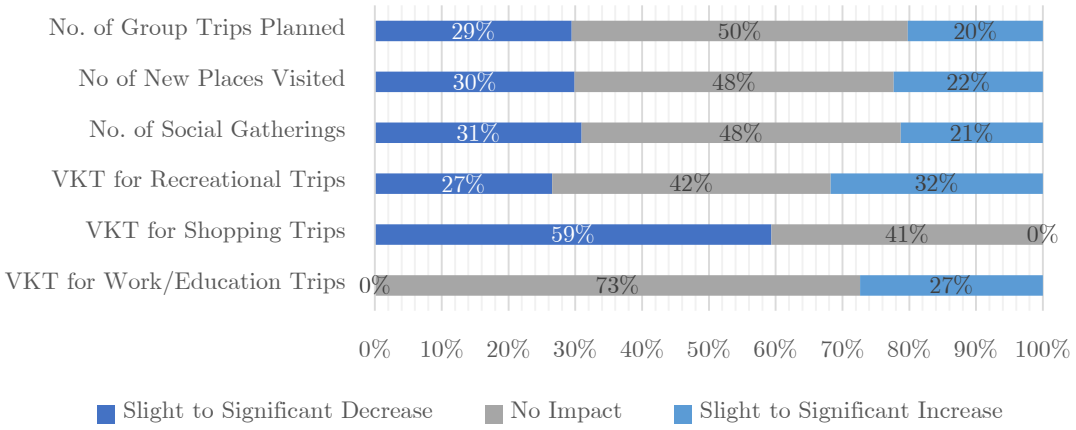

Figure 3. Outcome-wise, the share of responses on Impacts of Smartphone Apps

Smartphone app usage has the lowest influence on VKT for Work/Education trips as 73% of respondents stated, 'No Impact'. Contrary to expectation, about 27% have stated a slight to a significant increase in VKT for the same. For shopping trips, however, 59% of respondents have reported a decrease in VKT, and nobody has stated an increase in VKT. 42–50% of users have stated no impact of smartphone app usage on the rest of the travel outcomes. Only 27% of respondents stated a decrease in VKT for recreational trips, and 32% reported an increase in VKT for the same. A decrease in social gatherings was reported by 31% of respondents, while an increase was reported by 21%. A similar decline in the number of newly visited locations was reported by 30% and 29% of respondents, respectively and the frequency of planned group travel, respectively, whereas according to 22% and 20% of respondents, respectively, the use of smartphone apps has increased the number of new places visited and the number of group trips planned.

Table 3 shows the personal level attribute–wise stated impacts of Smartphone Apps Usage on Travel Outcomes.

Table 3. Personal level attributes and travel outcome–wise classification of Smartphone App Users

Travel Outcome	Stated Impacts	Gender		Age (in Years)						Years of Smartphone Use			
		Male	Female	18 - 24	25 - 34	35 - 44	45 - 54	55 - 64	65 +	< 1	1 to 3	3 to 5	> 5
VKT for Work /	Significant Decrease	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Education	Slight Decrease	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No Impact	69%	76%	48%	63%	80%	86%	100%	100%	100%	98%	91%	63%
	Slight Increase	19%	18%	27%	24%	20%	14%	0%	0%	0%	2%	8%	25%
	Significant Increase	12%	6%	25%	13%	0%	0%	0%	0%	0%	0%	1%	13%
		p-value = 0.053		p-value = 0.000						p-value = 0.000			

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Travel Outcome	Stated Impacts	Gender		Age (in Years)						Years of Smartphone Use			
		Male	Female	18 - 24	25 - 34	35 - 44	45 - 54	55 - 64	65 +	< 1	1 to 3	3 to 5	> 5
VKT for Shopping Trips	Significant Decrease	38%	34%	61%	53%	24%	22%	5%	0%	0%	0%	15%	49%
	Slight Decrease	21%	26%	19%	18%	37%	20%	30%	15%	0%	20%	19%	26%
	No Impact	41%	40%	20%	28%	39%	58%	65%	85%	100%	80%	66%	26%
	Slight Increase	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Significant Increase	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		p-value = 0.369		**p-value = 0.000**						**p-value = 0.000**			
VKT for Recreational Trips	Significant Decrease	4%	6%	0%	0%	0%	0%	25%	30%	0%	0%	1%	6%
	Slight Decrease	22%	22%	15%	16%	25%	29%	35%	25%	40%	15%	24%	22%
	No Impact	41%	42%	25%	24%	67%	63%	40%	45%	60%	85%	64%	28%
	Slight Increase	24%	21%	48%	35%	8%	8%	0%	0%	0%	0%	12%	30%
	Significant Increase	9%	9%	12%	25%	0%	0%	0%	0%	0%	0%	0%	13%
		p-value = 0.837		**p-value = 0.000**						**p-value = 0.000**			
Number of Social Gatherings	Significant Decrease	10%	5%	15%	0%	0%	0%	25%	28%	30%	13%	8%	6%
	Slight Decrease	22%	25%	14%	23%	23%	31%	28%	33%	10%	15%	29%	23%
	No Impact	47%	49%	35%	41%	59%	69%	48%	40%	60%	73%	58%	41%
	Slight Increase	16%	16%	29%	22%	18%	0%	0%	0%	0%	0%	5%	22%
	Significant Increase	5%	6%	7%	14%	0%	0%	0%	0%	0%	0%	0%	8%
		p-value = 0.339		**p-value = 0.000**						**p-value = 0.000**			
Number of New Places Visited	Significant Decrease	11%	8%	20%	0%	0%	0%	23%	35%	40%	16%	8%	8%
	Slight Decrease	20%	21%	10%	25%	23%	22%	23%	25%	10%	16%	29%	19%
	No Impact	47%	49%	35%	38%	54%	78%	55%	40%	50%	67%	58%	42%
	Slight Increase	17%	18%	28%	24%	23%	0%	0%	0%	0%	0%	5%	24%
	Significant Increase	6%	3%	6%	13%	0%	0%	0%	0%	0%	0%	0%	7%
		p-value = 0.596		**p-value = 0.000**						**p-value = 0.000**			
Number of Group Trips Planned	Significant Decrease	9%	9%	15%	0%	0%	0%	30%	38%	30%	11%	7%	9%
	Slight Decrease	20%	20%	15%	18%	24%	29%	18%	23%	10%	15%	22%	21%
	No Impact	48%	53%	40%	46%	57%	71%	53%	40%	60%	75%	66%	42%
	Slight Increase	17%	13%	23%	22%	19%	0%	0%	0%	0%	0%	5%	20%
	Significant Increase	6%	5%	7%	15%	0%	0%	0%	0%	0%	0%	0%	8%
		p-value = 0.709		**p-value = 0.000**						**p-value = 0.000**			

It can be observed that among the personal level attributes considered, Gender does not have a statistically significant relationship with the travel outcomes for most outcomes except VKT for work/education (as per a p-value of 0.05 or less for the Chi-Square test), thus showing that the difference in the stated impact of app usage on VKT for work/education between male and female respondents, is due to an inherent relationship between Gender and mentioned travel outcome (VKT for work/education). Age (and Years of Smartphone Use) have been found to have a significant relationship with the stated impacts of app usage for all the travel outcomes, with all the travel outcomes showing that respondents of different age groups have reported differences in their respective

travel outcomes due to this relationship. Impacts of smartphone app usage on travel outcomes across personal level attributes for statistically significant relations have been discussed below –

- **Gender**: A more significant proportion of female (76%) respondents stated that their commute to work/education has not been impacted by smartphone app usage, slightly different from male respondents (69%). Any respondent has reported no decrease in VKT. A significantly more significant proportion of male respondents (31%) reported a slight to a significant increase in VKT for work/education as compared to females (24%).
- **Age**: All respondents older than 55 years of Age, most users between ages 35 – 54 years (80% – 86%) and a significantly large number of users between ages 18 – 34 years (48% - 63%) stated no impact on VKT for work/education due to smartphone app usage. None of the respondents stated a decrease in VKT for the same. However, 52% and 37% of respondents from 18 – 24 years and 25 – 34 years, respectively, have stated a slight to a significant increase in VKT for work/education. Respondents belonging to middle age groups of 35 – 44 years and 44 – 55 years stated a slight increase in VKT for the same. In the case of VKT for shopping trips, the responses are different. Although still very significant, a comparatively lesser number of respondents have reported no impact on VKT for shopping trips, and it has been observed that as age increases, respondents reported lesser dependence on smartphone apps for shopping. It is also evident from the observation that most respondents from lower (18 – 34 years) to lower-medium (35 – 44 years) age groups have stated a slight to a significant decrease in VKT for shopping trips because of app usage. None of these users has reported an increase in VKT for shopping trips. It's interesting to note that while the majority of users from middle age groups (35 to 54 years) have reported no impact, some have reported a slight decrease in the number of group trips planned, the number of social gatherings attended, and the number of new places visited as a result of using smartphone apps. A very few have reported a slight increase. In comparison, younger and older age groups have reported slight to significant changes. Most respondents from younger age groups (18 – 34 years) have reported a slight to a significant increase, and most from older age groups (more than 55 years) have reported a slight to a significant decrease in the mentioned travel outcomes.
- **Years of Smartphone Use**: It has been observed that the respondents who are more experienced with using smartphones show more changes in travel outcomes due to smartphone app usage. All respondents with less than one year of experience have no impact on VKT for work/education. Even with one to three years of experience, only 2% of respondents stated a slight increase, and with three to five years of experience, only 8% stated a slight increase, and 1% stated a significant increase in VKT. With more than five years of experience with smartphone usage, 25% stated a slight increase, and 13% stated a significant increase in VKT for work/education trips. Nobody stated a decrease in VKT for the same with a gain of smartphone usage experience. In the case of VKT for shopping trips, all the respondents with less than one year of experience also stated no impact. However, unlike VKT for work/education trips, just with an experience of one to three years, 20% of respondents have stated a slight decrease, and with an experience of three to five years, 34% of respondents have stated slightly to a significant decrease in VKT due to app usage. About 75% of respondents have stated a slight to a significant decrease in VKT with more than five years of experience with smartphone use. No increase has been stated for this outcome. Another observation is that smartphone app users with less experience reported significant changes in VKT for recreation trips and other recreation-based outcomes. 40% of respondents with less than one year of experience reported a slight decrease in VKT for recreational trips. Although the majority of respondents indicated no impact, 30%, 40%, and 30% of respondents with less usage experience reported a significant decline in the number of social gatherings attended, new places

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visited, and group trips planned, respectively, as a result of smartphone app usage. However, more experienced users for these purposes have reported both rises and declines, with the decrease slightly greater than the increase in VKT for recreation, social gatherings attended, new places visited, and group trips planned.

Among the factors taken into consideration at the household level, the household composition shows a statistically significant correlation with some travel outcomes, such as the frequency of social gatherings, new places visited, and scheduled group trips (with a Chi-Square test at a 5% significance level). Table 4 shows household-level impacts of Smartphone Apps Usage on Travel Outcomes.

Table 4. Household-level attributes and travel outcome–wise classification of Smartphone App Users

Travel Outcome	Stated Impacts	HH Composition		Monthly HH Income					Vehicle Ownership							
									Four-Wheeler				Two-Wheeler			
		With	No	< ₹ 5k	₹ 5k – 20k	₹ 20k – 50k	₹ 50k –	> ₹ 100k	None	One	Two	> 2	None	One	Two	> 2
VKT for Work/Education	Significant Decrease	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Slight Decrease	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No Impact	69%	77%	100%	96%	68%	56%	43%	95%	64%	44%	48%	94%	72%	61%	31%
	Slight Increase	22%	15%	0%	4%	27%	24%	37%	5%	27%	31%	33%	5%	21%	25%	34%
	Significant Increase	9%	8%	0%	0%	4%	20%	20%	1%	9%	25%	18%	1%	7%	13%	34%
		p-value = 0.139		p-value = 0.000					p-value = 0.000				p-value = 0.000			
VKT for Shopping Trips	Significant Decrease	40%	32%	0%	5%	55%	64%	56%	8%	53%	62%	61%	10%	33%	61%	62%
	Slight Decrease	22%	25%	0%	38%	32%	25%	22%	18%	32%	22%	15%	11%	31%	24%	24%
	No Impact	38%	43%	100%	57%	14%	11%	22%	75%	14%	16%	24%	79%	36%	15%	14%
	Slight Increase	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Significant Increase	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		p-value = 0.211		p-value = 0.000					p-value = 0.000				p-value = 0.000			
VKT for Recreational Trips	Significant Decrease	5%	5%	0%	0%	8%	4%	11%	0%	7%	7%	12%	0%	5%	10%	3%
	Slight Decrease	21%	23%	21%	25%	24%	28%	11%	22%	25%	20%	12%	20%	27%	19%	10%
	No Impact	40%	44%	79%	75%	19%	19%	17%	73%	20%	20%	12%	72%	39%	21%	17%

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Travel Outcome	Stated Impacts	HH Composition		Monthly HH Income					Vehicle Ownership							
									Four-Wheeler				Two-Wheeler			
		With	No	< ₹ 5k	₹ 5k – 20k	₹ 20k – 50k	₹ 50k –	> ₹ 100k	None	One	Two	> 2	None	One	Two	> 2
	Slight Increase	25%	20%	0%	0%	48%	32%	34%	5%	38%	28%	42%	8%	22%	37%	31%
	Significant Increase	9%	9%	0%	0%	0%	17%	28%	0%	10%	25%	21%	0%	8%	13%	38%
		p-value = 0.592		**p-value = 0.000**					**p-value = 0.000**				**p-value = 0.000**			
Number of Social Gatherings	Significant Decrease	3%	13%	11%	6%	8%	8%	5%	8%	8%	7%	6%	10%	7%	9%	0%
	Slight Decrease	25%	20%	22%	29%	22%	24%	18%	25%	22%	25%	15%	27%	21%	25%	17%
	No Impact	49%	46%	67%	64%	39%	35%	34%	64%	37%	31%	42%	57%	52%	35%	34%
	Slight Increase	16%	15%	0%	0%	31%	24%	25%	4%	27%	22%	21%	6%	16%	25%	24%
	Significant Increase	6%	5%	0%	0%	0%	8%	18%	0%	5%	15%	15%	0%	5%	7%	24%
		p-value = 0.002		**p-value = 0.000**					**p-value = 0.000**				**p-value = 0.000**			
Number of New Places Visited	Significant Decrease	6%	14%	13%	11%	11%	8%	5%	11%	10%	6%	6%	12%	8%	10%	7%
	Slight Decrease	19%	22%	21%	36%	13%	19%	14%	27%	15%	16%	18%	25%	23%	15%	10%
	No Impact	49%	47%	66%	54%	38%	41%	40%	60%	39%	42%	36%	60%	45%	41%	45%
	Slight Increase	20%	14%	0%	0%	39%	22%	26%	3%	32%	22%	27%	4%	19%	26%	28%
	Significant Increase	6%	4%	0%	0%	0%	9%	15%	0%	5%	14%	12%	0%	5%	8%	10%
		p-value = 0.018		**p-value = 0.000**					**p-value = 0.000**				**p-value = 0.000**			
Number of Group Trips Planned	Significant Decrease	5%	13%	9%	7%	11%	11%	7%	8%	10%	10%	9%	10%	7%	14%	0%
	Slight Decrease	19%	22%	17%	32%	19%	21%	14%	23%	21%	16%	12%	23%	23%	13%	21%
	No Impact	54%	46%	74%	61%	40%	44%	33%	66%	39%	47%	21%	63%	52%	40%	28%
	Slight Increase	16%	14%	0%	0%	31%	15%	28%	3%	24%	15%	39%	5%	14%	21%	34%
	Significant Increase	5%	5%	0%	0%	0%	9%	18%	0%	6%	12%	18%	0%	4%	10%	17%

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Travel Outcome	Stated Impacts	HH Composition		Monthly HH Income					Vehicle Ownership							
									Four-Wheeler				Two-Wheeler			
		With	No	< ₹ 5k	₹ 5k – 20k	₹ 20k – 50k	₹ 50k –	> ₹ 100k	None	One	Two	> 2	None	One	Two	> 2
		p-value = 0.040		p-value = 0.000					p-value = 0.000				p-value = 0.000			

Impacts of smartphone app usage at the household level on travel outcomes for statistically significant relations have been discussed below –

- **Household Composition:** Although a large proportion of respondents from both types of households have stated no impact on travel outcomes like number of social gatherings attended, new places visited, and group trips planned because of smartphone app usage, ones with children slightly more than ones without children, majority of them have stated some changes. While 22 percent of homes with children and 30 percent of households without children reported a slight to significant increase in the number of social gatherings, 28 percent of households with children and 33 percent of households without children indicated the opposite. A slight to significant increase in the number of social gatherings was reported by 25% of households with children and 36% of households without children, compared to decrease stated by 26% of households with children and 18% of households without children. Similarly, 24% of households with children and 35% without children reported a slight to significant, whereas 21% with children and 19% without children reported a slight to a significant decrease in social gatherings.
- **Monthly Household Income**: None of the respondents with a household income less than INR 5,000 has stated any change in VKT for work/education, but with the increase in income levels, respondents have stated slightly to a significant increase in VKT for the same. No respondent has stated any decrease in VKT for work/education because of smartphone app usage. For VKT for shopping trips, the number of respondents stating no impact reduces with an increase in income, and respondents have reported a slight to a significant decrease in VKT for the same outcome. An exception is a group with an income of more than INR 100,000 where respondents stating no change (22%), although still very low, is higher than the relatively low-income group (INR 50,000 to 100,000) and thus, the proportion of respondents stating change is also comparatively lower. No respondent has stated any increase in VKT for shopping trips because of smartphone app usage. In the case of VKT for Recreational trips, it has been observed that unlike VKT for the other two outcomes, here, even the lowest income group has stated a slight decrease (21%). As the income increases, the proportion of respondents stating a decrease in VKT and those reporting an increase in VKT increases, so much so that in the highest income category, the majority of respondents (62%) have stated an increase in VKT because of app usage. A similar trend is observed for other outcomes like the number of social gatherings attended, new places visited, and group trips planned, with an even more significant proportion of respondents from lower income categories who have stated a slight to significant decrease and a little lower proportion of respondents from higher income categories who have stated slightly to a significant increase in travel outcome.
- **Vehicle Ownership**: It has been observed that most users with no household vehicle ownership (either four-wheeler or two-wheeler) have stated no impact on all travel outcomes, especially VKT for work/education (95%), and as the number of vehicles increases, the users have reported changes in travel outcomes. No decrease in VKT for work/education has been stated, but with the increase in vehicle ownership slight to significant increase has been stated, most in households with exactly two four-

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wheelers (56%) and households with more than two two-wheelers (68%). In the case of VKT for shopping trips, no increase has been stated, and respondents from households with lower vehicle ownership (1 to 2 four-wheelers or two-wheelers) have stated a slight to a significant decrease in shopping trips, especially if the household has two four-wheelers (84%) or if they have two or more two-wheelers (86%). In the case of VKT for Recreational trips, as vehicle ownership increases, changes have also been stated, and the proportions of respondents that stated a slight to a significant increase in VKT in each income category are much larger than those who stated a decrease in VKT. For outcomes like the number of social gatherings, new places visited, and group trips planned, most users from households with higher vehicle ownerships have reported a slight to a significant increase in travel and vice – versa.

5. Conclusion

This study aimed to better understand the characteristics of smartphone applications used for daily trip planning and travel outcomes using an exploratory analysis. Using Chi-Square analysis and graphical representation of survey data from a sample of respondents in Bhopal, the study examined trends in smartphone travel usage and the factors that influence them. This study has provided insight into how smartphone users be-have and engage with travel-related apps.

According to the study, there are some uses where the app usage differences between male and female users are significant, and female respondents are less likely to use smartphone applications than male respondents. Thus, a significantly more significant proportion of male respondents reported a slight to a significant increase in VKT for work/education compared to females. It has also been observed that the younger users are more likely app users and have stated a significant increase in travel outcomes due to smartphone app usage, except for shopping trips, where a decrease in physical travel has been observed. Longer years of experience with smartphone usage increase reliance on app usage and it has been observed that the individuals who are more experienced smartphone users show more variations in travel outcomes due to smartphone app usage and have reported an increase in travel for most outcomes.

Considering the household-related factors of the users, it has been observed that smartphone dependence is affected by the presence of children below 18 in the household for some purposes, and they have a slightly higher propensity to use apps for those purposes. However, despite higher usage, these households have stated lower impacts on travel outcomes. For most purposes, monthly household income is positively related to app usage, and the higher income of the household encourages it. However, even low-income households show considerable reliance on smartphone apps for some purposes. With the increase in household income, an increase in travel work/education has been observed, especially in the case of medium and high-income households, along with an increase in travel for recreation, social gatherings, visiting new places and group trips. Again, travel for shopping has been observed to decrease with an increase in income. Private four-wheeler and two-wheeler ownership seem to discourage app usage, and it has been observed that users belonging to households with at least one private vehicle seem to show less reliance on smartphone apps for various purposes. Travel Outcomes also seem to increase with higher vehicle ownership by the households to which the users belong.

Although the majority of respondents in the study reject the substitution or diminishing effects of smartphone use on travel, it will be interesting to further investigate how socioeconomic and other factors affect the use of smartphone apps for various travel-related purposes and their effects on travel outcomes through a multivariate analysis, which will highlight the trade-offs between different factors. Finding latent influences on this association between smartphone app usage and travel behaviour would also be of interest. Nevertheless, the outcomes of this study provide important behavioural insights. They may be helpful in policy discussions regarding the deployment of a smartphone

app-based mobility ecosystem in a medium-sized city like Bhopal as people become more accustomed to smartphones and the number of older people using them rises due to the development of more user-friendly smartphone apps with real-time information and services. The study's findings show that these travel applications need to be more user-specific and personalised based on socioeconomic/demographic criteria in order to of-fer consumers customised mobility alternatives that match their demands.

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