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# Systematic Literature Review of Factors Affecting Public Acceptance and Adoption of Urban Air Mobility

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**Abstract**
Articles are reviewed in this paper with a purpose to develop holistic knowledge upon the factors for UAM public acceptance and intention. The paper uses the PRISMA STATEMENT method to identify and organize literature for reviews. A total of 1206 articles are obtained for the three queries used as search keywords in the libraries of SCOPUS, Google Scholar and PubMeds.
The most common models for adoption of new Technology are the "technology acceptance model" (TAM), "theory of planned behavior" (TPB). In some cases, two of these models have been used together as the main theoretical frame of reference and another as extended theoretical model. Literatures available so far are contributing significant knowledge to explain the role of factors like Demographics, Socioeconomic status, Environmental Concerns, and Perceived Risk upon the acceptance and adoption of UAM but very less or insignificant works have been done so far to measure the impact of factors like Personal Innovativeness, Vehicle Ownership, Mobility Impairment, Trip purpose, Exposure to new technology, Facilitating Conditions, Hedonic Motivation.

**Keywords:** Urban Air Mobility (UAM), Flying Cars, eVTOLs, Theory of Planned Behaviour, Technology Adoption Model,

## Introduction

NASA defines Urban Air Mobility (UAM) as "a safe and efficient system for air transportation of passengers and cargo within an urban area" (Chan et al., 2018, p. 4.). The natural question is why is UAM not adopted and being used?
Perception of the consumer towards a product is a major driving force. Entrepreneurs in the history so far were able to deploy required and stretgeic resources to mould the consumer perceptions towards innovative products. However, the motivation of entrepreneurs towards the deployment of such tactical resources for the adoption of UAM as an additional mode of urban mobility seems insufcient. This paper reviews the works of researchers finding the appropriate reasons and possible alternatives for this problem.
The paper uses the PRISMA STATEMENT method to identify and organize literature for reviews. A total of 1206 articles are obtained for the three queries used as search keywords in the libraries of SCOPUS, Google Scholar and PubMeds.

**Background of the study**

The largest population of social animals on earth needs fast, safe and frequent modes of travelling. This cannot be achieved without adding carbon in the echology. It's the job of the scinteitsts and entrepreneurs to increase the speed, perfection, precision and safety of travel along with reducing carbon emission. Thus, UAM seems a reasonably significant alternative for all the existing modes of mobility. Transport plays a central role in society. Its economy, and at the same time, its user acceptablce makes a significant contribution to greenhouse gas emissions. The passenger transport component is an expansion of the existing passenger helicopter that operates at high frequencies and densities. It is made feasible by the burgeoning electric vertical take-off and landing (eVTOL) aircraft sector. There are currently no certified eVTOL passenger aircraft in the United States, but according to the Federal Aviation Administration (FAA), at least six aircraft intended for UAM operations are well advanced in the certification process (Garrett-Glaser, 2020). The first UAM passenger transport operations are expected to begin by 2022, with hundreds of simultaneous operations within a city projected by 2028 (Hackenberg, 2019). Vehicle configurations and the responsibilities of the pilot and operator are expected to change as technology and regulations allow, even though FAA regulations are projected to necessitate a pilot on board the aircraft in the near future.

It is important to understand the likelihood of urban air mobility adoption and use, as eVTOLs can transform mobility behaviors and user lifestyles. However, since eVTOLs are not currently publicly available, with the exception of a few prototypes in the testing phase, predicting exact travel demand in this context is challenging.

To enhance public acceptance of unaccompanied minor travel, it is imperative to extensively observe perceptions of danger and benefit in order to pinpoint the elements influencing adoption intent and acceptance among parents or guardians of unaccompanied minors, since "consumer perceptions ultimately determine the success or failure of travel of unaccompanied minors and may drive policy changes if unaccompanied minors become more common."

Although there are some review studies that provide insights into public acceptance and intention to use unaccompanied minors, a knowledge gap remains. To develop a comprehensive knowledge of the elements influencing acceptability and intention to use, thorough research is necessary, especially in light of the recent significant surge in publications on unaccompanied children. To our knowledge, no systematic literature review has been published that includes these most recent studies.

**Structure of The Article**

The present document is set up as follows. After reviewing the ideas and models that have been developed to date on technology acceptability and user adoption behaviour, Section 2 develops a research strategy. The results, including the overall conclusions and the categorized factors, are shown in Section 3. In Section 4, the limitations of the evaluated studies are discussed along with their practical implications for future study. The paper's conclusion, found in Section 5, outlines the main conclusions and their implications as well as any potential drawbacks to the current investigation.

**Theoretical Background**

The global society is growing increasingly interconnected. One of the most significant industries in society, transportation, implements creative improvements to the current procedures and offerings. Before,

transactions were not feasible. However, the Internet of Things (IoT) and location-based big data made it viable.

Previous studies focused on unaccompanied minors exemplified how socioeconomic characteristics correlate with acceptance of unaccompanied minors. In addition, researchers examined the importance of public perceptions, personal characteristics, and attitudes in determining intent to adopt unaccompanied minors. Public perception is "simply the kind of information gleaned from a public opinion poll". Public perception surveys of unaccompanied minors were conducted, considering people mainly as potential users. Individual attitudes towards unaccompanied minors are a major contributor to demand for technology, policy and future infrastructure investments.

The most common models for adoption of new Technology are the "technology acceptance model" (TAM), "theory of planned behavior" (TPB), and the "unified theory of acceptance and use of technology" (UTAUT). In some cases, two of these models have been used together as the main theoretical frame of reference and another as extended theoretical model. This was mainly due to the inability of the original theory to encompass all the factors of UAMs. According to Jing et al., "the application of theory-based models can provide stronger predictors and explanations about the determinants of AV adoption intention". All the paradigms, contributions, and representative constructs of these theories with their definitions, have been covered in Table 1.

**Rationale**

Transport plays a central role in society and the economy. It also significantly contributes to greenhouse gas emissions. The road transport density is alarmingly increasing. Road construction and adding more vehicles in the existing traffic doesn't appear to be a long term solution to the problem. Enhanced transportation already is causing several conflicting interests in the myriads of existing land use complexes. Using air routes for urban mobility can be a noble solution to this problem. However, air route transportation has to achieve the critical mass to obtain commercial success in the process of resolving this problem. After persistent efforts, air mobility now is not only technically viable but also commercially feasible. The only temporary challenge is the acceptance of UAM among the potential consumers. The real success of the industry can only be achieved by the consumer acceptance and adoption of Urban Air Mobility (UAM).

Technically accepted definition of Urban Air Mobility provided by NASA is that the Urban Air Mobility (UAM) as "a safe and efficient system for air transportation of passengers and cargo within an urban area" (Chan et al., 2018, p. 4).

A high-frequency, high-density expansion of the existing passenger helicopter, the passenger transport component of UAM is made feasible by the burgeoning electric vertical take-off and landing (eVTOL) aircraft industry. The first UAM passenger transport operations were expected to begin by 2022, with hundreds of simultaneous operations within a city projected by 2028 (Hackenberg, 2019). However this R&D in the process is still lingering waiting for the clearance from the concerned public authorities. It is important to understand the likelihood of urban air mobility adoption and use, as eVTOLs can transform mobility behaviors and user lifestyles. However, since eVTOLs are not currently publicly available, with the exception of a few prototypes in the testing phase, predicting exact travel demand in this context is challenging. To enhance public acceptance of UAM, it is imperative to closely observe perceptions of risk and reward in order to identify factors impacting UAM acceptability and adoption intent.The ultimate fact

is the consumer perception which determines the success or failure of UAM. It will further decide and may drive the course of policy changes if UAM sets for the common usage.

**Objective**

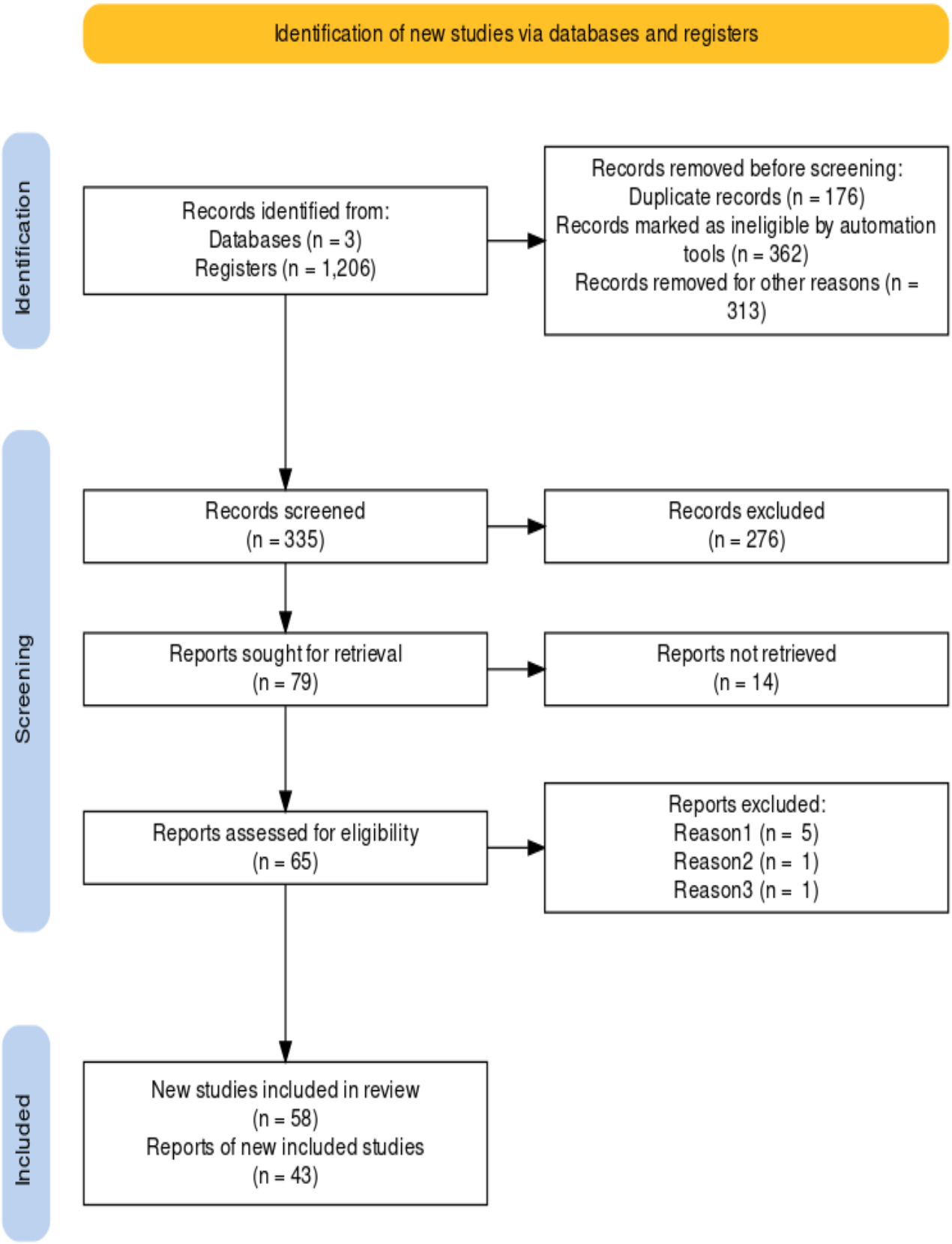
Although there are review studies available in libraries providing insights into public acceptance and intention to use UAM, the knowledge gap remains. To develop a comprehensive understanding of the elements influencing acceptability and intention to use, systematic study is necessary, especially in light of the recent significant surge in publications on UAM. No systematic literature review has been published that includes these most recent studies upon the public acceptance and intention to use of UAM. This paper aims to review the available literature with two objectives:

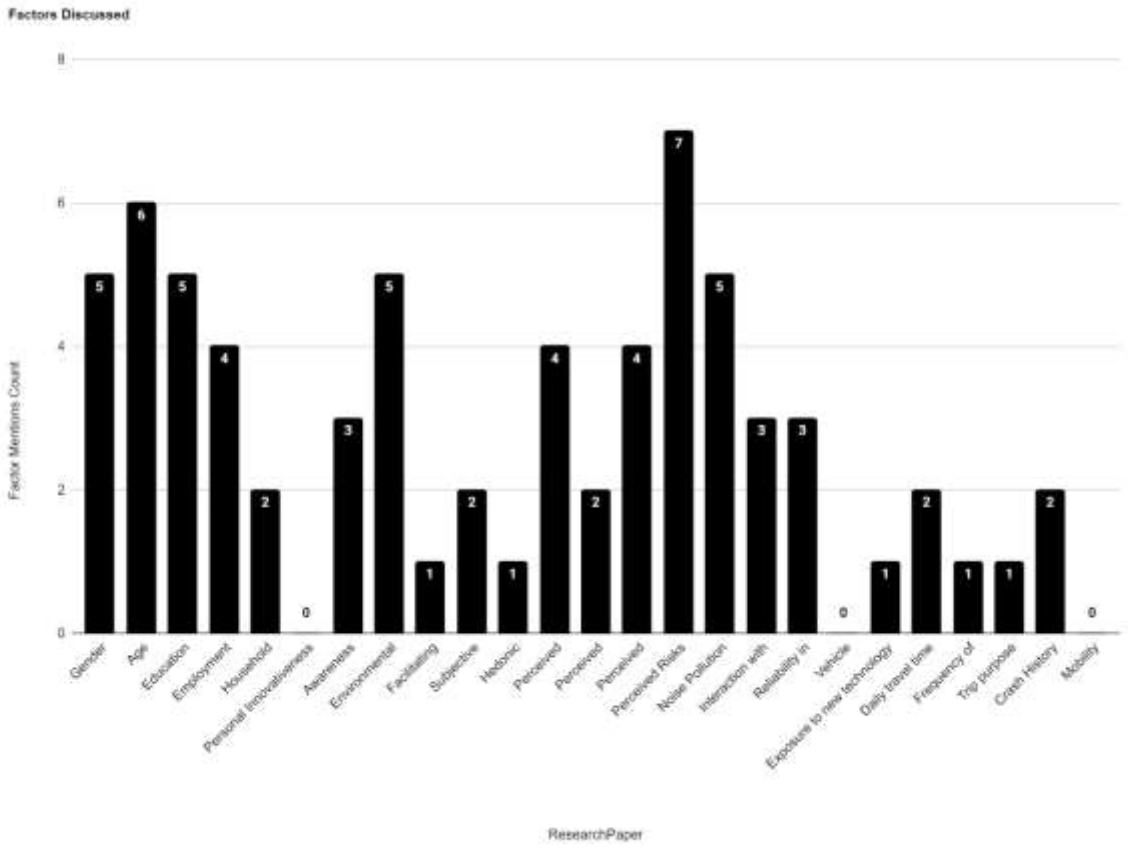
1. To identify the factors affecting UAM Public Acceptance
2. To classify the factors affecting UAM Intention to use

**Methods**

The paper uses the PRISMA STATEMENT method to identify and organize literature for reviews. A total of 1206 articles are obtained for the three queries used as search keywords in the libraries of SCOPUS, Google Scholar and PubMeds. From the papers obtained, 851 articles were removed citing duplicity, recency, lack of relevance and usability. After filtering out the articles based upon the various screening tools suggested in PRISMA Statement techniques, only 43 articles seemed important to review for the purpose aforesaid. The review of these 43 articles is organized in three sections. These forty three articles are then identified by their similarities and commonality of patterns in their research outcomes through eye-balling. In these articles the major characteristics and factors that influenced the public perceptions and adoption of UAM are highlighted. Articles further shortlisted based upon the best applicability of the themes to categorize the reviewed literature, which was based on the research aim. These articles are then validated on the basis of the assigned themes with the other literature and review studies. Adjust and allocate the categorization into different clusters that impact the AV public adoption intention.

**Figure 1. PRISMA 2020 flow diagram for new systematic reviews which included searches of database and registers only.**






**Literature Review**

**Kyriakidis et al. (2015)** e.g. find a positive correlation between openness towards automation and income. These findings support the assumption that AVs and UAM can be treated as closely related, as these results go in line with the study of Fu et al. (2019). They also identify travel time (including access, egress and waiting time) and travel cost as dominant factors.

**(Holden and Goel, 2016)** Travel costs that during early system deployment will be rather high could be a show stopper if the operator fails to address the right target segments. One approach could be to start early with awareness-raising efforts about automation. Initial research on UAM market shares finds huge differences in potential adoption rates since it assumes highly varied pricing.

Looking at numbers for UAM prices at taxi price levels, which goes in line with potential service provider statements (Holden and Goel, 2016), estimated modal share estimates converge towards 4% (Decker et al., 2013; Kreimeier and Stumpf, 2017; Syed et al., 2017).

**(Hansman and Vascik, 2016)** The civil usage of drones has already been studied in terms of acceptance, the assessment was until now limited to certain fields, e.g. noise or privacy issues **(Lidynia et al., 2017)** and did not only consider passenger services but for cargo delivery. While some factors like the perceived reliability of automation **(Nees, 2016),** the perceived vehicle's safety **(Silvia Gaggi, 2017)** or affinity towards automation **(Clements and Kockelman, 2017)** can be transferred from existing literature on autonomous vehicles (AV), others are very specific to the service offer and thus are hard to transfer from AV literature. Yet, aiming at a successful market introduction it is also essential to understand the reservations not only of the public but also of potential users **(Vascik, 2017)**. There hasn't been much research on UAM acceptance drivers up to this point because the area is still very young.

**Garrow et al. (2017)** Again, little research has been performed on mode choice including UAM. He emphasizes that passenger behavior for UAM is not totally comparable to passenger behavior that is seen in commercial aviation. Garrow et al. (2017, 2019) conducted focused group surveys in the US to understand UAM adoption. The recent work (Garrow et al., 2019) extends the earlier survey (Garrow et al., 2017) by introducing autonomous vehicles as a competing mode. So far, no model results have been published to our knowledge. Additionally, the study demonstrated that users of public transportation or soft modes are less likely to switch to UAM. There hasn't been much research done on mode choice, including UAM, up to this point. In summary, journey time—which includes access, egress, and waiting time—as well as travel expenses are the primary determinants of mode choice for UAM. An efficient system design that minimizes transfer time, thus, is essential.

**(Edward, 2017)** Six broad categories were identified as the sources of passenger concerns: perceived safety, noise and vibration, availability and access, environmental concern, passenger well-being, and vehicle motion.

**Fagnant and Kockelmann (2018)** as well as **Krueger et al. (2016)** show that waiting time is an important factor for people regarding AV use. They also demonstrate that people who now drive are more likely to switch to autonomous vehicles (AVs). Additionally, the choice of AV mode is influenced by sociodemographic factors.

**Garrow et al. (2019)** even see AVs as main competitor for UAM. Due to the services' similarities – especially due to their on-demand service offer - AV studies can serve as a proxy for mode choice decisions including UAM.

**(Yedavalli and Mooberry, 2019)** In talks on the introduction of UAM, public approval is considered as one of the dominant aspects. According to a market research on public acceptance, the public's top five worries are the safety of those on the ground, the kind and volume of noise that the vehicles make, the time of day that they travel, and the altitude at which they fly. Therefore, the greater the willingness of non-users to embrace UAM, the smaller the impact on them.

Using a more comprehensive methodology, Al Haddad et al. (2020) investigated the influence of factors influencing other modes of transportation's acceptability on the reported adoption time of UAM using a survey. The authors were able to demonstrate that while data worries, safety issues, and environmental concerns have a negative impact on stated UAM adoption, potential users' affinities for automation, online services, social media, and sharing have a favorable impact. It is necessary to take into account broad demand drivers of urban transportation in addition to the elements influencing user approval.

Furthermore, transparent services and technologies that tell the public about steps to protect (data) privacy as well as safety and security for both system users and non-user third parties are critical for user and public acceptance. Acceptance models that account for saveral considerations in the adoption of UAM include the Technology Acceptance Model developed by Davis et al. (1989). Adoption factors include affinity for automation, safety and trust, data concerns, social attitude, and sociodemographics. Additionally, it was discovered that a number of extremely significant factors included perceptions of automation costs, the value of time savings, and service reliability.

As **Straubinger et al. (2020)** show in a meta-analysis of mode choice studies, travel time and cost are the dominant factors affecting modal choice in cities. Social and demographic characteristics such as age, gender, income, and make-up of the household all play a big role in mode choice. Especially regarding travel time, UAM is expected to have a strong positive impact, in particular on long routes, where the fixed time demand for boarding and deboarding loses relevance.

**(Alhajyaseen et al., 2020)** When it comes to travel preferences for autonomous mobility, people are reluctant to choose shared and privately owned vehicles (PAV and SAV) above normal cars (NC), while public transportation (PT) is the least popular choice. Examples of these vehicles are on-demand taxi services. One of the most crucial considerations for Qatari citizens is the degree of comfort a car can provide. Students and unemployed individuals have shown an inclination towards SAV while full-time employed individuals have shown a higher preference for PAVs.

**(Rothfeld et al., 2020)** The main factors of passenger acceptance and potential passengers' value of time, demonstrate first UAM modeling approaches, and present potential spatial and welfare effects of UAM implementations.

**(Rimjha et al., 2021)** The number of vertiports located in the area and the sensitivity analysis of UAM demand to cost per passenger mile are used to determine whether the UAM mode is feasible. Based on the results, it appears that only at optimistically low UAM quoted fares can sufficient UAM demand be met for commuter journeys. Given the high cost of real estate in Northern California's urban areas, obtaining these fares may be difficult. Moreover, the reliability of the UAM mode must be comparable to the automobile mode; otherwise, it loses significant demand with increasing delays.

**(Keller et al., 2021)** Although urban air mobility is considered the third component of urban transportation, integrating it into cities requires a whole new strategy. The perspective of possible future users of urban air mobility by urban air transport.

**(Ahmed et al., 2021)** The desire of the general public to use and pay for shared flying car and flying taxi services, as well as the factors that influence this willingness. People's readiness to use and pay for flying taxi and shared flying car services was determined using information gathered via an online survey. Various socio-demographic characteristics and individuals' opinions towards the perceived benefits and challenges of flying cars affect public willingness to hire and pay for flying taxis and shared flying car services.

**(Goyal et al., 2021)** The potential for growth of AAM may be hampered by a variety of issues, including autonomous flying, the availability of vertiports for takeoff and landing, integration with other forms of transportation and airspace, and competition from shared automated vehicles. The scaled service that provides on-demand point-to-point passenger services throughout urban areas.

**(Ale-Ahmad & Mahmassani, 2022)** The demand, aircraft technology, and operational concept issues have cast doubt on UAT's viability. This research investigates the effects on average load factor and rate of rejected requests of exogenous parameters (demand intensity, demand dispersion, and ground speed) as well as design elements (aerial speed, maximum allowable delay, and reservations). The significance of demand spread, ground speed, and maximum acceptable delay in demand consolidation.

**(Rice et al., 2022)** UAMs remain a nascent product that have yet to be widely understood by the public. The flying public's choice of vertiports and air taxis. Convenience of use is rated as less important than safety and security items.

**(Yoo et al., 2022)** Safety risk and cyber risk i.e. the risk perception using air taxis would assist with creating a more strategic and efficient business model.

**(Fu et al., 2022)** The different trip purposes generate significant demands for UAM. The effective and sustainable UAM service should cannibalize existing public transport options; and second, minimize negative impacts on the environment and society to maximize public acceptance.

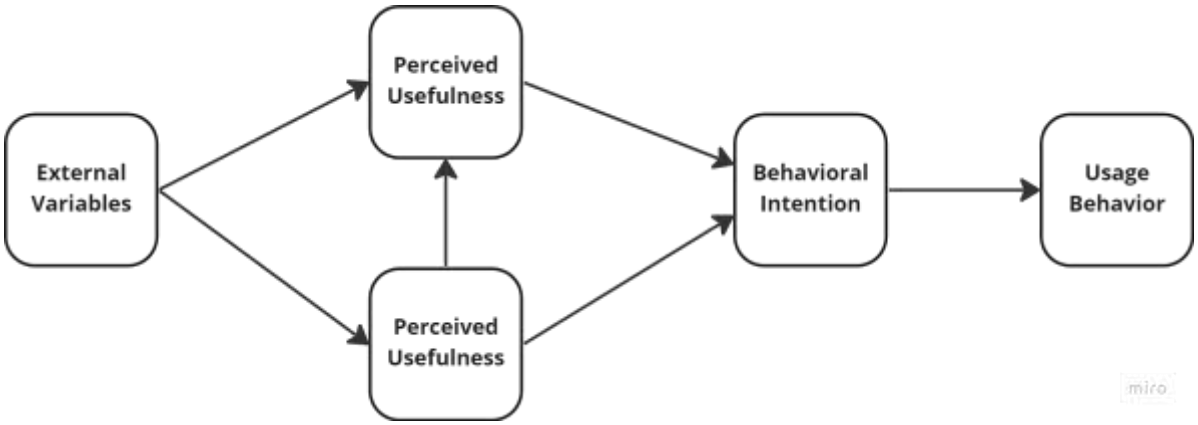
**(Kim et al., 2022)** While criteria pertaining to service quality impact UAM's perceived utility and simplicity of use, trust has a direct impact on attitudes and intentions regarding its use. The intention to

utilize UAM is positively influenced by trust, and the degree to which UAM is perceived as trustworthy is mostly determined by safety. Additionally, the perceived utility and/or convenience of use was largely predicted by criteria related to the quality of the transport service, such as availability, time-saving, comfort during the flight, and perceived cost. Path coefficients of the structural model indicate that trust has a greater impact on the user's attitude toward UAM than perceived usefulness.

**(Kalakou et al., 2023)** open-minded, pollution sensitive, first movers, emergency supporters, skepticals and deniers. Different rules and procedures are needed from the perspective of transport operators and policymakers for the specified clusters. The findings reveal that good sentiments regarding UAM are associated with a stronger intention to use these services, indicating the necessity for further efforts to better understand the expectations of each cluster. The study sheds light on societal aspects of technology deployment and provides insights to UAM stakeholders for the sustainable inclusion of UAM in societies catering for all citizen-related topics and contributing to the development and diffusion of the UAM ecosystem

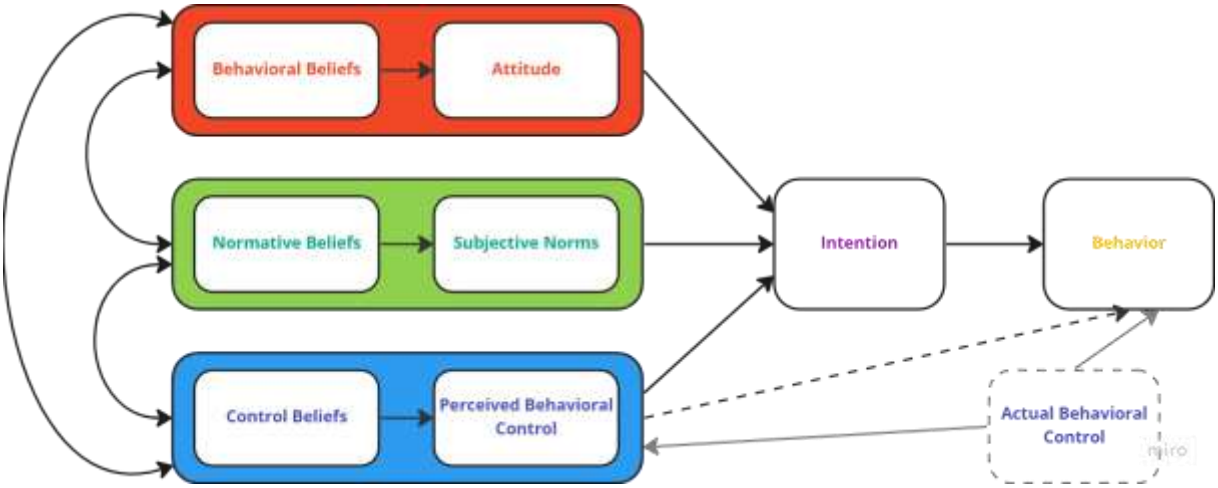
**(Yavas & Yavaş Tez, 2023)** The factors affecting users' acceptance of urban air mobility (UAM) systems, constructing a proposed theoretical urban air mobility acceptance and usage model (UAM-AUM). We propose that the following factors are important in determining behavioural intention to use in this context: intention to fly, UAM conceptual intention, environmental consciousness, UAM affordability, general dependability, and perceived utility variables. The suggested model is highly supported by the results of our structural equation modelling study, which we applied for model validation using data gathered from 348 participants and the UAM-AUM scale. The greatest predictor of user behavioural intention is determined to be perceived utility, which also acts as a mediator between the effects of UAM acceptance and other variables to influence the intention to utilize the system. General dependability is a crucial component in encouraging customers' good intentions toward UAM system utilization.

**Theory Characteristics of Technology Acceptance Model (TAM)**




The Paradigm and Contribution of this model is about the psychological reasoning of a person or group's attitude or behavior. This theory can explain how “users' perception of the usefulness and ease of use of Flying Cars influence the adoption of flying cars for Urban Air Mobility." It defines the attitude towards Behaviour. An individual’s positive or negative feelings (evaluative effect) about performing the target behavior”. Along with the perceived Usefulness. The degree to which a person believes that using a particular system would enhance his or her job performance”. The model also discusses the perceived Ease of Use. In the context of UAM, it refers to how much someone thinks utilizing a specific system would be effortless.

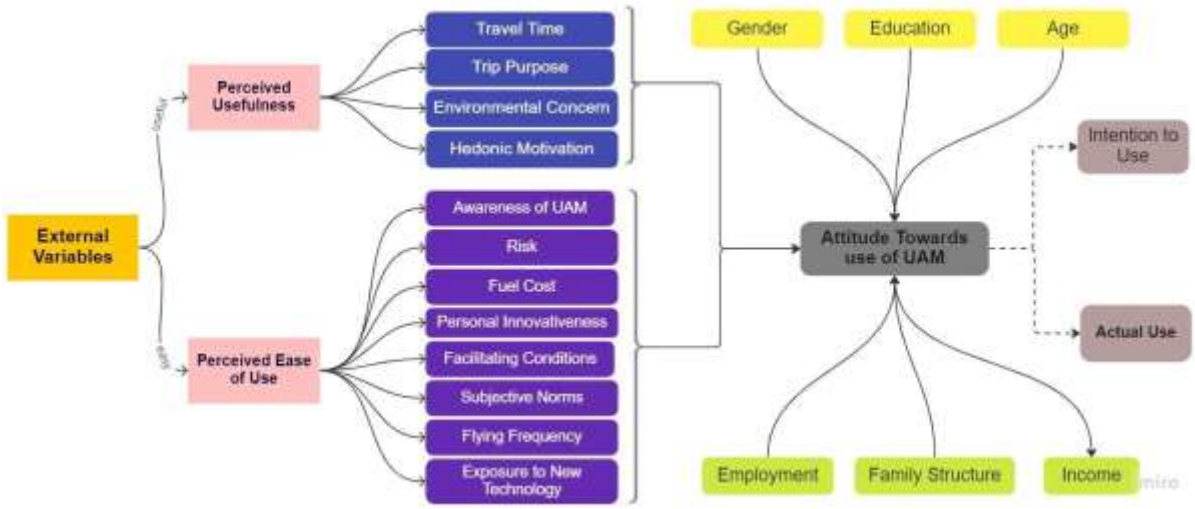
**Theory of Planned Behaviour (TPB)**




Theory of Planned Behaviour (TPB) also discusses the psychological aspects of the attitude and behavior. It can be treated in this paper as the extension of the TAM. This theory explains how components of normative, control, and attitude beliefs influence the uptake of AVs. In this theory the attitude towards the behavior is defined the same as in TAM. However, it further discusses the concept of subjective norm. The individual's belief about what the majority of those who matter to him believe about whether or not he should engage in the action in question. Perceived Behavioural Control plays a significant role in TPB and may be harmful in determining UAM consumer behaviour. The perceived ease or difficulty of carrying out the behaviour is known as perceived behavioural control.

**Interpretation of TAM & TPB for the Acceptance and Adoption of UAM**

In most of the articles reviewed, the technology adoption model and theory of planned behavior have played significant roles in obtaining the factors affecting the acceptance and adoption of UAM. The demographic variables such as gender education and age leads to the exposure of the individual to the new technologies which is also affected by the employment status, family structure and income band of the household. Factors shaping the perception of the potential users of UAM are the time of travel if optimized as compared to other available options. If the purpose of the trip justifies the adoption of UAM in comparison to other available options on roads. The debate over climatic consequences has a very high impact over the uses of high speed transportation. The ethical and moral arguments over the environmental concerns will affect the adoption of UAM. On the contrary, the same concerns and more such concerns will have no bearing over the hedonic motivation of using UAM. The value–image–desire linkages with the UAM will drive the utilitarian motives of the potential users (Han & Hyun, 2019). This literature has also studied the factors shaping the ease of use perception. The perception of UAM being easy enough to be used by the public is shaped by the factors like awareness, ability to perceive risk, cost of use especially the fuel, readiness to engage with innovative technologies, and the condition of the facilities offered by the UAM service providers. The peers, family groups and the social engagements of the individual will also shape the perception of how easy the use of UAM might be. The experiential learning by increased frequency of traveling and exposure to new technologies will also impact the perception of ease of use. However the gap between intention to use UAM and actual use of UAM stays out of the scope of logical deductions.




**Research Gap**

While there have been studies in vehicle concepts, Regulations, Integration, Operations, infrastructure, Market Access and modeling; there have been very few review papers revealing insights on public acceptance of Urban Air Mobility and Intention to use them. There is a knowledge gap and therefore there is a need to systematically study the factors affecting public acceptance of UAM. The search on Public Acceptance of UAM reveals that the publications were very few before 2019 and they have picked up momentum 2020 onwards. Literatures available so far are contributing significant knowledge to explain the role of factors like Demographics, Socioeconomic status, Environmental Concerns, and Perceived Risk upon the acceptance and adoption of UAM but very less or insignificant works have been done so far to measure the impact of factors like Personal Innovativeness, Vehicle Ownership, Mobility Impairment, Trip purpose, Exposure to new technology, Facilitating Conditions, Hedonic Motivation.

**Conclusions**

Articles reviewed to include various researches for understanding factors for UAM public acceptance and intention to use have provided aggregated understanding of the potential business success of UAM. It will further the research on its business validation, profitability, viability and forecasting the market demand. It might also help with decision-making when creating policies and taking other steps to create more intelligent and sustainable urban systems and mobility in cities. UAM Airport Shuttle Services shows that even concepts with sufficient demand might still not be adequate for a valid business case due to incomplete and a so far insufficient critical analysis of the overall operational environment (Straubinger, Michelmann & Biehle, 2021). Literatures available sofar are contributing significant knowledge to explain the role of factors like Demographics, Socioeconomic status, Environmental Concerns, and Perceived Risk upon the acceptance and adoption of UAM but very less or insignificant works have been done so far to measure the impact of factors like Personal Innovativeness, Vehicle Ownership, Mobility Impairment, Trip purpose, Exposure to new technology, Facilitating Conditions, Hedonic Motivation.

UAMs remain at the nascent product stage that has to be widely understood by the public. The flying public's choice of vertiports and air taxis. Convenience of use is rated as less important than safety and security items. Safety risk and cyber risk i.e the risk perception when employing air taxis would help in developing a more clever and effective company plan. The different trip purposes generate significant demands for UAM. The effective and sustainable UAM service should cannibalize existing public

transport options; and second, minimize negative impacts on the environment and society to maximize public acceptance. While criteria pertaining to service quality impact UAM's perceived utility and simplicity of use, trust has a direct impact on attitudes and intentions regarding its use. The intention to utilize UAM is positively influenced by trust, and the degree to which UAM is perceived as trustworthy is mostly determined by safety. Additionally, the perceived utility and/or convenience of use was largely predicted by criteria related to the quality of the transport service, such as availability, time-saving, comfort during the flight, and perceived cost. The structural model's path coefficients show that trust influences the user's attitude toward UAM more than perceived usefulness. Another critical factor for promoting consumers' positive intentions towards UAM system use is general reliability.

**Future Scope for Research**

Future research could focus on market entry strategies, business models for the different submarkets, relevant steps in certification, the competitive situation on the various sub-markets and potential regulatory answers, technological requirements for vehicle design, sensor developments, implications on the operational concept or the impact on third parties and the city. Estimation of the cost to revenue projections and impact on traffic congestion. Personal Innovativeness, Vehicle Ownership, Mobility Impairment, Trip purpose, Exposure to new technology, Facilitating Conditions, Hedonic Motivation are the factors seems important for the further investigation.

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