Research Article

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User-centric Smart City Services for People with Disabilities and the Elderly: A UN SDG Framework Approach

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Abstract: The publication presents the result of extensive research analysing how we can make smart cities more sustainable and inclusive. The central problem was to explore the readiness to adopt inclusive smart services that can sustainably foster, primarily, the inclusion of people with disabilities and the elderly. The secondary audience included the general population, facilitating a comprehensive examination of the varying needs among these demographics. The methodology involved an online questionnaire, formulated based on the Unified Theory of Acceptance and Use of Technology 2 model, and administered to a diverse sample of 302 participants from developing countries, Serbia, Bosnia and Herzegovina, and Montenegro, ensuring a broad representation of gender, age, educational backgrounds, and disability statuses. Key findings indicate a positive inclination towards smart city services across all demographics, particularly among the elderly and people with disabilities. Factors such as ease of use, and opportunities for social engagement are key drivers in the adoption of smart technologies. Research shows that all groups are interested in using smart city services if these would provide extensive environmental information, thereby improving their quality of life. The research contributes to the field by providing actionable insights for policymakers and urban developers to create more accessible and sustainable city environments.

Keywords: sustainable smart city services, United Nations sustainable development goals, readiness to use, marginal groups, increased quality of life

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1 Introduction

The growing potential for smart city development correlates directly with the increased urban population density. Smart city technologies offer daily assistance to residents by delivering extensive environmental information (Caragliu et al., 2011). Smart cities utilise Internet of Things (IoT) technologies, which play a pivotal role in augmenting assistive technologies. These advancements are instrumental in compensating for sensory and motor deficits, thereby promoting the inclusion of people with disabilities (PwD; Neirotti et al., 2014).

Although smart cities have been widely discussed, there is a relative gap in research focusing on their inhabitants, especially PwD and the elderly. Existing studies highlight that the integration of PwD remains a significant challenge, particularly in developing countries (Song, 2014). Literature points to the marginalisation of PwD, who are often excluded from activities and services available to the broader population, such as public transportation and access to public institutions (Tiwari, 2014). Including PwD more actively in society has the potential to decrease unemployment, boost GDP (OECD, 2022), and improve life quality not just for the individuals directly affected, but also for their families and carers (Wolniak & Skotnicka-Zasadzień, 2021).

This research addresses literature gaps, by investigating the readiness of PwD and the elderly to engage with smart city services. The findings were intended to inform and guide the design strategies of smart city service providers, including private enterprises and governmental bodies, enabling them to align their planning and development efforts with the identified needs of these key user groups.

Employing a mixed-method approach, the research combines theoretical development with empirical investigation. Methodologically, the research adopts synthesis, abstraction, generalisation, and classification techniques. The theoretical framework suggests a sustainable inclusive smart city ecosystem that adheres to the principles of universal design. Empirical data were collected through a survey method using an anonymous electronic questionnaire. The questionnaire was designed in alignment with the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) model, supplemented by questions specifically tailored to inclusive smart services. Following the collection of data, structural equation modelling (SEM) was applied to examine and validate the causal relationships within the conceptual framework. Statistical software SPSS and SmartPLS facilitated the analysis, with SPSS handling the descriptive statistics and SmartPLS verifying the model (Kline, 2005). The responses from 302 participants across Serbia, Bosnia and Herzegovina, and Montenegro revealed insights into the collective readiness for adopting smart city services, without a cultural bias necessitating individual country analysis.

The research is organised to cover the theoretical background in the first part of this article, focusing on the main areas in the field: sustainable inclusive smart city services and universal design. From an extensive literature review, we suggest a sustainable inclusive smart city ecosystem with key components that can serve as guidance when modelling sustainable inclusive smart city services. In the second part of the research, we provide insights into an exploratory study. The final part of this article offers recommendations for various stakeholders on how to make smart cities more accessible to all citizens.

2 Literature Review

2.1 The Role of Sustainability in Shaping Smart Cities

The Brundtland Report of 1987, “Our Common Future,” authored by the World Commission on Environment and Development, provides a definition of sustainability, which states: sustainable development is that which satisfies the needs of the current generation without jeopardising the ability of future generations to meet their own needs. Within the context of urban development, sustainability emerges as a crucial paradigm, advocating for the balanced progression of economic vitality, social equity, and environmental stewardship. This concept is further articulated through the framework of the “3Ps” – prosperity, people, and planet – proposed by the OECD (2013) and is expanded by the inclusion of two additional “Ps”, peace and partnerships, underscoring the comprehensive nature of sustainability.

Smart city technologies are increasingly being viewed through the lens of sustainability, focusing not just on system efficiency but also on the social dimensions of urban environments. Caragliu et al. (2011) define a smart city as one that prioritises citizen well-being and development, combining traditional and modern infrastructure to foster sustainable economic growth and enhanced quality of life. This approach emphasises investment in people and wise management of natural resources, integrating public administration participation.

Focusing solely on technological usability can complicate the pursuit of sustainability, necessitating a balanced integration of technology and social needs. This integration requires informed and educated policy-making (Grace et al., 2023), community involvement in smart city development, and innovative management approaches. Pira (2021) suggests that sustainability in smart cities can be viewed either broadly across various sectors or through specific areas such as health, energy, education, and transport (Carafoli et al., 2016; Frez et al., 2019; Gimpel et al., 2021; Rahman et al., 2021). To realise sustainable smart cities, there must be continuous interaction between residents and their urban environment, with information processing (Ko et al., 2018) adding on-going value (Zygiaris, 2013, p. 2).

The most comprehensive approach to understanding smart cities incorporates the principle of sustainability (Bibri & Krogstie, 2021). The author argues that his approach utilises innovative data-driven technologies from smart cities to optimise, enhance, and maintain the performance of sustainable cities. To realise this integration, significant institutional transformations are needed, encompassing new practices and competences.

To address the gap identified in the literature, the subsequent sections will analyse smart city services from the end users’ perspective, prioritising the social aspect over technology. This approach aligns smart cities with sustainability, focusing on the impact on end users as a key driver for a sustainable future.

2.2 The Convergence of Universal Design and Assistive Technology in Smart Urban Environments

The term “consumer normalcy” represents an individual’s engagement in the marketplace across four dimensions:

presence, distinction, competence and control, and equality (Baker et al., 2002). The consumer experience of PwD can be viewed through two lenses: the medical model, which concentrates on the individual's deficiencies, and the social model, which mandates institutional responsibility in ensuring equal service provision through design (Baker et al., 2001).

This article advocates for the social model within the context of smart sustainable cities. The preference for the social model is rooted in the recognition that PwD often belongs to lower socioeconomic statuses and may lack the resources to afford assistive technologies independently.

The broadened definition of disability, for the context of this article, encompasses any condition that diminishes an individual's quality of life and development, whether temporarily or permanently (Institute of Medicine, 2007). Furthermore, the National Academies Press discusses the impact of impairments on an individual's ability to engage in life situations. Functional limitations, whether at the physiologic or anatomic level, are considered measures of the net impact of an impairment or impairments on an individual's capacity. This view recognises that impairments, regardless of their duration, can significantly affect quality of life and daily functioning. The scope of inclusive design now extends to include women experiencing high-risk pregnancies and individuals with temporary injuries, reflecting the growing work on the inclusion of diverse populations.

Universal design, synonymous with inclusive design or design for all, emerged from the need to support the elderly in living independently into later life. This approach has since broadened to encompass the needs of PwD, recognising the overlapping requirements of these demographic groups (Design Council, 2008).

Universal design in the planning of spaces and facilities accessible to all plays a crucial role in enhancing the quality of life for PwD, reducing injury risk and associated costs of rehabilitation, healthcare services, and institutionalisation. Implementing universal design principles enhances public facilities and services, potentially boosting tourism in areas where such inclusive practices are evident.

This research article, in the following section, will analyse smart services through the lens of universal design, particularly focusing on adaptability for PwD and the elderly, who may experience sensory and motor challenges that technologies aim to compensate for. To help promote inclusive smart city designs, we are presenting Figure 1a set of recommendations for universal design, drawing from the guidelines established by the Government of Ireland. These recommendations are substantiated by real-world examples that demonstrate how universal design principles have been effectively implemented in various settings to enhance accessibility and inclusivity.

2.3 Multidimensional Sustainability – The Core of Inclusive Smart City Ecosystem

Based on the current state of the art in literature and our own work, we are suggesting the design of a holistic, multidisciplinary smart city that necessitates a breadth of knowledge across various domains (Zhao et al., 2021). Inclusive planning requires the involvement of all stakeholders, including designers, planners, community members, municipal managers, and residents. Such inclusivity ensures equality in decision-making, fostering a shared vision and respect for collective goals. It is particularly important to integrate PwD and the elderly as active participants in the problem-solving and planning processes to ensure the services meet their specific requirements.

Smart city design emphasises accessibility for all, with effective governance ensuring progress in education, health, and transportation sectors (Carafoli et al., 2016; Frez et al., 2019). The smart city value chain revolves around the gathering, processing, and utilisation of information by both public administrations and individual users to enhance service efficiency and daily living. The smart city ecosystem, supported by diverse stakeholders and public–private–people partnerships (Gao et al., 2023), should be driven by social entrepreneurship and social marketing that originates from the needs of the end customer.

Services within sustainable smart cities should adhere to the cradle-to-cradle principle of resource utilisation. For example, residents could donate old smartphones to city administrations for redistribution to those in need, potentially receiving incentives such as public transport discounts in return.

Sustainability within private companies and social enterprises is most effective when it aligns with organisational strategy and culture, supported by leadership and a forward-thinking ethos. Training for all employees in both public and private sectors on sustainability principles ensures the organisation's commitment to sustainable practices, enhancing the company's reputation.

Universal design and user-friendly products add commercial value for manufacturers, increasing user satisfaction and brand loyalty. The architecture of smart devices and their adaptability to the needs of PwD is critical (Baker & Moon, 2008). Manufacturers and lawmakers play key roles in ensuring that devices are accessible, catering to the growing population of PwD and the elderly. Political directives can motivate businesses to address the needs of these demographics.

Key components of an inclusive sustainable smart city are outlined in Figure 2. Each element within the diagram – Smart people, Social marketing, Inclusive smart city

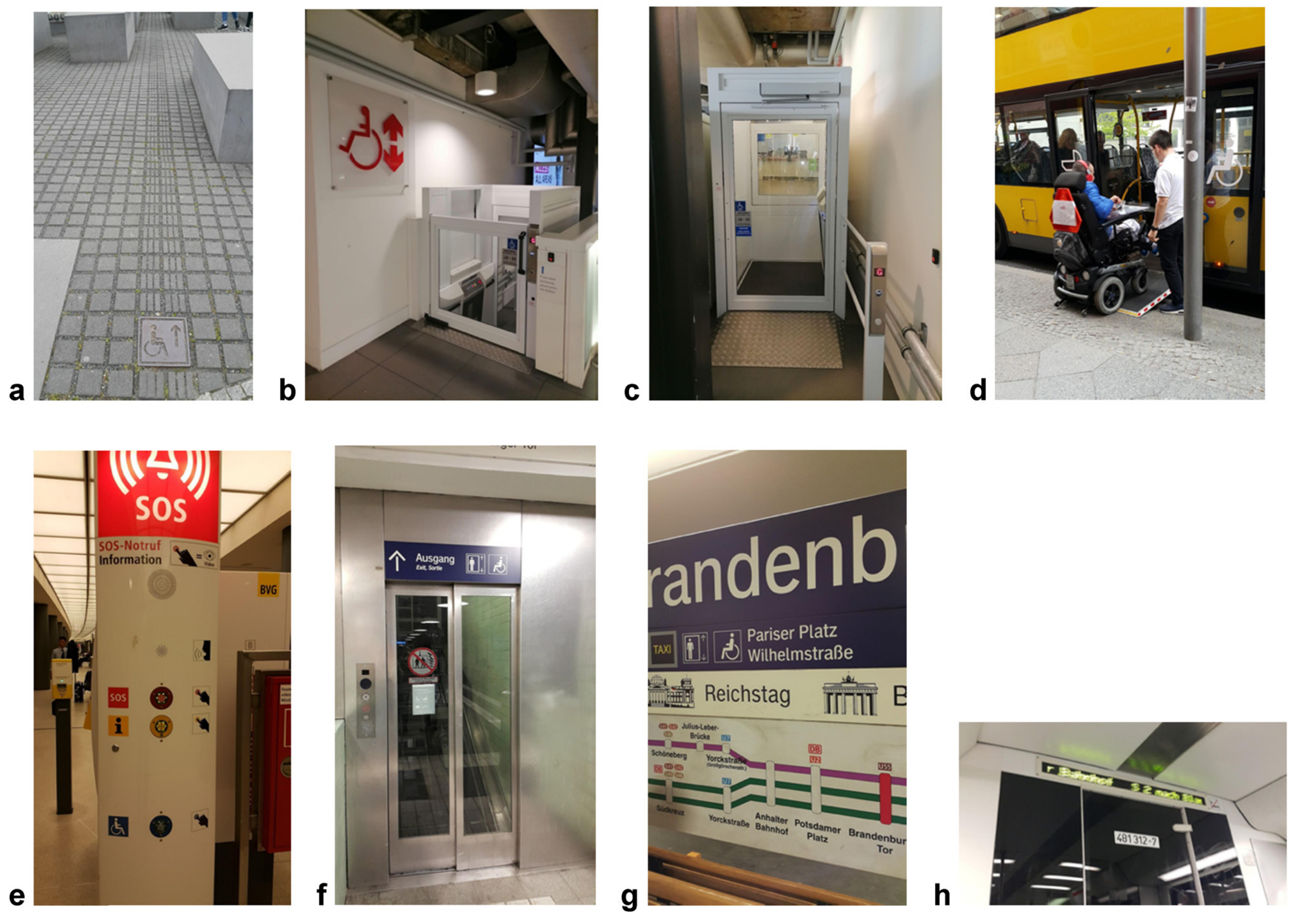

Figure 1: Recommendations for Universal design based on the Government of Ireland enhanced by real-life examples. (a) Intuitive spatial navigation and the accessibility of outdoor areas – Memorial to the Murdered Jews of Europe in Berlin, (b) and (c) The main entrance of facilities should be universally accessible, such as The Imperial College London, allowing all individuals to enter the building, d) Depicts a driver assisting an individual with a motor disability in boarding public transport, exemplifying the crucial role that trained personnel play in facilitating accessibility and mobility for all citizens. Berlin subway accessibility presented in (e) Information accessible in various formats and emergency exits accommodating everyone, (f) Subway accessible to citizens who use wheelchairs, (g) Demonstrates how Berlin's subway system communicates accessibility information effectively, where wheelchair-friendly stations are indicated through visual aids; the use of large fonts and contrasting colours facilitates easy navigation. (h) There are visual cues for deaf individuals, alongside audio notifications that assist blind passengers by informing them of their current location throughout their journey (authors' own resources).

services, Social entrepreneurship, Smart government, Universities, Non-governmental organisations (NGOs), corporate social responsibility (CSR), and foundations such as Sustainable development goals (SDG) goals and Triple bottom line reporting – plays a vital role in the functioning and development of a smart city. Following are the definitions for each suggested component (Table 1).

Elaborating more on a conceptual framework for an inclusive smart city, we are highlighting how various elements influence each other and work together to create a sustainable, smart urban environment.

Smart People through their education, creativity, and digital competence drive the demand for inclusive services and influence the nature and effectiveness of social marketing efforts. They are both the beneficiaries and participants in the city's smart governance and services. Social Marketing is a tool that can significantly impact Smart People by influencing their behaviour and encouraging their participation in sustainable practices. Inclusive Smart City Services are the result of cross-sector collaboration involving Smart Government, Universities, NGOs, and initiatives driven by Social Entrepreneurship.

Social Entrepreneurship initiatives often fill gaps in city services, innovating in areas where traditional corporation solutions may fail to address specific social needs. Smart Government can leverage partnerships with Universities and NGOs to drive innovation and inclusivity in service provision.

Universities contribute to this ecosystem by researching and developing new technologies and methodologies, training Smart people, and fostering a culture of innovation.

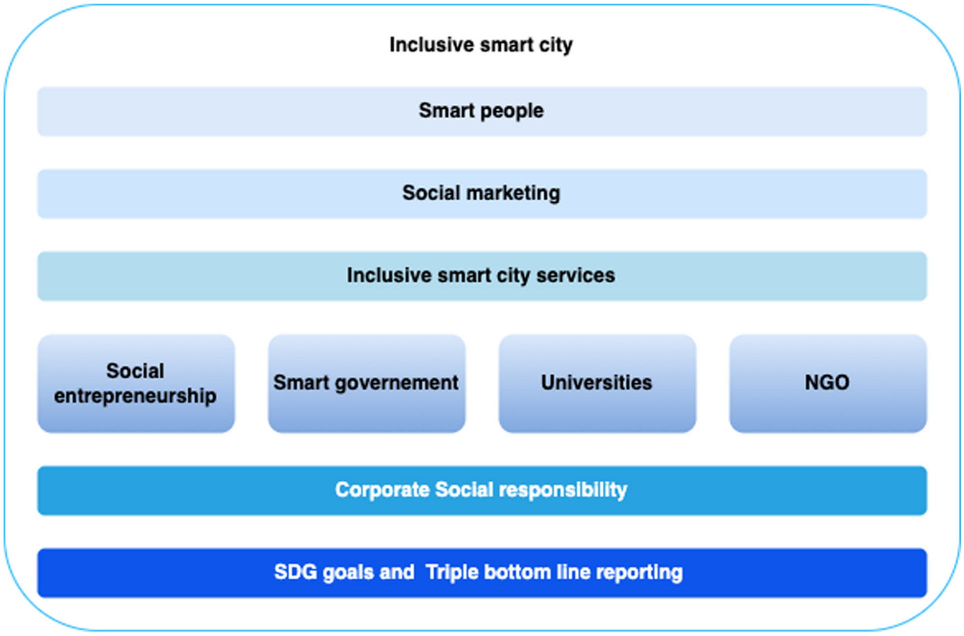

Figure 2: Sustainable inclusive smart city ecosystem.

Table 1: Definitions of components for suggested sustainable inclusive smart city ecosystem

Component	Definition
Smart people	Smart people are an essential component of smart cities, reflecting the human capital within the city in terms of education, creativity, and digital competence. The term often refers to the collective capacity of the city's inhabitants to facilitate sustainable development and quality of life improvements through participatory governance and smart technologies (Giffinger & Gudrun, 2010)
Social marketing	Social marketing is the application of commercial marketing principles and techniques to influence behaviours that will benefit individuals and communities for the greater social good. Effective social marketing campaigns can raise awareness about smart city initiatives, educate citizens about available services, and promote the adoption of these services (Kotler & Zaltman, 1971)
Inclusive smart city services	Inclusive smart city services are those that are accessible to all citizens. These services are designed to ensure that all community members can benefit from smart city initiatives, fostering a more inclusive society (Angelidou, 2015)
Social entrepreneurship	Social entrepreneurship involves the pursuit of innovative solutions to social problems. Social entrepreneurs combine business knowledge and processes to find sustainable solutions with a positive impact on society and the environment (Mair & Marti, 2006)
Smart government	Smart government refers to the use of digital technologies and data-driven approaches by government bodies to enhance public services, foster transparency, and improve the efficiency of governance processes (Gil-Garcia et al., 2015)
Universities	In the context of smart cities, universities are pivotal institutions for generating knowledge, fostering innovation, and providing education that empowers citizens to engage with and contribute to the sustainable inclusive smart city ecosystem (Yigitcanlar & Bulu, 2015)
NGOs	NGOs in smart cities engage in various activities, including advocacy, the delivery of services, and the promotion of public participation. They act as intermediaries between the government and citizens, often driving social innovation and community-led development (Spear, 2006)
CSR	CSR is a self-regulating business model that helps a company be socially accountable to itself, its stakeholders, and the public, pressuring companies to support community inclusion efforts, including work environments (Carroll, 1999)
SDGs	SDGs are a collection of 17 global goals set by the United Nations General Assembly, designed to be a "blueprint to achieve a better and more sustainable future for all" by the year 2030. United Nations (2015)
Triple bottom-line reporting	Triple bottom-line reporting expands the traditional reporting framework to consider social and environmental performance in addition to financial performance (Elkington, 1997)

NGOs often advocate for underserved populations and can be instrumental in ensuring smart city services are truly inclusive. CSR initiatives can support the goals of an inclusive smart city by funding innovations, providing services, or through advocacy and partnership efforts. SDG and Triple Bottom Line Reporting provide a strategic foundation and an evaluative framework for all the other elements. They ensure that the smart city's development aligns with broader global sustainability objectives.

When addressing sustainability in smart cities, we suggest that the United Nations SDG should be used, with appropriate indicators that would be used as a measure to implement sustainability of the city. The United Nations (2022) is providing several targets and indicators under United Nations Sustainable Development Goal 11, which is focused on making cities and human settlements inclusive, safe, resilient, and sustainable. These targets address a range of issues from ensuring access to adequate housing and basic services, developing safe and sustainable transport systems, promoting inclusive urbanisation, safeguarding cultural and natural heritage, reducing disaster impacts, improving environmental conditions in urban areas, to providing access to safe and inclusive green public spaces. Each target is accompanied by specific indicators to measure progress towards achieving these objectives by the year 2030.

It becomes clear that the advantages of implementing smart inclusive services extend beyond mere accessibility and that the broader social implications are profound. As individuals, particularly those with disabilities and the elderly, become proficient in navigating one digital solution, they inherently equip themselves to overcome further digital challenges. This mastery can significantly boost self-confidence, igniting a drive towards overcoming additional barriers and achieving complete societal integration.

3 Conceptual Model Development

The survey was designed around the UTAUT2 framework to assess readiness for adopting new technologies, incorporating specific questions tailored to smart inclusive services. The UTAUT2 is an extension of the original UTAUT model, which Venkatesh, Thong, and Xu introduced in 2012 to provide a more comprehensive understanding of technology adoption in consumer contexts. UTAUT2 integrates elements from the original model – performance expectancy, effort expectancy, social influence, and facilitating conditions – with three additional constructs: hedonic motivation, price value, and risk. These additions reflect the intrinsic enjoyment of using technology, the cost–benefit analysis consumers undertake, and the degree to which using the technology becomes a part of their daily routine. UTAUT2 has been widely applied in various fields to predict and explain consumer acceptance and use of technology, proving to be a robust framework that accounts for a significant proportion of the variance in user acceptance (Venkatesh et al., 2012).

The primary dependent variables – users' behavioural intention to adopt an inclusive smart service and their perceptions of its potential to enhance quality of life – are scrutinised. The independent variables, following the UTAUT2 model, include Performance Expectancy, Effort Expectancy, Facilitating Conditions, Social Influence, Perceived Risk, Price Value, and Hedonic Motivation. The influence of these variables is analysed across different demographics, considering factors such as age, gender, educational background, and the presence or absence of a disability. The questionnaire was designed to examine the readiness to use new technologies, with additional questions specifically related to smart inclusive services (Figure 3).

Individual hypotheses developed based on UTAUT2 model are as follows:

H1. Performance expectancy affects the willingness to use smart inclusive services depending on age, gender, level of education, and degree of disability.

H2. Effort expectancy affects the willingness to use smart inclusive services depending on age, gender, level of education, and degree of disability.

H3. Facilitation expectancy affects the willingness to use smart inclusive services depending on age, gender, level of education, and degree of disability.

H4. Social impact affects the willingness to use smart inclusive services depending on age, gender, level of education, and degree of disability.

H5. Perceived risk affects the willingness to use smart inclusive services depending on age, gender, level of education, and degree of disability.

H6. Hedonic motivation affects the willingness to use smart inclusive services depending on age, gender, level of education, and degree of disability.

H7. Price value affects the willingness to use smart inclusive services depending on age, gender, level of education, and degree of disability.

H8. Willingness to use smart inclusive services affects the quality of life of citizens.

3.1 Research Methodology

In this research, a variety of general and specific scientific methods and techniques were employed to ensure the

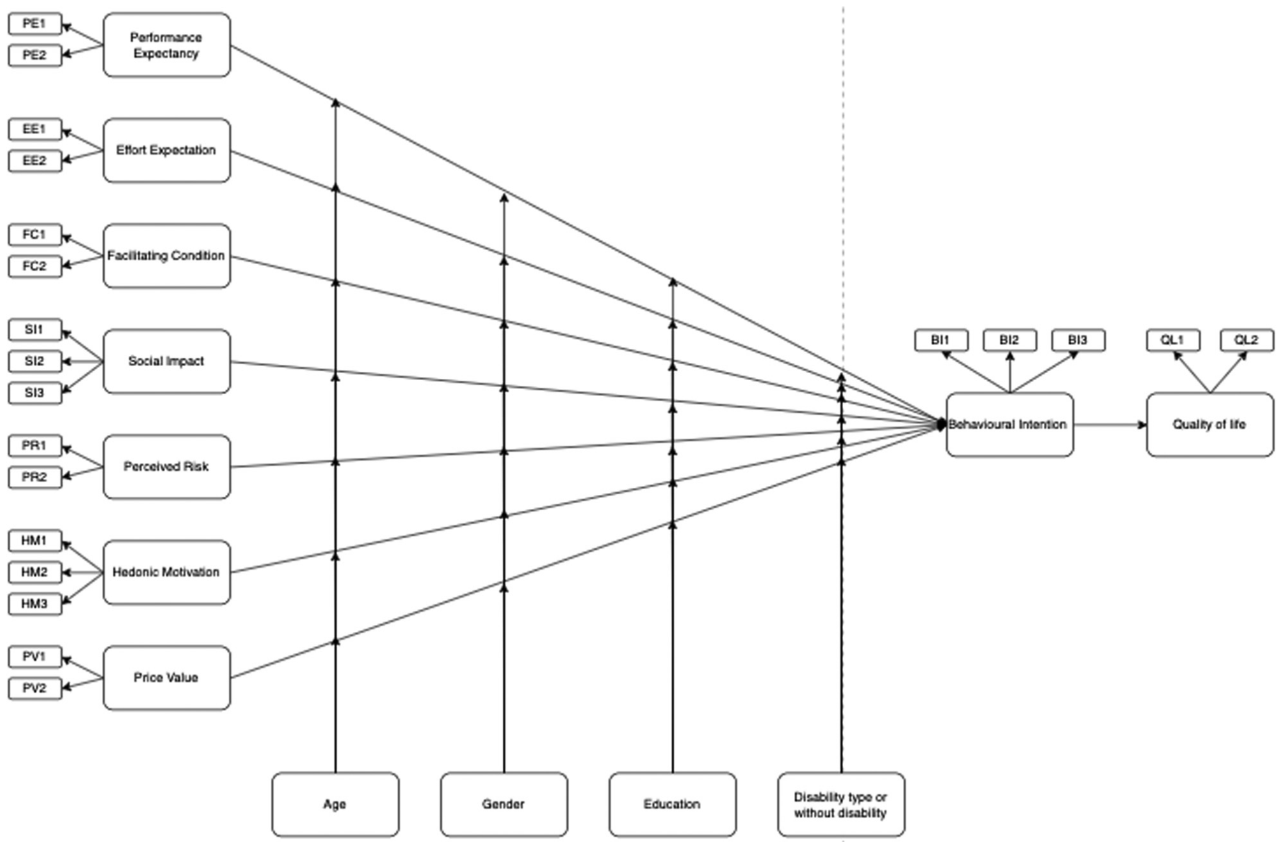

Figure 3: UTAUT2 model with variables and predictors, used as a base for the questionnaire for readiness.

acquisition of dependable results. The early phase involved utilising analytical methods to review existing literature and evaluate current smart city solutions. The descriptive method provided a detailed exposition of the challenges related to the inclusion of PwD and the potential solutions offered by smart city services. Inductive reasoning underpinned the formulation and validation of hypotheses.

The results are instrumental in validating the central hypothesis that posits an increase in inclusivity and ease of daily activities for PwD using smart city services. This methodological approach was selected to ensure a comprehensive study of the research process across all stages – problem identification, research design planning, data collection and analysis, and conclusion formulation – abiding by the fundamental tenets of scientific inquiry.

3.2 Data Collection Process

In the context of research concerning the Balkan region, particularly for the nations of Serbia, Bosnia and Herzegovina, and Montenegro, it is often considered acceptable to treat them as a singular population for analytical purposes. This is due to the relatively homogenous cultural characteristics that these countries share, stemming from their historical, linguistic, and social ties. As of the latest available statistics, Serbia has a population of approximately 7 million (Statistical Office of the Republic of Serbia, 2022), Bosnia and Herzegovina around 3.5 million (Agency for Statistics of Bosnia and Herzegovina, 2022), and Montenegro close to 620,000 (Statistical Office of Montenegro, 2022). Within these populations, it is estimated that around 8–10% of people are living with disabilities, and the elderly (aged 65 and over) constitute approximately 17–20% of the population. OECD (2022) The analysis benefits from the cultural congruence across these populations, allowing for a more streamlined approach to data interpretation and policy recommendation.

Participant access was facilitated through an online platform provided by Aparteko, a company with a user base of approximately 8 million across the Balkan region, as of 2011 (Aparteko, 2011). Aparteko is renowned for its "Slagalica" quiz, a highly popular family-oriented quiz show in the region, initially broadcast on TV RTS1 in 1993 (RTS, 2019). This database was specifically selected due to its diverse demographic coverage in terms of age, gender, and other variables, thereby meeting the requirements for a varied survey sample. The questionnaire was integrated into the user experience and presented to participants prior to engaging in gameplay across multiple platforms, including Facebook, as well as Apple and Android mobile applications. The survey was conducted from 1–20 August, 2022, during which time a mixed, representative sample segment was successfully compiled.

The study employed an anonymous online questionnaire consisting of 26 questions (Table 2). These included four demographic questions, 21 items evaluating the participants' readiness to adopt inclusive smart city services, and one open-ended question allowing respondents to voice additional concerns or comments on the given topic. A total of 302 individuals from Serbia, Bosnia and Herzegovina, and Montenegro participated in the study. Comprehensive demographic details of the participants are provided in Table 3.

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

3.3 Statistical Analysis

To evaluate the proposed conceptual model, the authors opted for the SEM analysis. SEM is a statistical multivariate analysis developed to explore and evaluate causal relationships (Kline, 2005). The SEM analysis stands on the principles of two statistical analyses: Principal component analysis (PCA) and multiple linear regression. The PCA allows the grouping of measured variables, in our case items or questions, into latent variables or constructs. Latent variables are variables which are newly formed as a linear combination of the measured variables which make them. Multiple linear regression allows the evaluation of the causal relationships between latent variables or between latent and measured variables (Asparouhov & Muthén, 2009).

When it comes to the SEM analysis, authors can choose between two methods: covariance-based SEM (CB-SEM) and partial least squares SEM (PLS-SEM). The CB-SEM was the first SEM method proposed and is observed as a parametric SEM. Being a parametric SEM analysis, there are multiple assumptions that must be met to conduct it, such as Normality of the data, sample size, and number of items per construct (Jöreskog & Sörbom, 1984). On the other hand, the PLS-SEM is seen as a non-parametric approach to SEM, which has loosened preconditions. Also, there is a slight difference in their goals: CB-SEM is primarily used to confirm theories, while the PLS-SEM represents a causal–predictive approach to SEM that emphasises prediction in estimating models (Hair et al., 2021).

The application of SEM analysis, both CB-SEM and PLS-SEM is wide and ranges from application in the field of marketing to human resource management (Jovanović et al., 2022) and assessment of organisation performance (Farrell & Mavondo, 2005). In the beginning, most of the studies in which the SEM was applied were related to the CB-SEM. However, a recent bibliometric study shows that PLS-SEM use has gained momentum relative to factor-based SEM in recent years (Ciavolino et al., 2022). Due to the above-mentioned and the wide range of software available for its implementation, PLS-SEM analysis has been increasingly applied to verify conceptual models in different fields of study (Hair et al., 2014). To verify the conceptual model proposed in this study, the authors used PLS-SEM and the SmartPLS Software version 4 (Smart PLS GmbH, 2023).

To evaluate the statistical significance of the paths between the constructs, we performed bootstrapping on 5,000 samples. Bootstrapping is a standard procedure in the application of PLS-SEM analysis. The aim of this approach is to randomly create samples from the overall sample and to apply the PLS-SEM to each of the created samples (Cheung & Lau, 2008). The obtained results are used to generate an empirical sampling distribution for each model parameter and to test its statistical significance (Hair et al., 2018).

To compare the models between different groups, we used the PLS Multigroup analysis (PLS-MGA). This approach is explained in detail in the works of Sarstedt et al. (2011) as well as Hair et al. (2018). Basically, a PLS-SEM model is created for each of the observed groups and different statistical tests are used to determine whether there are statistically significant differences between the calculated path coefficients. It is important to note that these tests do not compare the overall models, whereas they compare only the values of the path coefficients.

Regarding the field of the study, several conceptual models have been proposed and verified using SEM analysis. Pal et al. (2018) wanted to observe the end user perspective on the IoT (Abadía et al., 2022) and smart homes for elderly care. The authors created a complex nine-construct model which they validated using PLS-SEM and showed that the extended UTAUT model is valid in the Asian context. Maswadi et al. (2022) created a model of factors influencing the elderly's behavioural intention to use smart home technologies and tested it in Saudi Arabia. The results of the SEM analysis pointed out that with slight modification the model can be successfully implemented. Also, in a recent study, Dadhich et al. (2022) created a structural model to determine the purpose of using IoT gadgets in the clinical background and tested its validity using PLS-SEM. The same authors also noted that the PLS-SEM has been used with success in IoT healthcare research and provided valuable insights which can lead to further developments of these devices.

Table 2: Questionnaire used in this research

UTAUT2 variables	Questions used in research
Performance Expectation	PE1 – Using an inclusive smart city service, which provides me with information about various events and services around me, would help me navigate around the city more easily
	PE2 – Using a smartphone helps me get the information I need faster and improves my mobility around the city
Effort Expectation	EE1 – If there is organised training for how to use a smart inclusive city service, I need it and would be very happy to attend
	EE2 – I am confident that I have the necessary skills and knowledge to deal effectively with most problems that may arise with my usage of a smart mobile device (e.g. lost Internet connection)
Facilitating Condition	FC1 – I have access to the Internet wherever I am
	FC2 – I have a smart mobile device and I take it with me when I leave the house
Social Impact	SI1 – I think that public administration/private business systems should support the inclusion of PwD and the elderly in cities, by investing in smart technologies that facilitate the inclusion of PwD, the elderly, and residents in general
	SI2 – If the inclusive smart service provided by the public administration or private institution is well rated by the city population, I would use it
	SI3 – I would use a smart city service if I receive a recommendation from someone important to me that I should use it
Perceived Risk	PR1 – I am concerned that my private data from a smart mobile device may be misused
	PR2 – I think sharing my data with a smart service and making it available to the public administration is risky
Behavioural Intention	BI1 – If I saw in the inclusive smart service app that a disabled person/elderly person near me needed help, I would respond to help him/her navigate around the city
	BI2 – If the application/inclusive smart service gives me information about a disabled person with whom I need to meet, how to provide assistance to him/her, I would use it before meeting with that person
	BI3 – I plan to use the inclusive smart city service to get around the city if it becomes available
Quality of Life	QL1 – I think that using an inclusive smart city service where I can find all the necessary information in the environment in which I live and report problems around me is a simple way to communicate my needs to the city administration
	QL2 – I consider that an inclusive smart city service is useful for society in general and contributes to improving quality of my life
Price Value	PV1 – I am concerned that the price of a smart mobile device is unaffordable/expensive for me
	PV2 I think that an inclusive smart city service should be charged for usage according to the value it provides
Hedonic Motivation	HM1 – Which of the following pieces of information would you like to receive when in a public place, via an Internet connection? (You may choose up to three answers): • To find people in the area to hang out with • To find people around me who can help me • To check the weather forecast • To check the air pollution around me • To check where the crowds are in the pedestrian areas • To find the nearest local event • To find information about public transport (nearest station, transport arrival time) • To access maps for navigation.
	HM2 – For what activities would you/do you use the Internet? (Multiple answers may be chosen): • Google Maps/Similar Navigation Apps • For entertainment (music, video games, videos) • To receive calls/messages or call via Whatsapp/Viber • To read the daily news • For social networks (FB/IG/Twitter, etc.) • To check the weather forecast.
	HM3 – Which of the following do you think should be the priority of the public administration when introducing novel services for PwD (it is possible to choose up to four answers): • Security and data security of inclusive smart services • Transportation adapted to people with temporary or permanent disabilities/Elderly people and information on transportation • Access and information about educational content • Access to health care facilities • Adaptation of tourist attractions • Access and information about discounts from supermarkets and shops I pass • Access and information about banks and ATMs around me • Available button for quick help in emergency situations (automatic call of an ambulance or the nearest help around me).

Source: Authors' own work.

Led by these examples of good practice, as well as the fact that nonparametric SEM techniques are appropriate for multigroup analysis (Henseler et al., 2016), we chose the SEM analysis, its PLS variant, and the Smart PLS software to verify the proposed conceptual model.

4 Results

In this section, we present the results of our empirical study. After the surveying window was closed, the data were analysed using statistical software SPSS and SmartPLS. SPSS was used to perform the descriptive statistics analysis, while the SmartPLS was used to verify the conceptual model. To present the results in a structured manner, the section is divided into three subsections: sample characteristics, construct validity tests, and finally PLS-SEM results.

4.1 Sample Characteristics

The descriptive analysis of the sample shows that 302 participants took part in the survey. Half of the sample is females (50.66%), while males make up 47.68% of the respondents. The remaining 1.66% of the respondents declared their gender as Other. The age of the respondents was measured in five groups. Most of the sample (28.28%) are respondents older than 64 followed by those who are between 45 and 64 years of age (23.84%) and those who are between 25 and 34 years of age (20.86%). The remaining two groups are almost equally represented. When it comes to educational attainment, the respondents were grouped into two classes: those with lower and middle education (61.26%) and those with higher education (38.74%). For this variable, we opted for level collapsing. The idea of level collapsing is to fuse the levels of the categorical variables presuming their effects to be equal (Gertheiss & Tutz, 2010). Herein, we collapsed the categories of primary education and secondary education. The last characteristic of the sample presented here was the type of disability the respondent has or has not any type of disability. Most of the respondents can be classified as those who do not have a disability (41.72%), followed by those with motoric disability (31.46%). A smaller percentage of the respondents has other disabilities (17.89%) and sensory disability (8.93%). The sample is presented in Table 3.

The three questions within the construct *Hedonic motivation* were measured as the number of information the respondent wants to get in a public place when using the internet, the number of activities the respondent uses the Internet, and priorities in the respondents' perspective regarding the introduction of innovation for the disabled. To provide in-depth analysis and insights, in the next paragraphs, we present their answers in more detail.

When it comes to question HM1 and the information, the respondent wants to get in a public place when using the internet, 302 respondents provided 779 answers. On average, 2.57 answers per respondent. The obtained frequencies are presented in Figure 4. The most chosen information was the information regarding maps and navigation (22.5% of all answers), followed by public transport (19.9% of all answers), and weather (17.2% of all answers). The results also indicate that the respondents were the least interested in the information regarding air pollution, just 6.4% of all answers.

Respondents provided interesting insights regarding what they use the internet for (HM2); 897 answers were collected indicating that on average, the respondents used the Internet for 2.97 activities. The obtained frequencies are presented in Figure 5. The most chosen activity was sending and receiving messages (23.4% of all answers), followed by finding navigation (22.7% of all answers). The results also indicate that the rest of the offered activities have been chosen in a significant percentage. The activity which was chosen the least number of times was fun (music, games, and video), 11.7%.

It was valuable to collect information regarding the respondents' perspective on what the local communities and governments should focus on regarding the

Table 3: Sample characteristics

Variable	Frequency	Percentage
Gender		
Male	144	47.68
Female	153	50.66
Other	5	1.66
Age		
Below 25	38	12.60
Between 25 and 34	63	20.86
Between 35 and 44	43	14.24
Between 45 and 64	72	23.84
Above 64	86	28.28
Educational attainment		
Lower and middle education	185	61.26
Higher education (Bsc, Msc, PhD)	117	38.74
Type of disability		
Motoric disability (sport injury, complicated pregnancy, person is in a wheelchair)	95	31.46
Sensory disability (dyslexia, blindness, deaf)	27	8.93
Other	54	17.89
No disability	126	41.72

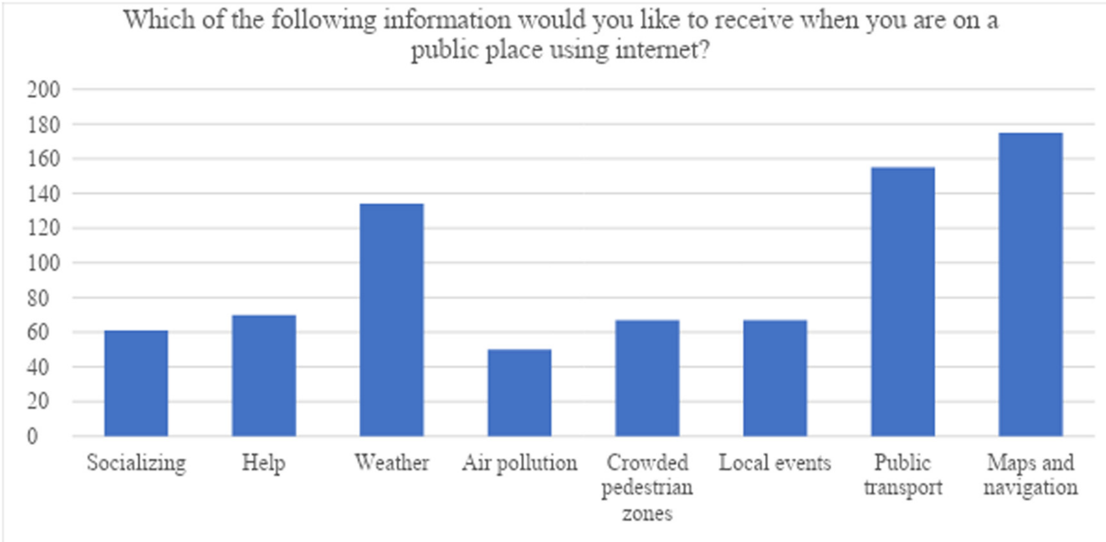

Figure 4: The information the respondents are interested in obtaining when in a public place, using the Internet.

introduction of innovation for the disabled. In total, 1,024 answers were collected, indicating that on average the respondent had 3.39 priorities marked. The innovation which was most frequently marked was the security and data security of inclusive smart services (19.9%), followed by transport suitable for people with temporary or permanent disabilities/Elderly people and information about transport (16.3%), and access to healthcare facilities (14.6%). The frequencies are presented in Figure 6.

4.2 Construct Validity Tests

One of the prerequisites when conducting SEM analysis is to observe the internal consistency and discriminant validity of the defined constructs. As well, it is valuable to inspect the possible issue of multicollinearity in the model. In the following paragraphs, we present the results of the conducted tests.

The most used metric of scale reliability is Cronbach's alpha (Cronbach, 1951). Average Variance Extracted (AVE), and Dijkstra-Henseler's rho A (Dijkstra & Henseler, 2015) indices take values from 0 to 1, where the closer they are to 1, the better the internal consistency is, thus indicating that the scale is reliable. The widely accepted level of acceptance of Cronbach's alpha is above 0.7 (Gliem & Gliem, 2003), while for AVE and rho A, it is above 0.5 (Dijkstra & Henseler, 2015). The calculated indices of internal consistency per construct alongside the number of items per construct are given in Table 4. All the indices were calculated on the overall sample. Out of nine constructs, six

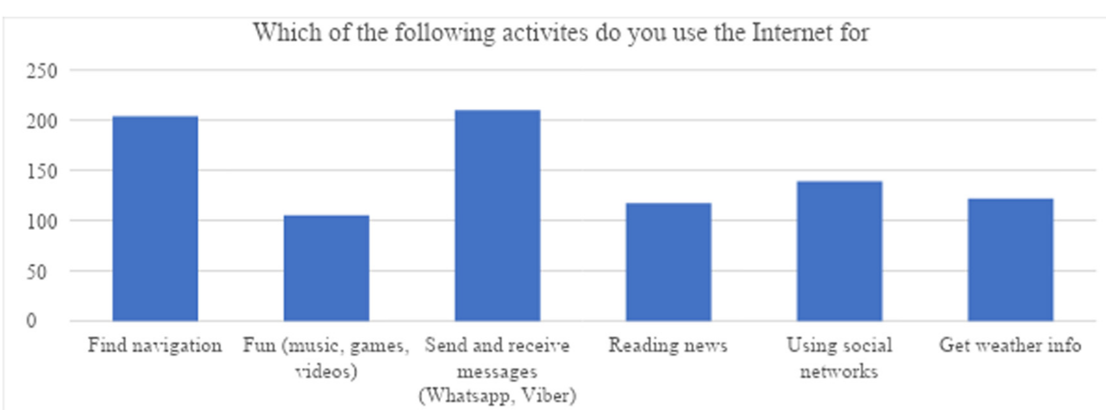

Figure 5: The activities respondents use the Internet for.

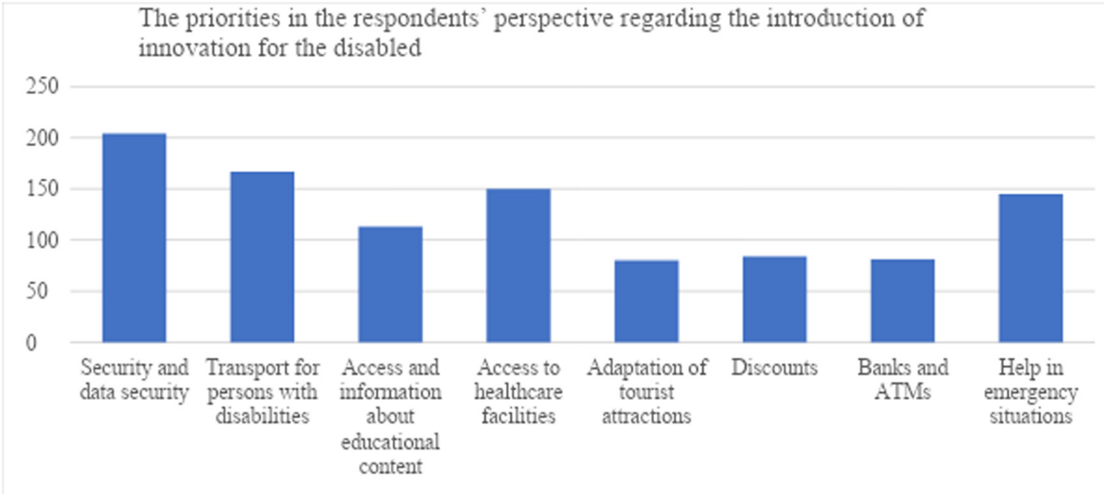

Figure 6: The priorities of the respondents' perspective regarding the introduction of innovation for those with disabilities.

have satisfactory scale reliability with Alpha, AVE, and rho A above or marginally close to the defined thresholds. However, three constructs draw attention to low construct reliability: EE, HM, and PV.

The measured reliability can be quite low for constructs with just two items. Namely, Cronbach's alpha is sensitive to the number of items per scale, whereas a low number of items might lead to a low Cronbach's alpha (Gliem & Gliem, 2003). Having in mind that EE and HM, have two and three items per scale, we can conditionally accept the reliability of EE and HM. However, the measured reliability of PV clearly indicates that changes have to be made to this construct. The change to the model that we introduced was the inclusion of the variables PV1 and PV2 individually.

The next analysis is related to the discriminant validity of the constructs. To do so, we used the Fornell–Larcker criterion which compares the amount of variance captured by the construct's AVE and the shared variance with other constructs (Fornell & Larcker, 1981). The discriminant validity compares the correlations between each pair of constructs and the value of the square root of the AVE of each construct. In other words, the discriminant validity assessment has the goal of ensuring that a reflective construct has the strongest relationships with its own indicators (e.g. in comparison with any other construct) in the PLS path model.

The results of the discriminant validity analysis are given in Table 5. The values in the table which are bold represent the square roots of AVE, while all other values indicate the correlation among constructs. The Fornell–Larcker criterion is satisfied when the value on the diagonal is greater than the correlations in the same row and column. The presented results indicate that the discriminant validity is confirmed in the proposed model.

Relevant literature in the field suggests that multicollinearity can significantly impact the quality of the SEM model (Jagpal, 1982). Multicollinearity is a statistical phenomenon which occurs when there is a high level or correlation among the variables in the model. High level of correlation among the variables leads to biased estimates, high standard errors, and inflated values of the *t*-statistics. Therefore, the potential presence of multicollinearity should be inspected. To assess the presence of multicollinearity, we used the variance inflation factor (VIF). If the value of VIF is above 5, there is multicollinearity in the model. Otherwise, there is no multicollinearity in the model. The obtained VIF per item is provided in Table 6. It can be concluded that there is no multicollinearity in the observed model.

Table 4: Obtained Cronbach's alpha, rho A, and AVE per construct and number of items per construct

Construct	PE	EE	FC	SI	PR	HM	PV	BI	QoL
Number of items	2	2	2	3	2	3	2	3	2
Alpha	0.715	0.382	0.728	0.768	0.599	0.512	0.159	0.668	0.793
AVE	0.634	0.612	0.786	0.683	0.706	0.660	0.542	0.751	0.707
Rho A	0.721	0.420	0.728	0.821	0.678	0.613	0.167	0.670	0.793

Source: Authors' own work.

Table 5: Discriminant analysis of the defined constructs

	PE	EE	FC	SI	PR	HM	PV1	PV2	BI	QoL
PE	0.840									
EE	0.639	0.783								
FC	0.557	0.429	0.887							
SI	0.654	0.602	0.366	0.841						
PR	0.166	0.161	0.088	0.231	0.812					
HM	0.333	0.244	0.342	0.307	0.038	0.826				
PV1	0.104	0.186	0.035	0.184	0.361	−0.044	1			
PV2	0.129	0.285	0.006	0.223	0.276	−0.117	0.087	1		
BI	0.718	0.621	0.364	0.780	0.219	0.373	0.220	0.164	0.796	
QoL	0.696	0.647	0.326	0.742	0.144	0.279	0.155	0.245	0.753	0.866

4.3 PLS-SEM Results

In the paragraphs that follow, we present the results of the PLS-MGA. We conducted four MGA, one per each categorical variable we previously defined. The explored and compared models are the models per gender category, per age category, per type of disability, and per educational attainment. The statistical procedure for all four models was the same and is as follows. Among the several MGA comparison tests, we opted for the Bootstrap MGA.

4.3.1 Comparison of Models per Gender Category

The first MGA model that we tested and compared were the female and male models. The five respondents who declared themselves as "other" were not considered in this analysis. The results show that in both models the PE, SI, and HM are statistically significant predictors of the BI. The same accounts for the BI as the predictor of the QoL. In models for males and females, all obtained statistically significant coefficients are positive, meaning that the increase in the value of the predictor increases the value of the dependent construct. For example, if PE increases for one unit, the BI will increase by 0.254. The obtained R squares for BI and QoL in both male and female models are satisfactory, indicating that the models have explanatory power. The results of the bootstrap MGA p-value indicate that there is no statistically significant difference between the path coefficients within the two observed models. This analysis points out that male and female respondents behave in the same way regarding the behavioural intention to use inclusive smart city apps and that Performance Expectation, Social Impact, and Hedonic motivation are factors which impact their decision. Hypothesis H1, H4, H7, and H8 are partially confirmed (Tables 7 and 8).

4.3.2 Comparison of Models per Age Category

In the second MGA, we compared five models based on the respondents' age. The answers of all 302 respondents were analysed using the same procedure as in the previous model. The models for the respondents below 25 and between 35 and 44 behave in the same way. For these two age groups, SI is the only statistically significant predictor of BI, and BI has a positive statistically significant

Table 6: Results of the CFA and multicollinearity analysis

Construct	Item	VIF	Construct	Item	VIF
PE	PE1	1.224	HM	HM1	1.880
	PE2	1.224		HM2	1.331
EE	EE1	1.059		HM3	1.905
	EE2	1.059	PV	PV1	1.008
FC	FC1	1.486		PV2	1.008
	FC2	1.486	BI	BI1	1.572
SI	SI1	1.457		BI2	1.629
	SI2	1.931		BI3	1.242
	SI3	1.897	QL	QL1	1.337
PR	PR1	1.134		QL2	1.337
	PR2	1.134			

Table 7: Results of the bootstrap MGA for female gender

Dependent construct	Predictor	Beta	t	R^2	Bootstrap MGA p-value
BI	PE	0.254	2.991*	0.707	No statistically significant differences
	EE	0.107	1.467		
	FC	−0.087	−1.157		
	SI	0.542	7.344*		
	PR	0.018	0.376		
	HM	0.143	3.022*		
	PV1	0.054	1.020		
	PV2	0.015	0.321		
QoL	BI	0.760	21.985*	0.577	

Note: *p < 0.001.

Table 8: Results of the bootstrap MGA for male gender

Dependent construct	Predictor	Beta	*t*	R^2	Bootstrap MGA *p*-value
BI	PE	0.364	5.785*	0.672	No statistically significant differences
	EE	0.135	1.878		
	FC	−0.092	−1.305		
	SI	0.433	6.727*		
	PR	0.033	0.558		
	HM	0.114	2.569*		
	PV1	0.097	1.942		
	PV2	−0.054	−1.024		
QoL	BI	0.700	13.014*	0.490	

Note: *$p < 0.001$.

impact on QoL. We can say that for these two groups of respondents, social impact has an impact on the behavioural intention. The behavioural intention of the respondents in the group of age between 45 and 65 is under the impact of social impact and performance expectancy. Those between 25 and 34 are additionally influenced by hedonic motivation. Those of age 64 and above and their behavioural intentions are impacted by PE, FC, SI, and HM. The *R* square of BI ranges from 0.596 (age between 45 and 64) to 0.883 (Age below 25), while the *R* square of QoL ranges from 0.355 (age between 45 and 64) to 0.687 (age below 25). The bootstrap MGA *p*-values are not presented for all pairwise comparisons of coefficients. However, there was one statistically significant difference detected, for the path between BI and QoL, between models of those below 25 years of age and those who are between 45 and 64. This result indicates that there is statistically significant behaviour between respondents from these two groups regarding the impact of BI on QoL – the impact is stronger for those within the age group below 25. Finally, the analysis shows that H1, H3, H4, H6, and H8 are partially confirmed (Tables 9–13).

Table 9: Results of the bootstrap MGA for age below 25

Dependent construct	Predictor	Beta	*t*	R^2	Bootstrap MGA *p*-value
BI	PE	0.204	1.499	0.883	QoL < -BI, Below 25 > Between 45 and 64, *p* = 0.042
	EE	−0.054	−0.389		
	FC	0.101	0.689		
	SI	0.606	5.299*		
	PR	0.044	0.488		
	HM	0.115	1.566		
	PV1	−0.001	−0.007		
	PV2	0.148	1.570		
QoL	BI	0.829	13.591*	0.687	

Note: *$p < 0.001$.

Table 10: Results of the bootstrap MGA for age range between 25 and 34

Dependent construct	Predictor	Beta	*t*	R^2	Bootstrap MGA *p*-value
BI	PE	0.351	3.656*	0.780	QoL < -BI, Below 25 > Between 45 and 64, *p* = 0.042
	EE	0.181	1.596		
	FC	0.004	0.038		
	SI	0.337	3.090*		
	PR	−0.086	−1.061		
	HM	0.216	2.700*		
	PV1	0.059	0.831		
	PV2	0.078	0.899		
QoL	BI	0.778	11.479*	0.606	

Note: *$p < 0.001$.

4.3.3 Comparison of Models Based on the Respondents' Disability

In the third MGA compared are four models based on the respondents' disability. The answers of all 302 respondents

Table 11: Results of the bootstrap MGA for age range between 35 and 44

Dependent construct	Predictor	Beta	*t*	R^2	Bootstrap MGA *p*-value
BI	PE	0.318	1.928	0.804	QoL < -BI, Below 25 > Between 45 and 64, *p* = 0.042
	EE	0.153	1.130		
	FC	−0.127	−0.805		
	SI	0.592	3.749*		
	PR	−0.061	−0.521		
	HM	0.004	0.041		
	PV1	0.043	0.476		
	PV2	0.114	1.080		
QoL	BI	0.790	8.706*	0.625	

Note: *$p < 0.001$.

Table 12: Results of the bootstrap MGA for age range between 45 and 64

Dependent construct	Predictor	Beta	*t*	R^2	Bootstrap MGA *p*-value
BI	PE	0.408	2.864*	0.596	QoL < -BI, Below 25 > Between 45 and 64, *p* = 0.042
	EE	0.092	0.679		
	FC	−0.148	−1.101		
	SI	0.428	3.594*		
	PR	0.041	0.421		
	HM	0.049	0.478		
	PV1	0.156	1.650		
	PV2	−0.105	−1.245		
QoL	BI	0.596	5.688*	0.355	

Note: *$p < 0.001$.

Table 13: Results of the bootstrap MGA for age above 64

Dependent construct	Predictor	Beta	*t*	R^2	Bootstrap MGA *p*-value
BI	PE	0.323	2.952*	0.774	QoL < -BI, Below 25 > Between 45 and 64, *p* = 0.042
	EE	0.147	1.670		
	FC	−0.173	−2.241*		
	SI	0.403	4.466*		
	PR	0.102	1.702		
	HM	0.166	2.483*		
	PV1	0.087	1.351		
	PV2	−0.053	−0.964		
QoL	BI	0.817	18.684*	0.667	

Note: *$p < 0.001$.

Table 14: Results of the bootstrap MGA for motoric disability

Dependent construct	Predictor	Beta	*t*	R^2	Bootstrap MGA *p*-value
BI	PE	0.268	2.892*	0.751	No statistically significant differences
	EE	0.125	1.050		
	FC	−0.058	−0.537		
	SI	0.440	3.765*		
	PR	0.003	0.033		
	HM	0.154	2.765*		
	PV1	0.141	2.054*		
	PV2	−0.001	−0.024		
QoL	BI	0.789	17.838*	0.623	

Note: *$p < 0.001$.

were analysed using the defined procedure. The models for those with motoric disability and other disabilities are the same when it comes to the predictors of BI. Namely, in both models, PE, SI, HM, and PV1 have a statistically significant impact on BI. When it comes to the model of those who have sensory disability, there are no statistically significant predictors of BI. Within the model for those who have no disabilities, their model slightly differs. In the observed model PE, EE, FC, and SI act as statistically significant predictors of the BI. In all four observed models, the BI is a statistically significant predictor of the QoL. The obtained *R* squares range from 0.598 (QoL, No disability model) to 0.793 (BI, Sensory disability).

The fact that the model with the highest *R* square is the model with no statistically significant predictors can be explained by the fact that the individual constructs have no impact on BI, but all together create a model which has explanatory power. The bootstrap MGA pointed out that there are no statistically significant behavioural differences between the four observed groups. Finally, the analysis shows that H1, H2, H3, H4, H6, H7, and H8 are partially confirmed (Tables 14–17).

4.3.4 Comparison of Models Based on Education Attainment

The last MGA that we conducted was for the models of the respondents with lower and higher educational attainment. The answers of all 302 respondents were analysed. The results point out that there are differences between the models. In both models, the PE, SI, and HM are predictors of the BI, as well as BI is the predictor of QoL. However, in the model for the respondents with higher education, EE and FC are also statistically significant predictors, while in the model for the respondents with lower education PV1 is also a statistically significant predictor. This can indicate that the higher educated respondents are aware of the effort and the facilitating condition, while lower educated respondents consider the perceived value. Again, the obtained *R* squares for BI and QoL in both lower and higher educated respondents' models are satisfactory, indicating that the models have explanatory power.

Table 15: Results of the bootstrap MGA for sensory disability

Dependent construct	Predictor	Beta	*t*	R^2	Bootstrap MGA *p*-value
BI	PE	0.269	1.040	0.793	No statistically significant differences
	EE	0.099	0.367		
	FC	0.328	1.335		
	SI	0.363	1.285		
	PR	0.136	0.591		
	HM	0.064	0.309		
	PV1	0.007	0.035		
	PV2	−0.129	−0.671		
QoL	BI	0.798	11.986*	0.637	

Note: *$p < 0.001$.

Table 16: Results of the bootstrap MGA for other disability

Dependent construct	Predictor	Beta	*t*	R^2	Bootstrap MGA *p*-value
BI	PE	0.437	2.536*	0.780	No statistically significant differences
	EE	0.057	0.376		
	FC	−0.105	−1.135		
	SI	0.357	2.882*		
	PR	0.028	0.332		
	HM	0.205	2.595*		
	PV1	0.234	2.727*		
	PV2	0.058	0.734		
QoL	BI	0.693	6.320*	0.480	

Note: *$p < 0.001$.

Table 17: Results of the bootstrap MGA for no disability

Dependent construct	Predictor	Beta	*t*	R^2	Bootstrap MGA *p*-value
BI	PE	0.357	4.253*	0.737	No statistically significant differences
	EE	0.205	3.088*		
	FC	−0.195	−2.878*		
	SI	0.515	7.014*		
	PR	0.053	0.896		
	HM	0.056	1.113		
	PV1	−0.011	−0.206		
	PV2	−0.017	−0.348		
QoL	BI	0.773	17.130*	0.598	

Note: *$p < 0.001$.

The results of the bootstrap MGA *p*-value indicate that there is no statistically significant difference in the values of the path coefficients within the two observed models. It should be mentioned that this test compares the values of the path coefficients, not whether are they statistically significant in the individual models. Finally, the analysis shows that H1, H2, H3, H4, H6, H7, and H8 are partially confirmed (Tables 18 and 19).

5 Managerial Impacts, Discussion, and Conclusion

This study holds substantial importance as it investigates the readiness of vulnerable groups to adopt advanced digital technologies, thereby contributing by proposing viable solutions to a variety of societal challenges in smart environments. The outcomes of this research are synthesised into specific, actionable recommendations for various stakeholders, as detailed in Table 20. Moreover, the contributions are further presented in this section.

Table 18: Results of the bootstrap MGA for lower educational attainment

Dependent construct	Predictor	Beta	*t*	*R*	Bootstrap MGA *p*-value
BI	PE	0.361	5.431*	0.702	No statistically significant differences
	EE	0.106	1.510		
	FC	−0.071	−1.100		
	SI	0.412	6.971*		
	PR	0.048	0.903		
	HM	0.115	2.848*		
	PV1	0.114	2.570*		
	PV2	−0.057	−1.283		
QoL	BI	0.733	15.683*	0.537	

Note: *$p < 0.001$.

Table 19: Results of the bootstrap MGA for higher educational attainment

Dependent construct	Predictor	Beta	*t*	*R*	Bootstrap MGA *p*-value
BI	PE	0.287	3.722*	0.767	No statistically significant differences
	EE	0.164	2.341*		
	FC	−0.158	−2.515*		
	SI	0.536	6.376*		
	PR	0.031	0.552		
	HM	0.130	2.534*		
	PV1	0.008	0.169		
	PV2	0.030	0.589		
QoL	BI	0.792	19.212*	0.628	

Note: *$p < 0.001$.

Table 20: Key implications for main stakeholder groups

Private Enterprises (Managers and practitioners)
Private companies engaged in developing various smart city applications should aim to cater to all user groups. This approach aligns with participant feedback indicating a preference for more comprehensive information in sustainable inclusive smart city mobile apps, especially concerning simplified and expedited urban mobility (Hypothesis 1). Additionally, private businesses should consider targeting early adopters in the age brackets of 25–35, as well as those above 64, as these demographics have shown a higher propensity to utilise a range of smart city services (Hypothesis 6).
Government and policymakers
The government's focus should be on conducting training sessions for potential users of smart city services, particularly targeting highly educated individuals and those without disabilities. Results suggest that this demographic is more likely to use and subsequently advocate for these services. Ensuring they thoroughly understand all aspects of a smart city application is crucial, for increased usage due to its ease of use (Hypothesis 2). In rolling out new smart city services, it is important for the government and policymakers (Mikucki, 2023) to prioritise the inclusion of PwD, ensuring accessibility for all user groups. Additionally, encouraging existing users to recommend the service to their friends through mobile applications can effectively broaden its user base (Hypothesis 4). For low-educated citizens, governments should explore opportunities to provide smart devices, such as smartphones, to facilitate access. Policymakers also need to ensure that the experiences of people with motor disabilities are comprehensively addressed in these services (Hypothesis 7).
Researchers
For researchers examining the digital divide in smart technology access and usage, the data indicate that smartphones, a key form of smart technology, are predominantly accessible to individuals without disabilities and those aged above 64 (Hypothesis 3). Future research should delve into the perceived risks associated with using smart city services (Petkova, 2024). Current findings suggest a lack of concern regarding data protection on private phones, potentially exposing users to various cyber threats and hacks. It is essential to investigate whether users of smart city services are sufficiently informed about potential cyber risks (Clarinval et al., 2023). Consequently, there is a critical need for every smart city solution to be equipped with robust cybersecurity measures (Wan & Dragičević, 2022) to safeguard users against malicious attacks (Hypothesis 5)

Examining performance expectancy predictors in relation to gender, it is evident that both male and female participants underscore the importance of having extensive information available through smart services. They also value the role of smart devices in aiding city navigation. This predictor highlights that respondents aged 25–34, and those 45 and older, exhibit a higher demand for comprehensive information (Guandalini, 2022) about their urban surroundings and more assistance in obtaining and navigating this information through mobile phones, compared to other age groups (under 25, and 35–44).

For the performance expectancy predictor, it was observed that the more a smart service contributes useful information accessible via smartphones, the more inclined people with motor and sensory disabilities are to use it. This trend is consistent among individuals without disabilities, indicating a universal preference for smart services that provide valuable and accessible urban information.

Regarding the social impact predictor, it was found that both male and female participants expressed a preference for receiving recommendations from trusted sources before using a smart service, indicating that such endorsements would increase their willingness to adopt these services. Additionally, participants of both genders expect that public administrations should invest in smart city services, thereby facilitating the inclusion of PwD and the elderly. This highlights the significant role of social validation and institutional support in the adoption of smart services. Furthermore, the analysis reveals that irrespective of their educational background, individuals show a tendency to rely on recommendations from reliable sources for the usage of smart public services, underscoring the importance of trusted endorsements in the decision-making process.

In the analysis of the facilitating conditions predictor, it is evident that this factor plays a crucial role for users over the age of 64, falling within the elderly category. The findings indicate that increased access to the Internet and personal smart devices does not necessarily correlate with higher usage intention among this group. Contrary to expectations, greater access to these technologies appears to diminish their willingness to use them, consequently leading to a reduced contribution to their surrounding society. This underscores the complexity of technology adoption among older populations and suggests the need for more tailored approaches to encourage engagement with smart services among the elderly.

The analysis of the hedonic motivation predictor reveals a heightened interest in utilising smart services among certain respondent groups. Specifically, when considering activities for which the Internet is used and prioritising tasks for public administration in smart service implementation, the elderly group demonstrates a notably higher interest in the proposed smart city services. Similarly, the age group of 25–34 years also shows increased enthusiasm for these services.

However, for other demographic categories, the results do not exhibit statistically significant variations. This suggests that hedonic factors, or the pleasure and satisfaction derived from using smart services, are more influential in driving usage among the elderly and the 25-to-34 age group, pointing to the need for smart service designs that cater to the specific interests and motivations of these segments.

In the evaluation of effort expectancy as a predictor, it is noteworthy that statistically significant results emerged predominantly among users without any disability. This group expressed a belief that they would benefit from training designed for using inclusive services and showed a willingness to participate in such training if offered. Additionally, these individuals perceive themselves as adequately skilled and knowledgeable to navigate various challenges that might arise while using a smart device. This self-assessment of competence and readiness for training positively correlates with an increased intention to utilise smart city services, highlighting the importance of user confidence and perceived capability in technology adoption.

The analysis of facilitating conditions as a predictor indicates an intriguing pattern among people with higher education. Despite having access to the Internet and mobile devices, their intention to use these technologies extensively appears to diminish. This could suggest that mere access to technology does not necessarily translate into increased usage. However, a positive aspect observed in both higher-educated individuals and other respondent groups is their willingness to assist others using the same smart inclusive app. This willingness to support fellow users reflects a communal spirit and a readiness to engage in collaborative problem-solving, which is essential for the effective adoption and utilisation of smart city services.

The analysis of education as a variable in the context of smart city service usage reveals insightful trends across different educational backgrounds. Respondents, irrespective of whether they have higher or lower education levels, uniformly value the extensive availability of information through smart city applications. They also consider reliance on a smartphone for navigation as crucial, which in turn enhances their willingness to engage with smart city services.

Among those with higher education, there is a notable agreement with the notion that they possess the necessary skills and knowledge to handle unexpected challenges while using a smart mobile device. This self-assessment of competence positively influences their inclination to use such devices, and they express a readiness to participate in training for smart services, should they be available.

Conversely, for respondents with lower education levels, the results do not show a significant statistical correlation regarding confidence in their skills or an eagerness to participate in training for smart services. This highlights a potential disparity in self-perceived digital proficiency and the willingness to engage in further learning, based on one's educational background, and underscores the need for tailored approaches in training and skill development for smart city services.

The analysis of the price value predictor reveals a notable distinction based on educational background, particularly regarding the perceived affordability of smart devices. Respondents with lower education levels indicated that cost is a significant concern for them. This perspective likely correlates with the general trend that individuals with lower educational attainment may have more limited income ranges, making the expense of smart devices more burdensome. This finding highlights the economic barriers faced by certain demographic groups in accessing technology, underscoring the need for more affordable solutions or financial assistance programs to enhance the inclusivity of smart city services.

The acceptance of services leveraging smart technologies and universal design is likely to be higher among the younger segment of the population, which constitutes a significant proportion in developed countries. As users age but remain accustomed to daily technology use, they tend to readily adopt applications that simplify their lives and enhance independence. However, challenges may arise among older individuals who lack foundational technology skills. This group may exhibit apprehension towards new technologies, potentially leading to resistance to adopting assistive technologies.

To address these concerns, it is crucial to provide education and support to the elderly and PwD. Such initiatives should aim to alleviate fears and misconceptions about technology, demonstrating how it can positively impact daily activities and independence. By doing so, it is possible to facilitate greater acceptance and utilisation of smart technologies across all age groups, particularly among those who are currently less familiar with these tools.

In examining the intention to use predictor, respondents from both higher and lower educational backgrounds displayed a positive inclination towards using smart city services, particularly to PwD. There is a readiness to engage with these services if they are made accessible, indicating a general willingness to embrace smart city solutions.

A notable positive correlation exists between behavioural intention and increased quality of life. Participants of both sexes indicated their willingness to assist PwD upon noticing their need for help via the smart inclusive application, thereby enhancing community well-being. This finding underscores the social value of such applications and their impact on improving the quality of life.

Finally, responses across all participant categories to questions in the social impact category were overwhelmingly positive. The more a smart service is perceived to positively impact society, the stronger the intention to use it among users of all age groups. Similarly, questions in the behavioural intention category consistently revealed that the greater the social contribution of a smart service – such as aiding a person with a disability or an elderly individual – the more likely respondents are to utilise the service. This not only indicates a higher intention to use these services but also suggests an improvement in the respondents' quality of life, transcending age barriers.

The study's findings indicate a significant relationship between the behavioural intention to use smart city services and the improvement of community quality of life. Across various educational backgrounds, respondents consistently expressed a willingness to engage with smart city services, particularly when these services facilitate the support of PwD, as identified through smart inclusive applications.

Furthermore, the data reveal a strong correlation between the perceived societal impact of smart city services and users' intention to adopt them. The greater the perceived positive influence of these services on society, the higher the usage intention across all age groups. This trend is especially pronounced in scenarios where smart services offer direct benefits, such as aiding disabled or elderly individuals.

As presented in our sustainable inclusive smart city ecosystem, a smart city is an interconnected urban ecosystem that leverages ubiquitous technologies to enhance living conditions and experiences. This article adopts an end-user-centric approach to analyse smart city services, focusing on the social dimensions and sustainability impact. Our research interweaves the concepts of sustainability and smart inclusive services, demonstrating that sustainable smart cities must be inclusive, equitable, and accessible to all citizens, thereby ensuring the well-being and resilience of the entire urban community.

Each element of our suggested sustainable inclusive smart city ecosystem supports and enhances the others, creating a dynamic, interconnected system. Smart People benefit from and contribute to Inclusive Smart City Services. In turn, these services are shaped by the innovation and research coming out of Universities and the Social Entrepreneurship sector. Smart Government uses Triple Bottom Line Reporting to measure the impact of these services and aligns them with SDG. NGOs ensure these services reach all segments of the population, and CSR initiatives fund and support projects that further these goals.

Concluding the needs of end users in this article, we aim for future research to involve evaluating the preparedness of public institutions and private sector solutions to facilitate comprehensive smart city changes. This includes the following:

1. study the effectiveness of existing public policies and regulatory frameworks in supporting the development of inclusive smart cities;
2. analyse the role of the private sector in promoting inclusive urban development and identify best practices; and
3. research how new smart services can be integrated seamlessly with existing urban infrastructure without significant disruptions or displacements.

Our research acknowledges limitations in its sample selection, as it is confined to three specific countries. This geographic focus may introduce a selection bias, potentially limiting the applicability of our results to developed countries. The study's reliance on an online community for participant access further narrows the demographic and socio-economic range of our sample, which may not fully represent broader, more diverse populations. Consequently, while our findings offer valuable insights within the studied regions, their generalisability to different socio-economic contexts, particularly in developed countries, should be considered with caution.

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Data availability statement: All the data necessary to reproduce the results in this study are available at e-questionnaire used to collect data can be found here: https://docs.google.com/forms/d/16k7ebt8U7Rf6NaAwp_-DR3Rf-M6XfIa3MYo7EU3zlno/edit table with raw data collected through a questionnaire can be found here: https://docs.google.com/spreadsheets/d/15wC86AabAzERak6z0uA5-2b5hn87idNT/edit?usp=sharing&ouid=105460316703250188636&rtpof=true&sd=true.

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