



Advancing equitable and safe access to care through pre-service telemedicine acceptability: a UTAUT guided pilot study[☆]

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ABSTRACT

The introduction of telemedicine services into healthcare's daily work routines brings both new resources and challenges. To ensure the development of safe and accessible services, it seems fundamental to co-design services with end-users and, concurrently, evaluate their acceptability to enhance care compliance. The current pilot study aims to develop, validate, and test a context-specific measurement tool grounded in the Unified Theory of Acceptance and Use of Technology (UTAUT) and its extensions. The main objective of the model is to evaluate end-users' acceptability and its antecedents before they have any experience with telemedicine services, thereby enabling context-specific evaluations of the proposed telemedicine services and fostering interest among patients. The model included different variables from both the original theory (performance expectancy, effort expectancy, and social influence) and its proposed extensions (compatibility, personal innovativeness, and acceptability). In total, we asked 429 participants from different residential contexts (i.e., urban, peripheral, and rural) in northern Italy to complete our cross-sectional survey. Confirmatory factor analysis demonstrated satisfactory convergent and discriminant validity, internal consistency, and full measurement invariance across gender and both educational and residential contexts. Structural equation modelling showed excellent model fit (CFI = 0.96; SRMR = 0.05). Performance expectancy ($\beta = 0.50$), compatibility ($\beta = 0.35$), and social influence ($\beta = 0.22$) significantly predicted telemedicine acceptability. In particular, the compatibility effect on acceptability was partially mediated by performance expectancy. Our research proposes a workflow that provides a practical framework for assessing preparedness and guiding communication strategies to promote safe and equitable telemedicine implementation.

1. Introduction

1.1. Telemedicine and benefits for rural areas

The digitalisation and innovation that have permeated our societies over the past 80 years have slowly revolutionised people's lives and the way they use social services (Yeasmin, 2024), including channels of access to healthcare (Stoumpos et al., 2023). Electronic health (e-Health) is an emerging and dynamic field at the intersection of medical informatics, public health, and the economic sector (Eysenbach, 2001).

E-health is often used as an umbrella term encompassing a broad range of digital health activities. Among these, telehealth encompasses both clinical and non-clinical services delivered remotely, whereas telemedicine refers specifically to the remote delivery of healthcare services (Herold et al., 2022; Mangion and Piller, 2025). In their various forms, telemedical services require a synchronous, interactive connection between the patient and the physician at a distance, that is, when they are not in the same place (World Health Organization, 2022). The connection is enabled through information and communication technologies (ICTs). Telemedicine services include: teleconsultation visits between

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patients and doctors remotely delivered with anamnestic, diagnostic, follow-up and treatment prescriptions aimed at improving patient outcomes (Pullyblank et al., 2023; Agenas, 2026); telerehabilitation treatment for both physical (Seron et al., 2021) and psychological (Burton and O'Connell, 2018) health issues; telemonitoring of vital parameters, usually delivered via specialised health devices (Boente et al., 2024); tele-expertise consulting activities between healthcare professionals on specific cases (Bucknell et al., 2024). In particular, telemedicine services cover all patient age groups, including pediatric cases (Juárez et al., 2018; Hines et al., 2019; Weaver et al., 2020).

The core feature of connecting professionals and patients at a distance makes telemedicine a great solution for bridging the gap in accessibility to healthcare services between urban and rural areas (Potter et al., 2016; Eberly et al., 2020; Hutchinson et al., 2022; Katta et al., 2024), helping to overcome the problem of care access given by physical distance with care providers. Residents of remote or isolated communities benefit from such services by reducing unnecessary in-person visits (e.g., follow-up or pharmaceutical prescription meetings) (Day et al., 2023), as well as the time and transportation costs required to reach clinics (Tromans et al., 2024). Furthermore, after the introduction of telemedicine services, rural residents report improved quality of life, reduced physical and emotional stress, and increased satisfaction with healthcare services (Mohammadzadeh et al., 2023). In general, it has been observed that telemedical services further reduce the number of visits to and access to emergency and specialised hospital departments (Ohlrigs et al., 2020) by enabling patients to access care more easily via ICTs. Applications of telemedicine services span a wide range of medical and operational needs, including emergency scenarios. Evidence of such applications can be seen in project implementations like the e-Rés@MONT. Between 2016 and 2018, five mountain huts located at altitudes of 1533–3500 m in the province of Aosta (Italy) introduced teleconsultation devices and trained nurses to provide first triage and treatment for visitors in case of medical emergencies. An ad hoc digital platform for communication and the transfer of multimedia material was set up, and the nurses had a 24-hour communication line to the main hospital in Aosta. A total of 702 teleconsultations were conducted. Thanks to successful data transmission, physicians were able to provide timely and appropriate clinical feedback despite the distance between healthcare professionals and patients. The use of teleconsultation facilitated rapid diagnosis and treatment planning, with an average response time of approximately 32 min per case. Around 30 emergency cases were reported, most frequently involving elderly individuals located at higher altitudes, a population particularly vulnerable to limited access to healthcare services. In these situations, nurses initially provided on-site treatment during the acute phase, followed by hospital transfer once the patients' conditions had stabilised. The implementation of telemedicine significantly improved access to healthcare while reducing unnecessary patient transportation, with an estimated 18 ambulance transfers and 12 helicopter rescue operations avoided, resulting in public economic savings of nearly 75489€ for the regional health structures (Martinelli et al., 2022).

1.2. Telemedicine services and patient safety

Innovations like telemedicine must be accompanied by changes at various institutional levels, including patient safety procedures. Patient safety can be described as “the absence of preventable harm to a patient and reduction of risk of unnecessary harm associated with health care to an acceptable minimum” (World Health Organization & WHO Patient Safety, 2010), and is considered an attribute of the healthcare system design that includes materials, procedures, settings, and training for professionals and patients (Emanuel et al., 2009). Scientific research has demonstrated how the employment of patient safety culture not only increases the quality of care delivered (Pozzobon et al., 2024) but also, indirectly, significantly reduces the number of adverse events occurring to patients due to negligent care (Hessels et al., 2019; Kakemam et al.,

2021; Cui et al., 2025; Putra et al., 2025). Telemedicine services propose new takes on safety by facilitating delivery of care for patients with chronic disease (Siminerio et al., 2023), simplifying the management of complex cases (Bidmead et al., 2020), and enabling access to care in rural areas during adverse natural events (e.g., floods, earthquakes, avalanches) (Doarn and Merrell, 2014). Furthermore, when properly implemented, telemedical approaches to care enhance patient safety by empowering self-management of symptoms and health status, boosting a sense of overall security, and enabling the recipient of care to have a clear picture of their health (Ekstedt et al., 2023).

Regardless of the positive effects on accessibility and safety, the rapid introduction of telemedicine services during the COVID-19 pandemic might not have fully prepared healthcare systems and communities with adequate guidelines and standards for adopting remotely delivered care (O'Malley et al., 2022). Recent investigations of the published literature (Oliveira et al., 2025) have identified several patient safety risks associated with digitally remotely delivered health services. These include concerns related to patient experience and the need for person- or community-centred services that address patients' needs (Viitanen et al., 2022); medication safety risks involving drug prescription and proper administration (Ray et al., 2019; Pathak et al., 2021); and failures in communication and information exchange regarding therapy and treatment instructions (O'Malley et al., 2022). Further risks include system vulnerabilities in the storage and sharing of confidential patient data (Sharifi et al., 2022), as well as the loss of clinically relevant information due to online communication and uncertainty in treatment decision-making (Darley et al., 2022). Finally, gaps in the training of health professionals in the use of ICTs and digital patient interaction, as well as difficulties in identifying patients who genuinely require remotely delivered services, have also been highlighted (Svendsen et al., 2021).

To address such risks and concerns, a panel of professional healthcare experts from the Institute for Healthcare Improvement (IHI) gathered to identify the key principles to ensure safe, equitable, and person-centred virtual care. The main output was the development of a two-level hierarchical framework for the adoption of telemedicine services (Perry et al., 2021). The model comprises six core aspects that interact with one another and that providers and professionals should consider when implementing telemedicine services: access, privacy, diagnostic accuracy, psychological and emotional safety, and human factors and system design. Technological access characteristics encompass users' capacity to utilise the system when needed. The utility concerns not only infrastructural characteristics (e.g., digital devices or internet connection), but also users' digital skills, and willingness to adopt the service. The service's privacy characteristics concern its predisposition to safeguard digital systems and maintain the confidentiality and protection of patient information, thereby reducing the risk of data leakage. Diagnostic accuracy refers to the ability of care providers to minimise errors during anamnesis and diagnosis. Proper training and educational courses should be provided to enhance the clinicians' resources for patient treatment. While video interactions surely pose a challenge for professionals, they can offer opportunities to see the realities and contexts in which patients live. Furthermore, a new communication style should be adopted to enable information transmission via digital devices, and for patients with disabilities or communication difficulties, specific technologies should be used to reduce misunderstandings between patients and physicians. Another key aspect concerns the patients' psychological and emotional states. Research has identified home environments as safer and more comfortable places to receive care than hospitals, as they reduce stressors associated with in-clinic visits (e.g., past traumas related to clinic settings or the need to take time off work and travel to the hospital). The authors suggest that it is necessary to highlight the potential of telemedicine consultations to safeguard patients' mental well-being during the delivery of care. In conclusion, the authors argue that accounting for human factors is necessary during systems development. It is imperative to include people's readiness to

engage with the system in prior evaluations, and create designs that meet the needs of the people using it, an aspect particularly relevant in the presence of patients with disabilities. These six core aspects interact with each other and are embedded in a higher-level framework that co-designs the service to account for different stakeholders, namely patients, healthcare professionals, service providers, and public health administrators. In Fig. 1 below, we present the recreated image from the work of Perry and colleagues (2021) as a clear reference for the theorised model.

1.3. Literature gap and research objectives

The successful establishment and integration of new telemedicine services is a complex process. It requires awareness among service proposers of multiple organisational and sociocultural factors, such as regional regulatory frameworks, local healthcare practices, population demographic characteristics, and end-users' (both clinicians and patients) digital skills (Tossaint-Schoenmakers et al., 2021; Uribe-Toril et al., 2021). Evaluations of communities' e-Health readiness (i.e., "the preparedness of healthcare institutions or communities for the anticipated change brought by programmes related to ICT use"; Khoja et al., 2007) must account for such system complexity. While the involvement of institutional figures and healthcare professionals has been highly regarded in scientific research (Jennett et al., 2005; Khoja et al., 2007; Shaqrah, 2010; Kim and Choi, 2021; Wubante et al., 2022; Safadi et al., 2026; Suwanbamrung and Endrias, 2026), comparatively less attention has been devoted to patients' and public preparedness (Mauco et al., 2016; Katz et al., 2024). This limited attention may lead to inadequate assessments of preparedness, ultimately contributing to fallacies and failures during implementation attempts (Stanimirovic, 2024). Recent works have identified the necessity of such sensitivity to patients' characteristics by investigating their knowledge and willingness to pay for broader telehealth services, underscoring the educational and service awareness potential of such investigations (Arize and Onwujekwe, 2017; Heboyan et al., 2025). However, evidence on end-users' acceptability before service implementation remains

comparatively fragmented, particularly regarding its integration into early service design and co-design processes (Byrne et al., 2026).

Although seemingly distinct, the dimensions of patients' preparedness, safety and telemedicine acceptance are deeply interconnected. A recent review work based on 47 studies identified in patients' adherence to care (i.e., 'non-attendance of the assessment visit', 'no show', 'number of missed pills', and 'adherence to self-monitoring') as one of the main safety-related indicators to assess telemedicine services (Lunova et al., 2025). To foster future community preparedness and support the development of safe, equitable, and person-centred telemedicine services, as advocated by Perry and colleagues' model (2021), patients' pre-service acceptability should be assessed and meaningfully integrated into co-design processes from the earliest stages of service ideation and development. While telemedicine service acceptance has been widely investigated across numerous situations (e.g., see Dario et al., 2016; Bonsignore et al., 2018; Peltan et al., 2020; Boente et al., 2024; Heneka et al., 2024; Tromans et al., 2024; Zhang et al., 2024), prospective UTAUT-based studies have also examined the acceptance of future or unreleased telehealth services (Cimperman et al., 2016; Koo et al., 2023). These studies have primarily focused on modelling acceptance or behavioural intention, leaving room to examine how prospective acceptability assessments can inform broader readiness and co-design processes across different residential contexts. However, the relationship between pre-service acceptability and subsequent patient safety outcomes has yet to be systematically examined.

Guided by a well-established technology acceptance framework (Unified Theory for Acceptance and Use of Technology, UTAUT; Venkatesh et al., 2003) adapted for telemedicine, this pilot study aims to develop a new context-specific research instrument to examine and evaluate the relationships among factors that influence end-user acceptability. A recent systematic review of telemedicine acceptance in rural settings highlighted substantial heterogeneity in definitions and measurement practices, limited use of standardised assessment tools, and a limited number of studies comparing acceptance across urban and rural contexts (Lezcano et al., 2026), with implications for the reliability and comparability of the evidence generated. To address these limitations, the present study draws on a theoretically grounded assessment framework and provides initial evidence for the instrument's validation, while identifying the psychosocial antecedents of telemedicine acceptability and examining its comparability across urban, peripheral, and rural contexts. In conclusion, building on existing readiness (Broens et al., 2007; WHO Regional Office for Europe, 2024) and safety (Perry et al., 2021) assessment and development frameworks, we will translate our findings into practical guidelines for the development of safe and accessible telemedicine services. In this regard, pre-service acceptability assessment may be a valuable component of such frameworks, enabling the identification of potential barriers and facilitators to telemedicine adoption prior to implementation. Integrating these assessments into early-stage co-design processes may further help developers and healthcare organisations identify context-specific needs, anticipate potential implementation challenges, and adapt services accordingly. Ultimately, this approach could support the development of telemedicine services that are safe, equitable, accessible, and responsive to the needs of the communities in which they are implemented.

1.4. Theoretical model for telemedicine assessment and variables of interests

1.4.1. History of the unified theory for acceptance and use of technology (UTAUT)

The development of theoretical psychological models to identify relationships between the antecedents of a specific technology began in the 80s and 90s with the establishment of different models that explained technology intention to use based on: attitudes and subjective norms (Fishbein and Ajzen, 1975); ease of use and perception of usefulness (Davis, 1989); intrinsic and extrinsic motivations (Davis et al.,

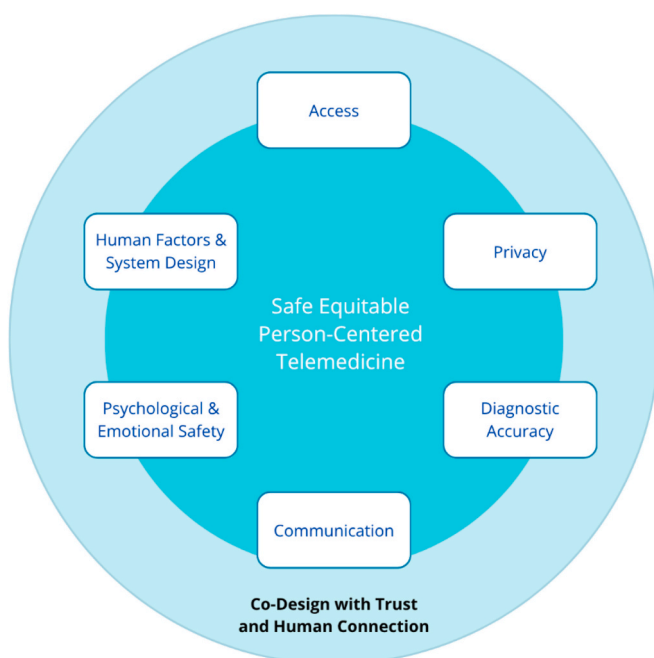


Fig. 1. Representation of the two-level hierarchical model and its variables created by Perry and colleagues (2021) to promote safe, equitable, and person-centred telemedicine services. The image was taken and recreated from Perry et al., 2021.

1992); or work performances as a result of use, anxiety, positive or negative affectivity and self-efficacy (Compeau and Higgins, 1995). In the early 2000s, a group of researchers devoted significant scientific effort to developing a common model and unifying the knowledge on technology acceptance models at the time. The first version of the Unified Theory for Acceptance and Use of Technology (UTAUT) was proposed by Venkatesh and colleagues (2003) with that precise objective in mind. The theoretical framework developed had solid roots based on eight well-established models (TRA, Fishbein and Ajzen, 1975; TAM, Davis, 1989; MPCU, Thompson et al., 1991; TPB, Ajzen, 1991; MM, Davis et al., 1992; C-TAM-TPB; Taylor and Todd, 1995; T-SCT, Compeau and Higgins, 1995; T-IDT, Moore and Benbasat, 1991). The UTAUT was developed to evaluate workers' acceptance of new technology during the introduction of new services in companies and organisations. It was a model based on four exogenous variables: performance expectancy (i.e., "the degree to which an individual believes that using the technology will help him or her to attain gains in job performance"), effort expectancy (i.e., "the degree of ease associated with the use of the technology"), facilitating conditions (i.e., "the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the technology"), and social influence (i.e., "the degree to which an individual that others perceives important believe he or she should use the new technology") (Venkatesh et al., 2003). The variables all had direct effects on both technology acceptance, operationalised as "intention to use the technology in the near future", and usage behaviour, defined as the frequency of technology use. One of the strongest aspects of the model was its flexibility in adapting to different technologies and its capacity to incorporate new context-dependent exogenous variables (Venkatesh et al., 2011). In 2012, an updated and adapted version of the model (UTAUT2) was developed to evaluate consumers' acceptance of new technologies. The study focused on mobile internet technology, and the theoretical model saw the introduction of three new exogenous variables: hedonic motivation (i.e., "the fun or pleasure derived from using a technology"; Brown and Venkatesh, 2005), price value (i.e., "cognitive trade-off arising from the cost of a service and the benefits obtained from using it"; Dodds et al., 1991), and habit (i.e., "the extent to which an individual believes the behavior to be automatic"; Limayem et al., 2007).

1.4.2. Model adaptation to telemedicine services

Telemedicine acceptance assessments have gained increasing interest in recent years, particularly with the advent of the COVID-19 pandemic. An overview of systematic reviews across the WHO European regions from 2011 to 2022 found that approximately 50% were published between 2021 and 2022 (Saigí-Rubió et al., 2022). While evaluating service acceptance, the adoption of consolidated theoretical frameworks appears limited (Lezcano et al., 2026), yet when implemented, the TAM and UTAUT models dominate the field over other technology acceptance frameworks (Harst et al., 2019). In this work, we applied the UTAUT theoretical framework to the study of telemedicine acceptability, conceptualised broadly and without a specific clinical application. The choice of the UTAUT over the TAM model stands out for its inclusion of social influence as a consolidated predictor of behavioural intention to use telemedical services (Salsabila and Ernawaty, 2022; Izadi et al., 2023). Before outlining the relationships among variables and the hypothesis guiding the present study, it is necessary to clarify the UTAUT model's application to our research. The framework proposed by Venkatesh and colleagues in 2003 was originally developed to identify determinants of behavioural intention to use a technology among individuals with direct experience of it. In the present study, however, participants had no prior exposure to telemedicine services. Consequently, we examined end-users' pre-service acceptability (ACC), conceptualised as "a prospective evaluative judgment toward a technology or intervention to be implemented in the future" (Distler et al., 2018), rather than post-use acceptance based on technology adoption. The adaptation of the two versions of the UTAUT (Venkatesh et al.,

2003; Venkatesh et al., 2012) to measure e-health services acceptability has already been documented in literature (Cimperman et al., 2016; Koo et al., 2023), making it possible for us to have solid grounds for the adaptations from the original framework we propose, but still unexplored. Our work will expand knowledge of research tools to assess antecedents of telemedicine acceptability before patients have hands-on experience with the service.

1.4.3. Performance and effort expectancy

Performance expectancy (PE) and effort expectancy (EE) are considered universal predictors of behavioural intention to use new technologies in the healthcare sector (Rho et al., 2015; Faqih and Jaradat, 2015; Liu et al., 2019; Park et al., 2020; Wang et al., 2021). When evaluating end consumers' acceptance of telemedicine, we adapted the UTAUT2 construct and defined performance expectancy as the degree to which telemedicine use will provide consumers with benefits for managing their own health. Concurrently, we adopted the construct of effort expectancy from the original UTAUT and defined it as the expected ease of use of telemedicine services. In the telemedicine context, these expectations concern whether prospective users perceive remote care as capable of providing meaningful benefits for health management and access to care, and whether engaging with the service appears sufficiently manageable before direct use. This distinction is particularly relevant in a pre-service assessment, where judgments of usefulness and required effort are necessarily based on anticipated service characteristics rather than on actual experience (Cimperman et al., 2016; Koo et al., 2023).

1.4.4. Compatibility and personal innovativeness

In 2022, a group of researchers proposed a meta-analysis of extensions (i.e., inclusion or exclusion of specific variables) of the UTAUT framework since its original publication. A total of 25,619 effect sizes collected across 1935 independent samples have been analysed to identify the strongest and most used predictors of behavioural intention. From the results, the researchers suggested the introduction of two new constructs, namely compatibility (i.e., "the degree to which an innovation is perceived as being consistent with existing values, needs, and experiences of potential adopters"; Moore and Benbasat, 1991), and personal innovativeness (i.e., "an individual characteristic reflecting a willingness to try out any new technology"; Agarwal and Karahanna, 2000), in future studies as exogenous variables (Blut et al., 2022). These constructs were included because they capture two conceptually distinct sources of prospective acceptability of telemedicine: the perceived fit of the proposed service with existing health-management practices and the individual's general openness to technological innovation. In our work, we defined compatibility (C) as the degree to which telemedicine is perceived as consistent with an individual's existing health management practices. This fit is particularly relevant to telemedicine, where introducing remote care may require patients to integrate new modes of access and interaction into established healthcare routines; mismatches between users' expectations and service development have been identified as potential barriers to telehealth uptake (Cimperman et al., 2016). Personal innovativeness (PI), by contrast, was retained as a general individual disposition to try new technologies and services, allowing us to examine whether openness to technological innovation contributes to telemedicine acceptability beyond service-specific perceptions, such as compatibility.

1.4.5. Social influence

Together with the other original variables presented in the UTAUT social influence (SI) construct, it plays a key role in predicting future use of health-related technologies (Fonseca et al., 2016; Rahman et al., 2018; Fitrianie et al., 2021; Salsabila and Ernawaty, 2022). In our work, we adapted the construct of social influence from the original UTAUT to telemedicine and defined it as the degree to which an individual perceives that important others believe he or she should use telemedicine

services for their own health. In telemedicine, this mechanism may be especially relevant before direct service experience, when individuals have limited first-hand information on which to base their evaluations and may therefore rely more strongly on cues from trusted clinicians, family members, or other significant actors. In this context, social influence may contribute to acceptability by reducing uncertainty about the appropriateness and legitimacy of receiving care remotely.

1.4.6. Mediated relationships

Several studies have documented a partial mediation of performance expectancy in the relationship between ease of use and behavioural intention (Cimperman et al., 2016; Koo et al., 2023), suggesting that the effect of perceived effort on adoption intentions may operate through the perceived benefits of use. A parallel mediating role of PE is similarly hypothesised in the relationship between compatibility and acceptability. When telemedicine is perceived as consistent with existing health-management practices, this fit may increase acceptability, in part because the service can be more readily seen as useful within the individual's established care-management practices.

2. Methods

2.1. Theoretical model and hypotheses

Based on the theoretical framework outlined in the Introduction, the present study examined the direct and indirect effects of performance expectancy (PE), effort expectancy (EE), compatibility (C), personal innovativeness (PI), and social influence (SI) on telemedicine acceptability (ACC). Fig. 2 illustrates the hypothesised relationships among the variables in the model. Regarding direct effects, the following hypotheses were formulated:

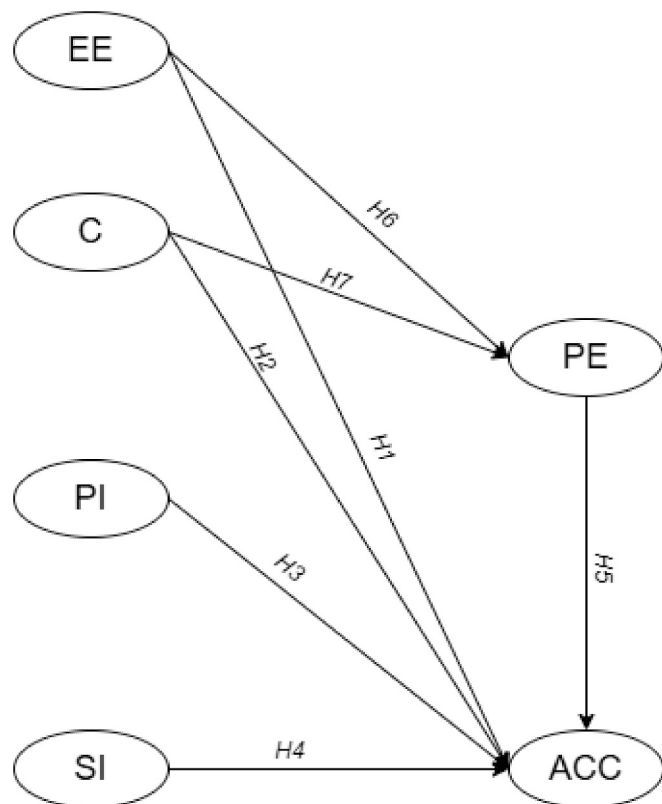


Fig. 2. Graphical representation of the hypothesised relationships among the different variables. EE = effort expectancy; PE = performance expectancy; C = compatibility; PI = personal innovativeness; SI = social influence; ACC = acceptability.

H1: Effort expectancy will have a positive direct effect on consumers' acceptability of telemedicine.

H2: Compatibility will have a positive direct effect on consumers' acceptability of telemedicine.

H3: Personal innovativeness will have a positive direct effect on consumers' acceptability of telemedicine.

H4: Social influence will have a positive direct effect on consumers' acceptability of telemedicine.

H5: Performance expectancy will have a positive direct effect on consumers' acceptability of telemedicine.

Regarding indirect effects, performance expectancy was hypothesised to mediate two relationships:

H6: The relationship between effort expectancy and telemedicine acceptability will be mediated by performance expectancy.

H7: The relationship between compatibility and telemedicine acceptability will be mediated by performance expectancy.

2.2. Materials

Since with our work we decided to evaluate end-users' telemedicine intention to use in participants without experience in using the service, before asking the participant to fill up our questionnaire, we made them read a short text containing key information on: what telemedicine is, what are the necessary tools to use it, and gave few examples of different services that the end-users' might adopt (e.g., teleconsultation, tele-monitoring, telerehabilitation, tele-expertise and remote medical reporting). The English translated version of the text can be found in Supplemental Material 1.

To build the questionnaire, we adapted existing research tools to telemedicine services, conceptualised them in their broadest, most general terms, and translated each item into Italian. Performance expectancy was adapted from the UTAUT2 original framework (Venkatesh et al., 2012) and composed of three items. Effort expectancy, social influence, and acceptability were adapted from the original UTAUT framework (Venkatesh et al., 2003) and, respectively, composed of four items for the former and three items for the latter. Compatibility was adapted from the scale developed by Moore and Benbasat in 1991, which consists of three items identified by the original authors as statistically consistent with the construct. Personal innovativeness was adapted from the scale developed by Agarwal and Karahanna in 2000, which consists of four items, with the second being reverse-coded. All items were measured by asking participants to indicate their level of agreement with a series of statements, each rated on a 5-point Likert scale: 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree.

In conclusion, at the end of the survey, we asked participants to self-evaluate their digital competencies by selecting one of the following options: poor, fair, sufficient, good, or excellent. Concurrently, we retrieved socio-demographic information such as age, level of education, gender, rurality of residence (i.e., urban, peripheral, or rural), and topography of residence (e.g., plain, mountain, or hill).

2.3. Materials quality evaluation

The short text introduction went down two review assessments. During the first evaluation, we asked 10 non-expert participants with no prior knowledge of telemedicine to write a short comment on the length, comprehensibility, clarity, and grammatical correctness of our introduction. After reviewing the comments, we decided to integrate the proposed changes and reassess the text. During the second evaluation, we asked 34 non-expert participants, different from the first ones, with no previous knowledge of telemedicine, to evaluate the clarity and comprehensibility of the text on two separate 10-point Likert scales ranging from "1 = Not clear/comprehensible at all" to "10 = Perfectly clear/comprehensible". The sample had a mean age of 51.97 years (SD = 18.75), with approximately 61% of participants aged 50 or older.

Around half of the participants were from urban areas, and around 62% had an educational level higher than a high school diploma. Across all participants, the average comprehensibility ($M = 9.18$; $SD = 1.24$) and clarity ($M = 9.00$; $SD = 1.25$) scores are high, indicating a good understanding of the provided text. Following, we decided to run a series of two-tailed t-tests to control for differences between participants residing in urban areas or not, over or under 50 years old, and between those with higher and lower or equal educational level to a high school diploma. From the results, we couldn't find any statistically significant differences, suggesting that comprehensibility and clarity of the text are not affected by age, provenance, or educational level. The results of the t-tests are reported in Table 1 below.

Concurrently, we decided to evaluate each item's comprehensibility. We asked 7 non-expert participants to rate each item on a scale from 1 = not at all understandable to 5 = completely understandable, and to leave a comment on their perception of the statement's length and clarity. Across all items, the average comprehensibility value was 4.28 ($SD = 0.87$), with no critical written comments regarding the length or clarity of the items. Further analysis of participants' item interpretation will be provided later via measurement invariance evaluations.

2.4. Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its subsequent amendments. The research protocol was approved by the Ethical Committee for Psychological Research at the Department of Human Science, University of Verona (code: 2024.44). Informed consent was obtained from all individual participants included in the study.

2.5. Data collection procedure

Data collection for our cross-sectional study began in September 2025 through the research team's participation in public events held in the mountainous areas of Selva di Cadore and Val di Zoldo in the Italian Dolomites, province of Belluno (north-east of Italy). During the events, the team engaged citizens by explaining the purpose of the data collection, providing a flyer with a QR code that directed them to the online survey. Concurrently, different approaches, including sharing a digital version of the flyer outlining the initiatives and the survey link, have been implemented in the province of Verona (northern Italy). We then asked people who had already completed the survey to share it with others and collected data via snowball sampling. We expected to collect at least 300 participants via this procedure.

Table 1
Differences across groups (over 50 years old; urban provenance; educational level) in comprehensibility and clarity of the telemedicine introductory short text provided.

	t value	Degrees of freedom (df)	p-value
Participants over 50 years old vs Participants with less than 50 years old			
Comprehensibility	-0.36	32	0.719
Clarity	-0.28	31	0.781
Participants living in urban areas vs participants not living in urban areas			
Comprehensibility	-0.82	32	0.416
Clarity	-0.83	31	0.412
Participants' educational level higher than a high school diploma vs participants educational level lower than high school diploma			
Comprehensibility	-1.23	32	0.228
Clarity	-0.56	31	0.577

2.6. Data analysis

All statistical analyses for this work have been conducted in Jamovi (The jamovi project, 2023, ver. 2.4.8) and R (v4.1.3; R Core Team 2021) using the following libraries: lavaan, lavaan.mi, semTools, semPlots, and moments. At first, we checked the normality of each variable's distribution by examining its kurtosis and skewness. As a criterion, we adopted the one of Byrne (2010) and Hair and colleagues (2010). They both argued that data distributions for each variable should be considered normally distributed if the kurtosis falls between -7 and $+7$ and the skewness falls between -2 and $+2$. Next, we examined the measurement model by testing for convergent and discriminant validity. To test convergent validity, we run a Confirmatory Factor Analysis (CFA), checking for the Average Extracted Variance, calculating construct reliability (McDonald's omega), and Composite Reliability (CR) for each variable. During CFA, validity was assessed by examining the factor loadings for each variable and, following the guidelines proposed by Hulland (1999), identifying good convergent validity when factor loadings are ≥ 0.70 . To evaluate AVE and CR, we used the thresholds proposed by Bagozzi and Yi (1988): $AVE \geq 0.50$ and $CR \geq 0.70$. The calculation of AVE occurred in R, while the calculation of CR occurred via the use of an online tool provided by the Mental Health and Psychometrics group (Calculating Composite Reliability - Mental Health and Psychometrics, 2025). Concluding, the choice of the McDonald's omega coefficient over the Cronbach's alpha relies on the omega's stability in congeneric scales (i.e., when items contribute in different amounts of stability to the total score) (Trizano-Hermosilla and Alvarado, 2016; McNeish, 2018). To establish good reliability, omega's value should be ≥ 0.80 (McDonald, 1999). Discriminant validity was assessed by applying the criteria of Fornell and Larcker (1981) and testing if the construct's AVE square root was greater than its correlation with the other latent variables (Fornell and Larcker, 1981). Furthermore, we accounted for and assessed systematic error variance (Common Method Variance; CMV) during our measurements and evaluated it using Harman's single-factor test (Podsakoff et al., 2003; Chang et al., 2010). A total explained variance by the single factor below 50% indicates that the CMV was not a relevant problem for our analysis and results interpretation. Concluding the evaluation of the measurement models, we tested measurement invariance across gender (male vs female), residence provenance (urban, peripheral, and rural), and educational background (educational level higher than a high school diploma vs educational level equal to or lower than a high school diploma). Gender was specified as a grouping variable in the multi-group analyses. For residence provenance, three dummy-coded grouping variables were created to enable separate comparisons (urban vs non-urban, peripheral vs non-peripheral, and rural vs non-rural), while educational level was dichotomised based on the highest educational certificate held by the participant. Measurement invariance was examined using multi-group confirmatory factor analysis (MG-CFA). Configural invariance was first evaluated by estimating the same factor structure across groups without imposing equality constraints. Metric invariance was then tested by constraining factor loadings to equality across groups, followed by scalar invariance, in which item intercepts were additionally constrained to equality. Model comparisons were primarily evaluated using changes in approximate fit indices rather than relying solely on chi-square difference tests, given the chi-square statistic's sensitivity to sample size. Following Cheung and Rensvold (2002), invariance was supported when the change in Comparative Fit Index (ΔCFI) was ≤ 0.01 . Consistent with Chen (2007), invariance was further supported when $\Delta RMSEA$ was ≤ 0.015 . After establishing the adequacy of the measurement models, we used Structural Equation Models (SEM) to test our hypotheses. The analysis was conducted using the Maximum Likelihood estimation method (ML) (estimator = "ML" in R). The decision regarding the estimator stems from the measurement scale used (a 5-point Likert scale), which allows us to interpret the observed variables as continuous rather than ordinal (Xia and Yang, 2019; Rhemtulla et al.,

2012). The model fit was confirmed using the Tucker-Lewis (TLI) and comparative fit index (CFI), as well as the root mean squared error of approximation (RMSEA) and the standardised root mean square residual (SRMR). To further evaluate the robustness of our results, we adopted bootstrapping (bootstrap = 5000 in R) to assess direct effects and Monte Carlo simulations (Nrep = 100000) to assess indirect and total effects of mediations (Preacher and Selig, 2012; Tofghi and MacKinnon, 2016). Continuing our analysis, we reported the explained variance (R^2) for the mediator and outcome variables to assess the model's explanatory strength. In doing so, we stick to the guidelines proposed by Hair and colleagues (2011) (i.e., $R^2 \geq 0.25$ for weak explanation; $R^2 \geq 0.50$ for moderate explanation; $R^2 \geq 0.75$ for substantial explanation). To explore the role of gender, participants' provenance, and educational background, we decided to run a multi-group path analysis across subgroups in our sample. To maintain consistency and enable comparison of results across groups with different numerosity, we decided to use only observed variables.

3. Results

In total, we collected data from 429 participants across the provinces of Belluno and Verona in Italy. In Table 2 below, we report on the sociodemographic characteristics of our participants.

3.1. Normality assumption

While testing for normality, we checked the skewness and kurtosis for each variable. In accordance with the methodological guidelines articulated by Byrne (2010) and Hair et al. (2010), thresholds of -2 to $+2$ for skewness and -7 to $+7$ for kurtosis were adopted to evaluate univariate normality. Examination of the distributional indices presented in Table 3 indicates that all observed values fell within these recommended parameters. Accordingly, the assumption of normality was met for the variables included in the present analyses.

3.2. Convergent validity

The results concerning the CFA, AVE, CR, and McDonald's omega are

Table 2
Sociodemographic characteristics of participants.

Characteristic	Total
Age (in years)	
Continuous mean (standard deviation)	34.84 (15.48)
Gender, n (%)	
Female	211 (49%)
Male	215 (50%)
Third gender/non-binary	1 (0.25%)
I prefer not to answer	2 (0.75%)
Educational background, n (%)	
High school or lower	238 (55%)
University	178 (42%)
Graduate school	13 (3%)
Residence, n (%)	
Urban	205 (48%)
Peripheral	126 (29%)
Rural	98 (23%)
Territorial topography, n (%)	
Land	258 (60%)
Hill	68 (16%)
Mountain	77 (18%)
Coast	19 (4%)
Island	7 (2%)
Digital Competencies, n (%)	
Poor	20 (5%)
Fair	44 (10%)
Sufficient	117 (27%)
Good	176 (41%)
Excellent	72 (17%)

Table 3

Skewness and kurtosis values for each variable considered in the analyses.

Variable	Skewness	Kurtosis
Effort Expectancy (EE)	-0.45	3.10
Performance Expectancy (PE)	-0.42	3.17
Compatibility (C)	-0.08	2.63
Personal Innovativeness (PI)	-0.06	2.58
Social Influence (SI)	0.55	3.06
Acceptability (ACC)	0.01	2.54

presented in Table 4.

As shown in the table, five items, one from effort expectancy (EE_1) and compatibility (C_1), one from acceptability (ACC_3), and two from personal innovativeness (PI_2R, PI_3) did not reach the criteria (≥ 0.70) of Hulland (1999). Although these items fell marginally below the suggested threshold, the overall measurement model demonstrated satisfactory psychometric properties. Specifically, AVE values exceeded the recommended minimum of 0.50, and both CR and McDonald's omega coefficients surpassed the conventional 0.70 and 0.80 criterion, indicating adequate internal consistency and construct reliability. Taken together, despite minor deviations at the item level, the pattern of results provides sufficient empirical support for the model's latent constructs' convergent validity.

3.3. Discriminant validity

The results presented in Table 5 provide evidence of discriminant validity based on the criterion proposed by Fornell and Larcker (1981). As shown in the correlation matrix, the square root of the average variance extracted (AVE) for each construct (displayed on the diagonal) exceeds the corresponding inter-construct correlations. This pattern indicates that each latent construct shares more variance with its indicators than with indicators of other latent variables in the model, thereby supporting discriminant validity.

3.4. Common method variance (CMV)

To control for methodological artefacts introduced in our work via measurement-method bias, we constrained all items in an Exploratory Factor Analysis to a single factor with no rotation and obtained a total explained variance of 38.81%, below our 50% threshold. The current result allows us to make meaningful interpretations, enabling us to ignore interpretational problems related to systematic error variance.

3.5. Measurement invariance

Measurement invariance was examined sequentially by testing configural, metric, and scalar models across residential context (urban, peripheral, and rural), gender, and educational level. Invariance decisions were based primarily on changes in CFI ($\Delta CFI \leq 0.01$; Cheung and Rensvold, 2002) and RMSEA ($\Delta RMSEA \leq 0.015$; Chen, 2007). Our results, presented in Table 6 below, underline the presence of the investigated invariance measures across all the confrontations.

In conclusion, across residential contexts (urban, peripheral, and rural), gender, and educational levels, full metric and scalar invariance was supported based on changes in CFI and RMSEA, even when chi-square difference tests were statistically significant. These findings indicate that the measurement model operates equivalently across groups, permitting meaningful comparisons of latent constructs and latent means.

3.6. Hypotheses testing

To test our hypothesis, we applied structural equation modelling techniques to our data. After specifying our model, we extracted fit

Table 4Results of CFA, AVE, CR and ω (McDonald's omega).

Variables	β	Estimate	Std.Err	p-value	AVE	CR	ω (McDonald's omega)
EE^a					0.59	0.85	0.85
EE_1	0.68	1.00	—	—	—	—	—
EE_2	0.80	1.34	0.09	<.001	—	—	—
EE_3	0.81	1.30	0.09	<.001	—	—	—
EE_4	0.77	1.22	0.09	<.001	—	—	—
PE^b					0.62	0.82	0.82
PE_1	0.81	1.00	—	—	—	—	—
PE_2	0.71	0.86	0.05	<.001	—	—	—
PE_3	0.82	1.08	0.06	<.001	—	—	—
C^c					0.60	0.81	0.80
C_1	0.64	1.00	—	—	—	—	—
C_2	0.84	1.33	0.09	<.001	—	—	—
C_3	0.82	1.29	0.09	<.001	—	—	—
PI^d					0.51	0.80	0.80
PI_1	0.79	1.00	—	—	—	—	—
PI_2R	0.62	0.83	0.07	<.001	—	—	—
PI_3	0.62	0.82	0.07	<.001	—	—	—
PI_4	0.82	1.06	0.06	<.001	—	—	—
SI^e					0.76	0.90	0.90
SI_1	0.88	1.00	—	—	—	—	—
SI_2	0.87	1.01	0.04	<.001	—	—	—
SI_3	0.86	0.98	0.04	<.001	—	—	—
ACC^f					0.63	0.83	0.82
ACC_1	0.87	1.00	—	—	—	—	—
ACC_2	0.81	0.98	0.05	<.001	—	—	—
ACC_3	0.68	0.76	0.05	<.001	—	—	—

EE^a = effort expectancy;PE^b = performance expectancy;C^c = compatibility;PI^d = personal innovativeness;SI^e = social influence;ACC^f = acceptability.**Table 5**

Results of discriminant validity by applying Fornell and Larcker criterion (1981).

	EE ^a	PE ^b	C ^c	PI ^d	SI ^e	ACC ^f
EE ^a	0.77					
PE ^b	0.60*	0.79				
C ^c	0.64*	0.73*	0.77			
PI ^d	0.57*	0.44*	0.56*	0.71		
SI ^e	0.22*	0.33*	0.43*	0.21*	0.87	
ACC ^f	0.49*	0.68*	0.69*	0.45*	0.54*	0.79

Note. * = $p < 0.001$.EE^a = effort expectancy;PE^b = performance expectancy;C^c = compatibility;PI^d = personal innovativeness;SI^e = social influence;ACC^f = acceptability.

indices and variable regression values. For the former, the results indicated an excellent fit between the model and the collected data, with CFI = 0.96, TLI = 0.96, RMSEA = 0.05 (CI, 0.04 – 0.06), and SRMR = 0.05 (Bentler and Bonett, 1980; Hair et al., 2010). Testing the structural relationships among our hypotheses confirmed H2, H4, H5, and H7. We confirmed the presence of a strong, direct effect ($\beta > 0.30$) of performance expectancy ($\beta = 0.50$, $p < 0.001$) and compatibility ($\beta = 0.35$, $p = 0.037$) on telemedicine acceptability. Concurrently, the effect of compatibility was partially mediated by performance expectancy (indirect effect: $\beta = 0.40$, $p < 0.001$; total effect: $\beta = 0.75$, $p < 0.001$), underscoring the role of perceived usefulness in shaping pre-service telemedicine acceptability. From our analysis, social influence had a moderate effect ($\beta = 0.22$, $p < 0.001$) in predicting telemedicine acceptability. Concurrently, the direct relationships between effort expectancy ($\beta = -0.12$, $p = 0.126$) and personal innovativeness ($\beta = 0.03$, $p = 0.646$) with telemedicine acceptability were not statistically

Table 6

Results obtained for participants' gender (male vs female), provenance (urban vs non-urban, peripheral vs non-peripheral, rural vs non-rural), and educational level (certificate higher than high school diploma vs equal or lower than high school diploma) characteristics, across all different models (configural, metric and scalar).

	$\chi^2/\Delta\chi^2$	Df/ Δ Df	p-value	CFI/ Δ CFI	RMSEA/ Δ RMSEA
Invariance across participants' gender (male vs female)					
Configural	538.01	321	<.001	0.956	0.056
Metric	12.32	14	0.581	0.001	−0.001
Scalar	33.66	14	0.002	−0.004	0.001
Invariance across urban residents					
Configural	542.52	321	<.001	0.956	0.057
Metric	13.90	14	0.457	0.000	0.001
Scalar	25.03	14	0.034	−0.002	0.000
Invariance across peripheral residents					
Configural	544.57	321	<.001	0.955	0.057
Metric	25.20	14	0.033	−0.002	0.000
Scalar	23.20	14	0.057	−0.002	0.000
Invariance across rural residents					
Configural	513.30	321	<.001	0.961	0.053
Metric	6.87	14	0.940	0.001	−0.002
Scalar	22.49	14	0.069	−0.002	0.000
Invariance across educational levels					
Configural	546.14	310	<.001	0.952	0.060
Metric	14.51	14	0.412	0.000	−0.001
Scalar	28.88	14	0.011	−0.003	0.001

significant, thus failing to confirm our hypotheses H1 and H3. Furthermore, we found no mediation of performance expectancy in the relationship between effort expectancy and telemedicine acceptability (indirect effect: $\beta = 0.06$, $p = 0.139$; total effect: $\beta = -0.06$, $p = 0.401$), thereby falsifying H6. In conclusion, we examined the explained variance of both our endogenous variables, PE as a mediator and ACC as an outcome. Based on the results and in line with the guidelines of Hair et al. (2011), we conclude that the model explains a substantial

proportion of the variance for both performance expectancy (PE; $R^2 = 0.77$) and acceptability (ACC; $R^2 = 0.79$), indicating strong explanatory power. Below, in Table 7, the results for each hypothesis, including unstandardized and standardised estimates (β), standard errors, confidence intervals, and p-values, are summarised. After the table (Fig. 3), we present the structural relationships in our model graphically.

3.7. Multi-group path analysis

From our results, constraining paths between variables across gender groups ($\Delta\chi^2(7) = 7.79$, $p = 0.352$, $\Delta RMSEA = 0.023$) and educational background ($\Delta\chi^2(7) = 9.26$, $p = 0.234$, $\Delta RMSEA = 0.039$) did not significantly worsen the model fit, showing no differences in variable relationships across groups. Similar results has been found for urban ($\Delta\chi^2(7) = 10.35$, $p = 0.170$, $\Delta RMSEA = 0.047$), and rural ($\Delta\chi^2(7) = 4.33$, $p = 0.741$, $\Delta RMSEA = 0.000$) provenance of participants, while a statistically significant difference has been observed for peripheral participants provenance ($\Delta\chi^2(7) = 19.46$, $p = 0.007$, $\Delta RMSEA = 0.091$). In particular, a stronger effect of social influence on acceptability has been found among peripheral residents than among non-peripheral residents ($\beta_{\text{peripheral}} = 0.32$ vs $\beta_{\text{non-peripheral}} = 0.26$; $\chi^2(1) = 11.447$, $p = 0.001$). While significant and sound, this result should be interpreted cautiously, given the impossibility of running full SEM models with all indicators due to sample size limitations in both groups. Nevertheless, the current exploratory analysis should be considered the starting point for future work, with research groups investigating the roles of gender, educational level, and urbanisation of origin as antecedents of telemedicine acceptability.

4. Discussion

Ensuring equitable and safe access to care should be considered a prerogative of health systems. Telemedicine services pose a new challenge for health systems and their care delivery models. Recent approaches to evaluating patient safety have largely focused on patients'

Table 7

Unstandardized and standardized estimates (β), standard error, and p-value for each hypothesis.

Hypothesis	β	Estimate	Std. Err	Confidence Interval 95%	p-value
H1					
EE ^a $\rightarrow$ ACC ^f	-0.12	-0.18	0.10	[-0.42 0.03]	0.126
H2					
C ^c $\rightarrow$ ACC ^f	0.35	0.48	0.18	[0.02 0.94]	0.037
H3					
PI ^d $\rightarrow$ ACC ^f	0.03	0.03	0.06	[-0.10 0.17]	0.646
H4					
SI ^e $\rightarrow$ ACC ^f	0.22	0.22	0.06	[0.11 0.34]	<.001
H5					
PE ^b $\rightarrow$ ACC ^f	0.50	0.59	0.13	[0.28 0.93]	<.001
H6					
EE ^a $\rightarrow$ PE ^b	0.11	0.14	0.09	[-0.05 0.33]	0.103
Indirect effect EE ^a $\rightarrow$ ACC ^f	0.06	0.08	0.06	[-0.02 0.16]	0.139
Total effect EE ^a $\rightarrow$ ACC ^f	-0.06	-0.09	0.11	[-0.22 0.10]	0.401
H7					
C ^c $\rightarrow$ PE ^b	0.79	0.93	0.10	[0.75 1.14]	<.001
Indirect effect C ^c $\rightarrow$ ACC ^f	0.40	0.55	0.13	[0.18 0.63]	<.001
Total effect C ^c $\rightarrow$ ACC ^f	0.75	1.03	0.13	[0.55 0.94]	<.001

EE^a = effort expectancy;
 PE^b = performance expectancy;
 C^c = compatibility;
 PI^d = personal innovativeness;
 SI^e = social influence;
 ACC^f = acceptability.

compliance with care (Lunova et al., 2025). From this perspective, assessing patients' pre-service acceptability may help identify potential barriers to engagement and provide an empirical basis for informing service design and implementation. Such assessments may also support patient involvement in the co-design of telemedicine services, allowing their perspectives and needs to be considered before implementation. With our pilot study, we therefore aimed to develop a new measurement tool and model to assess patients' pre-service acceptability of telemedicine and support more informed service design and implementation.

4.1. Validation of the measurement

The results from the measurement model highlighted the value of developing new research tools grounded in well-founded research frameworks. Following the guidelines and thresholds present in literature (Fornell and Larcker, 1981; Bagozzi and Yi, 1988; Hulland, 1999; McDonald, 1999; Byrne, 2010; Hair et al., 2010; Hair et al., 2011) we managed to provide solid evidence over the convergent and discriminant validity of our tool, as well as its invariance in measurement between men and women, different educational levels, as well as participants residing in urban, peripheral or rural areas. Given the comprised advantages that rural and remote dwellers get from the use of these services (i.e., reduction in transportation time and costs associated with accessing healthcare services; decrease in hospital admissions and avoidance of unnecessary medical visits; optimizing the delivery of care for patients with chronic diseases and enhancing the management of complex cases; support during emergency situations arising from natural disasters) (Doarn and Merrell, 2014; Ohligs et al., 2020; Mohammadzadeh et al., 2023; Bidmead et al., 2020; Day et al., 2023; Siminerio et al., 2023; Tromans et al., 2024) we believe that invariance results over participants residence prove good applicability in context most in need for these type of assessment. At the same time, the comparable interpretation of the items across participants from urban, peripheral, and rural areas supports the instrument's use for examining and comparing telemedicine acceptability across settings. This cross-context applicability enhances the tool's potential for real-world telemedicine implementation, where differences in local contexts may influence users' perceptions and acceptance of services. Future studies should further adapt and validate the instrument across different telemedicine services and clinical populations, thereby extending its applicability and contributing to a broader understanding of acceptability among diverse patient and public groups.

4.2. Relationship interpretations of acceptability antecedents

The structural model based on the UTAUT provided a good representation of the observed data, accounting for substantial proportions of variance in both performance expectancy ($R^2 = 0.77$) and acceptability ($R^2 = 0.79$). These findings provide initial empirical evidence on the psychosocial antecedents of pre-service acceptability of telemedicine (i.e., users' evaluations of telemedicine services before direct experience).

Among the hypothesised relationships, performance expectancy, compatibility, and social influence showed direct effects and associations with telemedicine acceptability. The current findings suggest that prospective users may assess a telemedical service not only on their willingness to use it but also on whether it appears useful for managing their own health, compatible with current systems, and socially supported by important others. The inclusion of end-users from urban, peripheral, and rural settings provides preliminary indications regarding the dimensions investigated as potential actionable targets, which may help identify barriers to adoption before implementation.

4.2.1. Compatibility and performance expectancy

In line with the suggestions of Blut and colleagues (2022), congruence between existing and new procedures must be considered when proposing telemedicine services, with compatibility being the second-

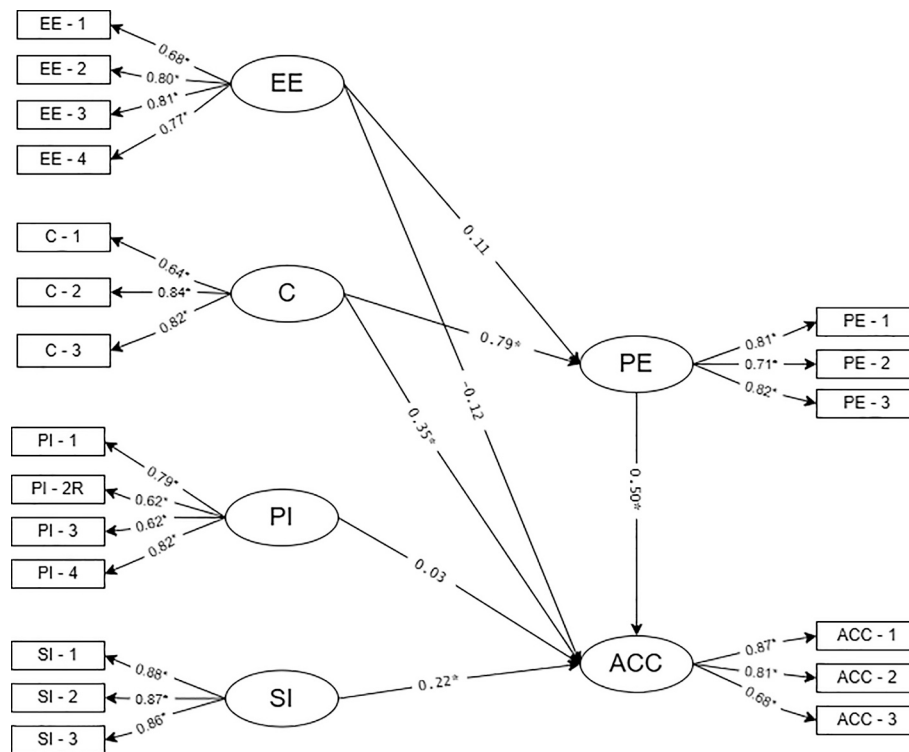


Fig. 3. Graphical representation of latent variables relationships Note: * = statistically significant relation.

strongest positive predictor of acceptability ($\beta = 0.35$, $p = 0.037$). This result highlights the necessity of conceptualising telemedicine services not as stand-alone solutions, but as additions to current tools, routines and care delivery systems. We suggest that developers and providers first develop an in-depth understanding of how patients manage their healthcare and how the proposed service could fit within existing practices. The prior assessment should consider both the physical and digital systems available to patients and aim to address current gaps, simplifying care delivery rather than adding complexity. Local healthcare professionals may serve as valuable sources of information, and their involvement could help identify potential mismatches between current and proposed services (Tuckson et al., 2017). Such considerations may become even more relevant for clinical populations experiencing accessibility barriers, including people with disabilities, for whom incompatibilities between existing tools and telemedical technological solutions could represent an additional source of exclusion.

Based on our results, the relationship between compatibility and acceptability was partially mediated by performance expectancy. The findings indicated an indirect effect ($\beta = 0.40$, $p < 0.001$), followed by a strong and positive total effect ($\beta = 0.75$, $p < 0.001$), between the variables. The mediation suggests that the perceived congruence between existing healthcare practices and new telemedicine services may partly contribute to acceptability, as patients view more compatible services as more useful. In practical terms, ensuring compatibility could be more than a matter of procedural convenience; it could help users recognise the value of telemedicine in relation to their existing healthcare needs.

Performance expectancy was the strongest predictor of acceptability ($\beta = 0.50$, $p < 0.001$), consistent with current scientific literature highlighting its key role as a driver of new healthcare technologies (Rho et al., 2015; Faqih and Jaradat, 2015; Liu et al., 2019; Park et al., 2020; Wang et al., 2021). Our findings extend the existing literature by showing that performance expectancy may play an important role even before patients have direct experience with a telemedicine service. The current result has important consequences for pre-service communication and design. We suggest that when introducing a new telemedical service, developers should clearly communicate the expected benefits

and how telemedicine would improve or facilitate patients' care experience. Such claims should be grounded in real service characteristics and patients' needs, rather than solely on generic representations of telemedicine benefits.

Taken together, the findings on performance expectancy and compatibility suggest that pre-service assessment should examine not only whether end-users are willing to use the service, but also whether they perceive it as meaningful and compatible with the characteristics of the current healthcare system. These types of assessments can help providers identify patients' needs and potential structural barriers before implementation.

4.2.2. Social influence

Social influence showed a significant positive association with pre-service acceptability of telemedicine use, although its effect is smaller than those observed for compatibility and performance expectancy ($\beta = 0.22$, $p < 0.001$). The current findings are consistent with Koo and colleagues (2023), who reported a similar effect of peers on the acceptability of mobile health applications for accessing care services among patients with chronic diseases (Koo et al., 2023). The importance of social influence may be particularly relevant when users have limited direct experience of telemedicine or when new technologies are characterised by uncertainty, mistrust, or scepticism towards healthcare innovations (Boulware et al., 2003; Reimann et al., 2017). In such circumstances, opinions expressed by trusted individuals may help shape prospective evaluations by future technology users and appropriately frame the service by correctly conveying its legitimacy and usefulness.

The multi-group analysis of participants' geographical provenance identified a statistically significant difference between participants from peripheral and non-peripheral urban areas ($\Delta\chi^2(7) = 19.46$, $p = 0.007$, $\Delta RMSEA = 0.091$). The effect of social influence on telemedicine acceptability was stronger among peripheral residents compared to non-peripheral residents ($\beta_{\text{peripheral}} = 0.32$ vs $\beta_{\text{non-peripheral}} = 0.26$; $\chi^2(1) = 11.447$, $p = 0.001$). The current results suggest that the role of social influence in shaping pre-service acceptability may be amplified in geographically peripheral settings, where limited access to care leads

individuals to rely more on community networks. While statistically significant and theoretically meaningful, we want to further underscore caution regarding this service interpretation due to methodological limitations. Therefore, these findings should be considered exploratory and hypothesis-generating, rather than confirmatory. Overall, our results suggest that, although most structural relationships underlying telemedicine acceptability appear broadly invariant across general geographical context, the influence of social processes may vary in more marginal or peripheral settings. We propose that future studies investigate the role of territorial and sociodemographic factors as potential moderators of telemedicine acceptability, ideally using larger, more balanced samples that enable full multigroup structural equation modelling.

From an implementation perspective, the findings on the role of social influence support the involvement of trusted healthcare professionals, champions, and other relevant local actors in the communication and co-design of telemedicine services, helping to mitigate resistance to change (Broens et al., 2007; Katz et al., 2024). Rather than treating social influence as an individual-level patient characteristic, implementation strategies may benefit from considering the broader social environment in which patients form expectations of new telemedicine services.

4.2.3. Effort expectancy

Surprisingly, effort expectancy was not associated with acceptability ($\beta = -0.12$, $p = 0.126$), nor was it partially mediated by performance expectancy (indirect effect: $\beta = 0.06$, $p = 0.139$). The current result contrasts with existing literature that reports effort expectancy as one of the main antecedents of telemedicine acceptance (Rho et al., 2015; Faqih and Jaradat, 2015; Liu et al., 2019), and its role remains ambiguous in prospective telemedical service implementation studies, with some authors supporting its role (Cimperman et al., 2016) and others contradicting it (Koo et al., 2023). One possible explanation of our result concerns the broad conceptual nature of our assessment. Participants evaluated telemedicine as a general category, rather than a specific service with already conceptualised procedures, interfaces, and patient requirements. We hypothesise that, under such circumstances, end-users may have had difficulty judging whether telemedicine would be easy to use in practice. Future studies should include more comprehensive, detailed descriptions of the necessary actions required to use the service when evaluating telemedicine technology concepts. Consequently, effort expectancy may become more salient when users are presented with concrete information. Where feasible, involving potential users in practical simulations would allow researchers and developers to assess not only anticipated acceptability but also service usability, and to identify accessibility and safety challenges that may emerge during actual interaction with the service.

4.2.4. Personal innovativeness

From our results, personal innovativeness was not significantly associated with telemedicine acceptability ($\beta = 0.03$, $p = 0.646$). Even though these variables are often considered in models of technology adoption, our findings suggest that individual predisposition towards technological innovation may not, by itself, be sufficient to explain whether prospective users accept a telemedicine service. The absence of a significant relationship, it may be due to our sample characteristics. Participants were relatively young ($M = 34.84$; $SD = 15.48$), and some may have limited experience with the care provided by local institutions. In this context, telemedicine may not necessarily have been perceived as a particular novelty in managing health. Concurrently, participants varied across territorial provenance. While geographical remoteness should always be considered to conduct between-group analyses and identify facilitators and barriers for each group (Lezcano et al., 2026), local disparities in healthcare services and knowledge of service availability should also be considered. These interpretations of personal innovativeness roles remain exploratory and should be

examined in future studies using samples with substantial variation in age, healthcare experience, and evaluations of local services. We believe that particular attention could be given to patients with chronic conditions, who may be more familiar with healthcare technologies due to repeated interactions with health services. These patients might offer meaningful insights and practical steps, and their participation in co-design processes could therefore contribute to the development of services that are more closely aligned with real-world patterns of healthcare use.

4.2.5. Implications of the tested model on telemedicine pre-service assessment and co-design

Taken together, these findings provide initial evidence that pre-service telemedicine acceptability is shaped by multiple and potentially interacting psychosocial factors. Performance expectancy was the strongest predictor of service acceptability, followed by compatibility, partially mediated by service usefulness, and social influence. Effort expectancy and personal innovativeness did not show significant associations in the present sample. Even if limited, these results have implications for the development of readiness and safety frameworks.

Acceptability should be conceptualised not as a static, post hoc outcome but as a dynamic, formative construct that can actively guide design decisions. Embedding acceptability assessment early in the development lifecycle would allow developers and healthcare organisations to progressively refine service features, communication strategies, and delivery models in response to users' expectations and perceived needs. This approach is particularly relevant for telemedicine, where successful implementation and safety-oriented service development may also be informed by alignment with existing care pathways, organisational constraints, and patients' everyday healthcare practices. Moreover, incorporating acceptability assessment into readiness frameworks could support a more structured identification of potential barriers to adoption before large-scale deployment. For example, low perceived compatibility or weak performance expectancy identified at an early stage could signal the need to redesign specific service components or to strengthen user education and communication strategies. Similarly, variations in social influence across different communities could inform targeted engagement strategies involving healthcare professionals, caregivers, and local stakeholders. From a safety and equity perspective, early acceptability assessment may also help prevent the unintended exclusion of specific user groups. By systematically involving diverse populations during the co-design phase, including individuals with limited digital literacy or reduced access to healthcare resources, developers can better anticipate accessibility challenges, provide initial health literacy training, may help reduce the risk that telemedicine services do not exacerbate existing health disparities. In conclusion, these considerations support a shift towards a continuous, user-centred evaluation model, in which acceptability is repeatedly assessed and integrated throughout the design, development, and implementation phases of telemedicine services, rather than treated as a final validation step. The results, together with their practical implementation, are summarised in Table 8.

The present findings should be interpreted as initial evidence of associations among the proposed constructs rather than evidence of causal relationships, given the study's pilot and cross-sectional design. Future validation studies should also investigate whether the observed relationships are stable across relevant demographic, geographical, and healthcare-experience groups. Concurrently, future research should consider prospectively validating the proposed workflow in telemedicine implementation projects to assess whether higher pre-implementation acceptability predicts subsequent adoption and patient safety outcomes.

Table 8
Interpretation and practical implications of the results obtained in the current work.

Findings from the present study	Practical Implication
Compatibility → Acceptability ($\beta = 0.35$)	Assess whether the proposed service fits the existing healthcare system, routines, and technologies. Where compatibility is low, consider revising appointment or access pathways, integration with existing care, or other service features that conflict with patients' usual healthcare practices.
Performance Expectancy → Acceptability ($\beta = 0.50$)	Demonstrate to patients the expected benefits and added value of the proposed service in managing their own health. Where performance expectancy is low, assess whether the proposed service addresses patients' perceived needs and revise either relevant service features or the way its intended benefits are communicated.
Compatibility → Performance Expectancy → Acceptability ($\beta = 0.40$)	Compatibility should be evaluated not only as operational congruence with the current system, but also to strengthen the perceived usefulness of the proposed service.
Social Influence ($\beta = 0.22$)	It is important to identify trusted healthcare professionals, champions, and relevant community actors and involve them in communication strategies and co-design. Where social influence is particularly relevant, these actors can be more directly involved in service introduction and communication.
Effort Expectancy → Acceptability ($\beta = -0.12$, n.s.)	In the present study, expected ease of use was not directly associated with pre-service acceptability. Therefore, practical information about the proposed service should be provided during early assessments, while effort and usability should be reassessed once users can directly interact with the service.
Personal Innovativeness → Acceptability ($\beta = 0.03$, n.s.)	Personal innovativeness was not directly associated with acceptability in the present sample. Therefore, general interest in new technologies should not be considered sufficient to infer prospective users' interest in a specific telemedicine service; greater attention may instead be given to service characteristics and contextual needs.

4.3. Practical guidelines for the pre-service assessment and co-design of telemedicine services

In this final part of the discussion, we propose a practical framework for integrating pre-service telemedicine assessment with end users into the co-design and implementation of telemedicine services. The proposed framework is based on the interaction between our results and existing safety and readiness evaluation frameworks and tools in the literature (Broens et al., 2007; Perry et al., 2021; WHO Regional Office for Europe, 2024). Since Perry and colleagues' model (2021) on the development of safe telemedicine tools has already been thoroughly described, before presenting our results, we will propose a brief explanation of the telemedicine implementation of Broens and colleagues (2007), and the support tool to strengthen telemedicine developed by the World Health Organisation (2024).

The telemedicine implementation model of Broens and colleagues (2007) stems from the need to identify the key stakeholders who should act as enablers at different organisational levels and stages of telemedicine development. Through a literature review encompassing 45 published papers, the researchers identify five antecedents at different levels that influence telemedicine implementations, namely: technology itself, technology acceptance, funding and reimbursement for service use, the structural organisation of care services and roles, and policy and

legislation. The review led the authors to produce practical guidelines on actions necessary at different stages, which are reproduced and presented in Fig. 4. With our work on telemedicine pre-service acceptability assessment, we want to shift acceptance evaluations from the small-scale pilot level to the prototype level by including patients in technology development, by assessing the acceptability of service conceptualisation.

The support tool to strengthen telemedicine, developed by the European regional office of the World Health Organisation (2024), is based on an empirically validated checklist created by healthcare professionals and is intended as a quick tool to assess organisational and community readiness for implementing telemedicine services. The tool is based on five core principles: 1) Assessment of the current situation, 2) Development of a telemedicine strategy, 3) Development of organisational changes, 4) Development of telemedicine services, and 5) Monitoring, evaluation, and optimisation of the implementation of telemedicine. The authors specifies that only after the successful evaluation of the first core principle concerning the state of the art including professionals capacity of using the technology, the needs and resources of the territory, the suitability of the context, the clinical needs of the area, the infrastructure and fundings available, and the legal regulatory issues, it is possible to continue with all the other principles in an iterative way, without going back to the first one. Our work aims to be positioned in the core principle, informed by preliminary evaluations of the context. We believe that telemedical pre-service evaluations would fit inside the analysis of contextual adaptations of telemedicine services to local areas by involving patients and the public, a group currently left out of the assessment tool.

Applying our findings to current literature, we now propose a practical framework for integrating pre-service acceptability assessment into the development of telemedicine services (Table 9). The proposed framework follows an iterative process in which contextual assessment precedes service design; pre-service acceptability informs service refinement; practical testing is conducted once the main modifiable acceptability concerns have been identified and an appropriate refinement strategy has been defined; and post-implementation evaluations modify the design, implementation, and delivery of care through telemedicine services. Rather than providing a specific set of fixed variables, the framework provides a structure for identifying context-specific factors that could influence users' willingness to adopt a proposed service.

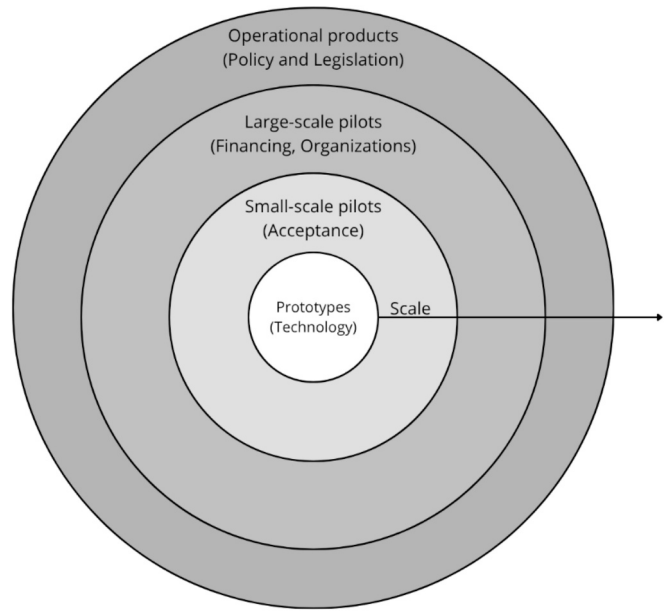


Fig. 4. Layered implementation model proposed by Broens et al., 2007. The image was taken and recreated from Broens et al., 2007.

Table 9

Integration of current findings with existing safety and readiness frameworks (Broens et al., 2007; Perry et al., 2021; WHO European Regional Office, 2024).

Assessment stage	Purpose	Recommended action	Assessment/evidence	Output/Informed decision
1 – Context and structural readiness evaluation	Understand if the local territory has the resources and capabilities to develop and apply telemedicine services.	It is suggested that current healthcare procedures, clinical needs, available infrastructure and funding, digital health literacy, and regulatory conditions be evaluated with healthcare managers, local care professionals, technical/IT staff, and relevant organisational or regulatory actors.	Use of the WHO telemedicine support tool (2024); base evaluations on the model proposed by Broens and colleagues (2007).	At this stage, it will be possible to define telemedicine needs, the target population, implementation constraints, and organisational service requirements.
2 – Service conceptualisation	To develop a telemedicine concept that responds to clinical needs and is feasible with the current resources.	Co-design the service concept with healthcare institutional figures, local care professionals, system technicians, and relevant community actors.	Evaluate different opinions until they fit existing care practices, organisational structure, professional digital expertise and capabilities, and care delivery safety regulations.	At this stage, the initial characteristics of the service use will be defined, together with the expected benefits.
3 – Pre-service patient acceptability assessment	Determine whether prospective users perceive the proposed service as acceptable before they actually use it.	The service should be presented with a sufficiently practical and concrete description, and its acceptability psychosocial antecedents should be assessed. Psychosocial antecedents should be grounded in well-established technology acceptance frameworks and include context-relevant variables identified at different stages. Evaluations should include space for patient comments to identify doubts about the proposed service.	Interpretation and conclusions should be drawn from the relationships between antecedents and acceptability. Depending on the results, particular attention should be given to key antecedents of acceptability during future stages.	At this stage, the output will outline the factors that may influence future patients' use, doubts, barriers, and interest in promoting the service to others.
4 – Patients informed of service refinement	Translate users' evaluations into design decisions by incorporating actionable feedback.	Compare pre-service acceptability results with the initial service proposal, and involve patients and professionals in iterative refinements. Refinement moments can include guided focus groups between different stakeholders (e.g., institutional actors, healthcare professionals, patients). For example, lower compatibility may prompt revision of how the service is integrated into existing care or appointment pathways; lower performance expectancy may indicate the need to reconsider specific service features or communicate their intended value more clearly; and where social influence is particularly relevant, trusted clinicians or community actors may be more directly involved in co-design and communication. Effort- and usability-related concerns should be reassessed once users can interact with a prototype, and may inform simplification of access, onboarding, or training.	Repeated assessments should be used to identify persistent barriers and determine whether these can be addressed through service refinement. Progression to practical testing should not depend on fixed numerical cut-offs, which have not been established by the present pilot, but on whether the main modifiable acceptability concerns have been identified and an appropriate refinement strategy has been defined.	At this stage, it will be possible to identify which modifiable antecedents of telemedicine acceptability should be targeted through service refinement and to develop communication strategies based on the results obtained.
5 – Safety, equity and person-centred assessment	Assess whether the refined services meet broader quality and safety requirements.	Evaluate the redesigned service against access, privacy, diagnostic accuracy, communication, psychological and emotional safety, and human factor/system design with healthcare organisational actors and local care professionals.	The evaluation of the service's safety features should follow the theoretical model proposed by Perry and colleagues (2021). The results must be integrated with previous findings.	At this stage, it will be possible to identify and address safety, accessibility, and equity risks before deployment.
6 – Prototype and practical testing	Determine whether anticipated pre-service acceptability aligns with practical interaction and post-use acceptance.	It is possible to allow prospective users to interact with the prototype in demonstrations or simulations; besides adapting pre-service acceptability surveys to post-use acceptance ones, it is important to gather feedback on the used technology by assessing its usability, users' self-evaluated digital skills, accessibility, net promoter score, and potential barriers and problems that emerged during use.	The evaluations will include: post-use service acceptance, usability assessment, digital skills, net promoter score, and identification of barriers in simulated environments.	At this stage, it will be possible to identify discrepancies between anticipated acceptability and practical acceptance and further refine the service design.

(continued on next page)

Table 9 (continued)

Assessment stage	Purpose	Recommended action	Assessment/evidence	Output/Informed decision
7 – Pilot implementation and post-use assessment	Examine acceptance after final service implementation and direct experience.	Implement telemedical services on a limited scale and reassess the same users over time (depending on the type of service and expected frequency of use) after service exposure.	Evaluations and analyses should encompass pre- and post-service acceptability and acceptance; usability, satisfaction, safety, and efficacy of the service; net promoter score; and adoption operationalised as actual patient use, measured by counting the frequency of adoption relative to parallel or equivalent in-person services.	At this stage, it will be possible to identify which anticipated determinants are confirmed or vary over time, becoming more or less relevant with use experience; gain the first evidence on the interest and functioning of the service.
8 – Monitoring and iterative optimisation	Maintain alignment between the service and users' needs over time	Continuously monitor acceptance, usability, safety, accessibility, and relevant service outcomes with service managers, healthcare professionals, patient representatives, and technical teams.	For these evaluations, it is necessary to refer to the WHO core principles 2, 3, 4, and 5 and conduct repeated user assessments.	At this stage, each output will be confronted with previous ones. When results are not satisfactory, and new needs or barriers emerge, it may be necessary to return to earlier stages and revise service design.

Concurrently, it integrates pre-service acceptability with broader evaluations of readiness, safety, usability, and accessibility.

5. Conclusion

This pilot study developed and provided initial validation evidence for a context-specific instrument, grounded in the Unified Theory of Acceptance and Use of Technology (UTAUT), to assess pre-service acceptability of telemedicine among prospective end users before direct experience with the service. The structural model showed good fit and explained a substantial proportion of variance in both performance expectancy and acceptability. Performance expectancy, compatibility, and social influence emerged as significant antecedents of pre-service acceptability of telemedicine, highlighting the importance of perceived usefulness, contextual fit, and social support in shaping prospective users' evaluations of telemedicine. Beyond identifying these relationships, the study addresses the growing need to more systematically incorporate patients and the public into telemedicine readiness and development processes. We propose that pre-service acceptability assessment should not be considered a standalone evaluation, but rather integrated into broader frameworks for community readiness, co-design, safety, equity, and person-centred implementation. From this perspective, assessing prospective users before implementation may provide an opportunity to identify potential barriers and facilitators early, refine service characteristics, and address contextual mismatches before they lead to implementation difficulties. The proposed approach, therefore, complements existing readiness and safety frameworks by extending end-user assessment to the early stages of telemedicine service conceptualisation and development. In particular, the findings suggest that examining perceived usefulness, compatibility with existing healthcare practices, and social influence may provide actionable information for the iterative co-design of telemedicine services. Subsequent practical testing and post-use assessment can then determine whether anticipated acceptability translates into actual acceptance and identify changes arising from direct experience with the service. Given the pilot nature of the study, the findings should be considered preliminary and require further validation in larger, more representative samples across different telemedicine services, geographical contexts, and clinical populations. Future studies should also examine how pre-service acceptability relates to post-use acceptance, actual patterns of service use, usability, and safety-related outcomes. Extending the assessment to healthcare professionals and other relevant stakeholders would further support a more comprehensive understanding of telemedicine readiness across the different actors involved in implementation. Overall, this study positions pre-service acceptability of telemedicine as a potentially valuable component of proactive readiness and safety assessment, providing an empirically grounded basis for involving prospective users in developing telemedicine services before implementation. Embedding such

assessments within iterative co-design and monitoring processes may contribute to the development of telemedicine services that are safer, more equitable, more accessible, and better aligned with the needs of the communities they serve.

Declaration on the use of generative AI

During the writing and internal revision of the present manuscript, we used the Grammarly tool, provided by the University of Verona, to check for semantic, syntactic, and spelling errors.

CRedit authorship contribution statement

Marco Lezcano: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Margherita Pasini:** Writing – review & editing, Supervision, Project administration, Funding acquisition, Conceptualization. **Vicente González-Romá:** Supervision, Formal analysis. **Marika Palma:** Writing – review & editing, Writing – original draft, Formal analysis. **Maria Gabriella Landuzzi:** Writing – review & editing, Supervision, Project administration, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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