Telemedicine Use Among Older Adults in Finland

A Regional Ecological Study Analysis

Nonye Georgina Anasonye

Supervisor: Margarida Santos

Invited Assistant Professor, Iscte - IUL

Date: 25.05.2026

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To God Almighty, for His guidance, wisdom, knowledge and understanding, my Family for their love and patient and my supervisor for her immense support through this study.

Abstract

Telemedicine has become an essential component of Finland's digital healthcare ecosystem, yet older adults continue to engage with such services unevenly across regions. This study examines regional patterns of telemedicine use among adults aged 75 years and older using an ecological design based on data from the Finnish Institute for Health and Welfare (THL) Digital Services and E-Transactions 2024 dataset. The analysis addresses three questions: regional and age-related variation in telemedicine use, the role of user experiences and barriers, and the association between digital skills, perceived benefits, and challenges with telemedicine uptake. Descriptive statistics, correlation analysis, and ordinary least squares regression were applied to assess regional-level relationships. The results reveal substantial regional variation and a consistent age gap, with lower telemedicine use among those aged 75+. Regions with higher digital skills and perceived convenience show greater uptake, while security concerns and accessibility challenges are negatively associated. The model explains approximately one-third of regional variation. These findings highlight the importance of regional digital ecosystems in shaping telemedicine adoption and underscore the need for targeted digital inclusion and service design improvements.

Keywords: Telemedicine; Older adults; Digital health; Ecological analysis; Digital divide

JEL Classification

J14; R12;

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Chapter 1 Introduction

Digital transformation has reshaped how healthcare services are delivered globally, with telemedicine emerging as a central tool for improving access and continuity of care. In digitally advanced countries such as Finland, national strategies have long supported electronic health systems and digital communication tools (Laukka et al., 2024). Despite this infrastructure, telemedicine adoption among older adults remains uneven. International research consistently shows that older individuals face unique barriers, including technological unfamiliarity, cognitive load, and reduced digital self-efficacy (Park, 2025). In Finland, recent studies suggest that digital health engagement is shaped not only by individual capacity but also by contextual and environmental features, such as regional service design, perceived usability, and trustworthiness of digital interfaces (Rosenlund et al., 2024).

Older adults commonly report both positive and negative experiences with digital health. Benefits such as reduced travel burden, flexible access, and improved information flow are frequently noted (Torkki et al., 2026). However, concerns about data security, confusing interfaces, and limited accessibility remain significant barriers (Laukka et al., 2024). Because these experiences can vary widely across regions, an ecological perspective which is studying wellbeing services counties as the unit of analysis is essential. Regional differences in broadband coverage, local social welfare and healthcare services provider digitalisation, community digital support, and socioeconomic conditions may create distinct digital ecosystems (Park, 2025).

1.1. Statement of the problem

The ageing population in Europe is increasing rapidly, the only main age group that is expected to grow both in relative and absolute terms. Those aged 75+ projected to expand by 56.1% by 2050 (Eurostat, 2023). It is projected that elderly 65 years and above will increase to 32.5 % in 21 centuries from 21.1% at the beginning of 2022 and the working age group (15- 64 years) to decrease from 63.9% to 54.4% in 2100. (Eurostat, 2025). The old-age dependency ratio will also increase to 59.7% in 21 centuries from 33.0. According to the source, number of older people under care will increase, that is two elderly people for every three people of working age group in 21 centuries against one elderly to three people working age group at the beginning of 2022 (Eurostat, 2025). This implies increase in the burden of healthcare professionals. The visual diagrams are shown in Annex A, B and C. Digital health solutions are essential to support independence and healthcare access (Raja et al., 2021). Despite national efforts to promote digital inclusion, telemedicine use among older adults in Finland remains uneven. Recent indicators show that while 17.9% of adults aged 65+ engaged in digital contact with a social welfare and healthcare services professional in 2024, the rate drops to 14.5%

among those aged 75+ (Finnish Institute for Health and Welfare, 2024). This age-related decline suggests persistent barriers affecting the oldest age groups.

Additionally, significant regional variation exists. For example, telemedicine use among the 75+ population is highest in Helsinki (26.0%) and lowest in South Ostrobothnia (8.4%), highlighting disparities in digital readiness and service accessibility across wellbeing services counties ((Finnish Institute for Health and Welfare, 2024). At the same time, older adults report a mix of benefits such as convenience and ease of accessing services and challenges, including security concerns, usability issues, and accessibility barriers (Laukka et al., 2024; Rabbani et al., 2025). These experiences may influence telemedicine engagement, yet the extent (positively or negatively) to which they relate to telemedicine use remains underexplored using national quantitative data.

This research adopts an ecological design which means that the analysis was regionally based and not individually to examine telemedicine use among adults aged 75 and older in Finland. Using Finnish Institute for Health and Welfare, (2024) regional indicators, the research explores: (1) how telemedicine use varies by region and age, (2) how older adults' digital experiences relate to telemedicine use, and (3) how regional digital skills, perceived benefits, and digital barriers influence telemedicine adoption. The goal is to identify regional digital inequalities and inform targeted strategies to promote equitable telemedicine access for older adults.

An ecological design is an observational design in which exposure and outcome variables are analysed at the population or group level rather than at the individual level (Levin, 2003).

1.2. Research Goals

Based on what has been described, the purpose of this research is to examine how older adults in Finland use telemedicine and how their experiences with digital health services shape this use. Specifically, the study uses national survey indicators from Finnish Institute for Health and Welfare, (2024) to: Compare telemedicine use across age groups (65+ and 75+) and regions, Identify the most common benefits and challenges encountered when using digital and telemedicine services and Analyze how digital skills, perceived benefits, and reported challenges relate to telemedicine use at the regional level.

By combining descriptive, correlational, and regression analyses, this study aims to provide a comprehensive understanding of the interplay between capability, experience, and digital uptake among Finland's older population. To address these goals, this research is trying to answer the following questions: 1. How does telemedicine platform use in Finland by the elderly vary by age and region. 2. What are the most common experiences (benefits and challenges) elderly face in using

digital and telemedicine services in Finland and how it affects digital and telemedicine services use among elderly in Finland. 3. How do digital skills, perceived benefits, and reported challenges relate to telemedicine use at the regional level in Finland?

1.3. Significance of Study

This study is significant because it addresses the growing need to ensure that older adults, particularly those aged 75 and above, are included in Finland's shift toward digital-first healthcare. By examining the factors influencing their use of telemedicine, it helps identify ways to reduce digital regional inequality and improve access. The findings also provide valuable insights for regional policymakers, highlighting disparities in telemedicine uptake and guiding targeted investments in infrastructure and digital literacy. Additionally, the study supports healthy aging by exploring how telemedicine can enhance continuity of care, reduce travel burdens, and enable aging in place, while recognizing barriers to its use. Finally, by relying on national-level data, it offers strong, evidence-based insights that can inform policy decisions, healthcare planning, and future research.

Chapter 2 Literature Review

Based on the literature, telemedicine adoption among older adults can be understood through three interrelated domains: Capability which includes digital skills, confidence, and familiarity. Experience which includes Perceived usefulness, convenience, accessibility, and satisfaction and Context which includes regional digital infrastructures, service availability, social support, and demographic characteristics. The Finnish Institute for Health and Welfare (THL) dataset provides indicators that map directly onto these domains, enabling empirical analysis of how each contributes to telemedicine use.

2.1. Definition of Telemedicine

The term telemedicine broadly refers to the use of electronic information and communication technologies to provide and support health care when participants are separated by distance (World Health Organization [WHO], as cited in Rasmussen et al., 2018). More precisely, in their review, Ekeland et al. (2009) defines telemedicine as "the remote delivery of healthcare services via telecommunications and information technologies" (p. 12). According to the United States National Center for Biotechnology Information (NCBI) Bookshelf, telemedicine is "the use of electronic information and communications technologies to provide and support health care when distance separates the participants" (Bashshur, Shannon, & Smith, 2014, p. 3). Telemedicine is defined as the remote delivery of healthcare services using digital communication technologies, including video consultations, remote monitoring, and mobile health applications (mHealth) (Wootton, 2020). In practice, telemedicine may include synchronous (real-time) video or audio consultations, asynchronous (store-and-forward) data or image transmission, remote monitoring, and mobile health (m-health) applications.

2.2. Types of Telemedicine

Telemedicine encompasses a broad range of modalities through which healthcare services can be delivered remotely. The classification of telemedicine can be based on the nature of interaction, timing of information exchange, technology used, or the specific clinical purpose. The World Health Organization (WHO, 2010) identifies four main modalities: real-time (synchronous), store-and-forward (asynchronous), remote monitoring, and mobile health (m-health).

2.2.1. Real-Time (Synchronous) Telemedicine

Real-time or synchronous telemedicine involves live, two-way interactions between a healthcare professional and a patient through audiovisual communication systems (Koonin et al.,

2020). This approach closely replicates the traditional face-to-face consultation but takes place via digital means such as video conferencing, telephone, or secure messaging platforms. Real-time consultations are widely used in primary care, mental health (telepsychiatry), urgent care triage, and follow-up appointments (Hollander & Carr, 2020). The advantages of synchronous telemedicine include immediate feedback, patient engagement, and more personal interaction that fosters trust. However, it requires stable internet connectivity, suitable equipment, and privacy safeguards (Bashshur et al., 2016).

2.2.2. Store-and-Forward (Asynchronous) Telemedicine

In store-and-forward telemedicine, patient data such as medical images, lab reports, and recorded videos are collected and transmitted to a specialist or clinician for evaluation later (Dorsey & Topol, 2020). This method eliminates the need for simultaneous presence of the patient and provider, making it particularly useful for specialties like dermatology, radiology, and pathology (Marcin et al., 2016). Asynchronous systems allow for more efficient resource use, enabling clinicians to review cases during non-peak hours. However, a key limitation is the absence of real-time feedback, which may delay diagnosis or limit immediate clarification (Keesara et al., 2020).

2.2.3. Remote Patient Monitoring (RPM)

Remote patient monitoring refers to the use of digital technologies to collect medical data from individuals in one location and electronically transmit the information securely to healthcare providers for assessment and recommendations (Kruse et al., 2017). RPM is extensively used in the management of chronic diseases such as diabetes, hypertension, chronic obstructive pulmonary disease (COPD), and heart failure (Totten et al., 2016). The system enables continuous assessment of patient conditions through wearable sensors, home blood pressure monitors, or glucose meters that send data to a central system. This form of telemedicine supports proactive management, early detection of deterioration, and personalized care adjustments (Breen et al., 2022).

2.2.4. Mobile Health (m-Health)

Mobile health or m-health involves the use of mobile devices such as smartphones, tablets, and personal digital assistants (PDAs) to deliver healthcare information, monitor health parameters, and promote healthy behaviors (WHO, 2011). M-health applications can track physical activity, medication adherence, and provide health education to users. The widespread availability of mobile

technology makes m-health an accessible and cost-effective component of telemedicine, especially in low-resource settings (Free et al., 2013).

2.2.5. Other Modalities

Other emerging telemedicine modalities include tele-education, which delivers medical education and training remotely, and telepharmacy, which allows pharmacists to provide counseling, medication therapy management, and prescription verification from a distance (Poudel et al., 2020). Teleradiology, telepathology, and telecardiology have also gained prominence in specialized medical services where digital imaging and diagnostics are critical. Overall, these modalities illustrate the versatility of telemedicine and its adaptability to diverse clinical and technological environments.

2.3. Applications of Telemedicine in Health Care

Telemedicine has extensive applications across a range of healthcare domains, from preventive and primary care to specialized and emergency services. Its flexibility enables health systems to enhance accessibility, continuity, and efficiency of care delivery (Kichloo et al., 2020). Telemedicine has become integral to primary care, particularly for routine consultations, medication reviews, follow-up appointments, and chronic disease management (Greenhalgh et al., 2020). It allows general practitioners to conduct virtual assessments, discuss test results, and adjust treatment plans without requiring in-person visits. During the COVID-19 pandemic, telemedicine was essential in maintaining continuity of care while minimizing infection risk (Koonin et al., 2020). Preventive applications include remote screening programs, lifestyle counseling, and vaccination outreach facilitated through digital platforms (Haleem et al., 2021). For instance, remote smoking cessation programs and digital weight management initiatives have demonstrated effectiveness in improving public health outcomes (Torous et al., 2018).

In the mental health care context, we can find telepsychiatry and telepsychology are among the earliest and most successful applications of telemedicine. Through video or phone consultations, mental health professionals can deliver therapy, medication management, and crisis interventions (Yellowlees et al., 2018). Studies have shown that telepsychiatry achieves outcomes comparable to in-person care, with high patient satisfaction and reduced waiting times (Hilty et al., 2020). Telemedicine also plays a vital role in extending mental health support to rural or underserved communities, where specialist services are often scarce. The scalability and privacy of online platforms can help overcome social stigma associated with seeking mental health care (Krzewski et al., 2020).

Also, telemedicine enables ongoing monitoring and personalized interventions for chronic diseases such as diabetes, hypertension, asthma, and cardiovascular conditions (Kruse et al., 2017).

For example, telemonitoring systems for patients with heart failure can transmit daily weight, blood pressure, and oxygen saturation data to clinicians, who can promptly adjust medication or schedule reviews if abnormalities are detected (Totten et al., 2016). In diabetes management, mobile apps and wearable devices support glucose tracking, insulin titration, and dietary education. Such systems have demonstrated improved glycemic control and adherence to treatment (Marcolino et al., 2018).

2.4. Use of Telemedicine to Improve Health Services

Telemedicine has transformed healthcare delivery by improving access, efficiency, and quality of services across primary, secondary, and tertiary care settings. Its adoption addresses key barriers such as geographic distance, workforce shortages, and cost inefficiencies. The integration of telemedicine into healthcare systems aligns with global health goals, including the World Health Organization's (WHO) aim of achieving universal health coverage and equitable access to essential services (WHO, 2021). One of the most significant contributions of telemedicine is its ability to enhance healthcare accessibility, particularly in remote, rural, and underserved communities (Scott Kruse et al., 2018). In regions where healthcare infrastructure is limited, telemedicine allows patients to connect with specialists without the burden of long-distance travel. For example, in rural parts of sub-Saharan Africa and South Asia, teleconsultations bridge the gap between primary care providers and tertiary specialists (Mars & Scott, 2017). Telemedicine also improves access for individuals with mobility challenges, the elderly, and those with chronic conditions requiring frequent follow-up (Greenhalgh et al., 2020). Through home-based teleconsultations, patients receive timely care while minimizing disruption to their daily routines. This approach supports inclusivity and continuity of care, ultimately contributing to health equity (Bashshur et al., 2016).

Telemedicine, defined as remote communication between healthcare professionals and patients, is increasingly used to manage chronic conditions, provide follow-up care, and improve service accessibility. Research shows that telemedicine offers clear advantages for older adults, including reduced physical strain and enhanced continuity of care (Park, 2025). However, several studies indicate that older adults adopt telemedicine at lower rates than younger populations due to usability issues, device limitations, and familiarity challenges (Rabbani et al., 2025). Digital literacy is one of the strongest predictors of digital health engagement. Older adults with higher digital competence report greater confidence, better navigation ability, and increased telemedicine use (Rosenlund et al., 2024). Perceived benefits such as improved service convenience are also associated with stronger digital adoption (Torkki et al., 2026). Conversely, negative experiences such as privacy concerns, distrust in digital platforms, and difficulty accessing digital services deter engagement (Laukka et al., 2024).

Regional factors also influence digital health adoption. Regions with higher digital readiness, greater social welfare and healthcare services provider digitalization, and more extensive support systems tend to report higher telemedicine uptake among older adults (Park, 2025). Ecological studies emphasize that telemedicine adoption is shaped not only by individual characteristics but also by broader contextual features, making regional-level analysis essential in understanding digital health inequalities.

Telemedicine has become increasingly important in digitally advanced health systems such as Finland, where digital infrastructure and ehealth strategies are well established. However, research shows that older adults continue to experience barriers to digital health adoption, even in highly digitalized contexts (Laukka et al., 2024). This highlights a growing need to understand user level factors, including digital skills, perceived benefits, and challenges that shape telemedicine engagement.

2.5. Telemedicine Use Among Older Adults

Telemedicine offers remote access to healthcare, potentially reducing the need for travel and improving access for older adults. Yet older individuals consistently adopt telemedicine at lower rates than younger groups, often due to limited confidence, usability concerns, and habitual reliance on face-to-face care (Park, 2025). Qualitative research in Finland shows that older adults' uptake of digital services is strongly influenced by their comfort with technology and the degree to which services match their preferences and capabilities (Laukka et al., 2024).

Digital literacy is one of the most powerful determinants of telemedicine adoption. Older adults often exhibit lower levels of digital competence due to limited exposure, anxiety about technology use, and reduced access to digital training opportunities (Rosenlund et al., 2024). Studies from multiple Finnish regions also confirm that digital competence predicts the perceived usability and benefits of digital services in later life (Torkki et al., 2026). Because digital health services increasingly require autonomous navigation, digital skills function not just as a technical asset but also as a psychological enabler building self-efficacy, trust, and willingness to use telemedicine platforms (Rosenlund et al., 2024).

Commonly reported benefits among older adults include time/place flexibility, reduced travel burden, easier access to information, and improved wellbeing. Finnish surveys show that older adults especially value digital services that simplify everyday tasks and allow flexibility in scheduling and access (Torkki et al., 2026).

International evidence also notes that telehealth enhances chronic care management and promotes aging in place when users perceive clear advantages (Rabbani et al., 2025). When benefits are salient, engagement tends to increase. Despite the benefits, older adults report numerous

challenges that negatively affect telemedicine adoption, including: a) technical barriers, for instance, navigation difficulties, device incompatibility, poorly adapted interfaces, and limited broadband access remain significant obstacles (Park, 2025); b) psychological barriers, when there is fear of making mistakes, low perceived competence, and anxiety about unfamiliar digital tools reduce motivation to use telemedicine (Rosenlund et al., 2024); c) security and privacy concerns , when data security concerns are prominent among Finnish seniors and are repeatedly cited as barriers to digital service adoption (Laukka et al., 2024; Rosenlund et al., 2024), and such concerns directly undermine trust in telemedicine technologies; d) accessibility issues, as barriers such as difficulty logging in, small text, or unclear instructions disproportionately affect the 75+ age group (Laukka et al., 2024).

2.6. Telemedicine regional inequalities among older adults

Studies indicate that telemedicine adoption differs greatly between regions depending on digital infrastructure, local training programs, and service availability (Torkki et al., 2026). Like international trends, Finnish rural areas may experience weaker digital ecosystems and lower baseline digital readiness (Park, 2025). Studies have highlighted its potential in managing chronic diseases, reducing hospital visits, and enhancing the quality of life for older adults (Wang et al., 2021).

In Finland, a country known for its advanced digital healthcare infrastructure, telemedicine has been widely implemented in elderly care. Studies show that Finland's elderly population benefits from remote consultations, home monitoring devices, and digital health applications (Hyppönen et al., 2019). The Finnish government has invested in digital health solutions to support aging populations, particularly in rural areas (Vuokko et al., 2019). Government initiatives such as the Kanta Services and a Finnish National Digital Channel/Service for Social Welfare and Healthcare (written as Omaolo, which is the Finnish name) aim to enhance telemedicine accessibility and usability for older adults (Finnish Ministry of Social Affairs and Health, 2021). The study which was conducted on the telehealth and digital technology adoption among Europeans aged 75+, focusing on experiences, barriers, and facilitators from 1998–2018 reveals evidence that Telehealth and digital devices can improve independence and provide a sense of security, but adoption often requires extra effort and adaptation (Raja et al., 2021). The study shows that elderly patients' experiences vary widely and technology can make life easier or harder. Technology facilitators were identified as being capable of increasing the quality of life of the elderly, thereby enhancing their wellbeing. Technology barriers were also identified as complexity of devices and difficulty remembering instructions, physical limitations and lack of confidence, technical issues and unreliable systems, privacy concerns (e.g., cameras in robots), low education and insufficient training, and high costs and design limitations. Benefits include ease of use (most critical factor), social support (help from family or caregivers),

perceived usefulness and meaningfulness, ability to connect with healthcare providers or family, and a sense of security and autonomy.

Several studies have identified key success factors in the adoption and effectiveness of telemedicine for older adults. Many advantages have been identified in the review of telemedicine services in Finland (Khatri et al. 2011). According to the authors, the biggest of them is saving time from travel required for appointments for both patients and healthcare professionals, administrative tasks, cost due to organizational workload, administrative resources, use of consultation services from a distance, and a patient's efforts (Khatri et al., 2011). Accessibility and Convenience: Telemedicine reduces the need for physical hospital visits, offering greater accessibility for elderly patients with mobility challenges (Kruse et al., 2020). Chronic Disease Management: Telemedicine has proven effective in monitoring chronic diseases such as hypertension, diabetes, and heart disease, leading to better health outcomes (Kvedar et al., 2019). Improved Mental Wellbeing: Studies indicate that telemedicine can reduce social isolation and improve mental health among elderly patients by providing continuous interaction with healthcare providers (Batsis et al., 2021). Cost Efficiency: Telemedicine can lower healthcare costs for both patients and providers by reducing travel expenses and hospital admissions (Mehrotra et al., 2020). Medication adherence intervention: Studies shows that telemedicine may improve medication adherence of patient with mental illness such as depression, schizophrenia and bipolar diseases using different telemedicine technology tools and medium due to high intervention it has over face-to-face medication adherence intervention (Basit et al., 2020). Decision making: Studies show that older adults may benefit from shared decision making which is possible through digital tools in making decisions concerning their health issues. (Rosenlund et al., 2024).

Other authors have also identified challenges in telemedicine adoption in older adults, these includes digital literacy and usability (Czaja et al., 2021), technological barriers due to poor internet connectivity, especially in rural areas, which can limit access to telemedicine services (Latulippe et al., 2020), lack of human touch whereby older adults prefer in-person consultations, perceiving telemedicine as impersonal and less effective (Shulver et al., 2017), privacy and security concerns (Bujnowska-Fedak & Grata-Borkowska, 2015), lack of access to telemedicine services arising from difficulties in using video visit platforms, language barriers, difficulty in learning the new technology and the desire to get assistance when needed in using telemedicine (Mao et al, 2022). Similarly, older people have trouble remembering instructions relating to the use of technology in telehealth and digital devices (Raja et al, 2021) and negative emotional experiences such as frustrations, fear, anxiety, and fear of incompetence and embarrassment when is associated with older people's use of digital health services (Valkonen & Kujala, 2024).

The literature consistently shows overall that telemedicine use declines with age, digital literacy is a major enabler of adoption, convenience and perceived usefulness motivate older adults to use digital health services, security concerns, usability issues, and accessibility barriers inhibiting engagement and regional disparities reflect unequal access to digital infrastructure and local support systems (Laukka et al., 2024, Park, 2025, Rosenlund et al., 2024, Torkki et al., 2026,). These themes frame the interpretation of results in this research and highlight the importance of comprehensive digital inclusion strategies applied to telemedicine to support regions in an increasingly digitalized health system.

2.7. Ecological study

An ecological study is an observational design in which exposure and outcome variables are analysed at the population or group level rather than at the individual level (Science Insights, 2025). In ecological studies according to the British Medical Journal, “the unit of observation is the population or community” (BMJ,2020). Disease rates and exposures are measured across groups, such as regions or countries, to investigate macro-level associations (BMJ, 2020). While efficient and well suited to evaluating contextual or policy-related factors, ecological studies cannot infer individual-level relationships because of the risk of ecological fallacy (Levin, 2003). Ecological studies are useful in making large-scale comparison, for example comparing telemedicine across region, Comparing environmental exposure and disease rates between countries (BMJ, 2020; Levin, 2003). They are relevant especially when barriers such as cost or confidentiality makes individual-level data unavailable or impractical. They are useful for studying rare outcomes through data aggregations (regional averages, country level percentages, national rates, environmental measurements, policy-level indicators) which allows enough cases to detect patterns (Levin 2003).

Chapter 3 Methodology

This chapter describes the methods used in the study; the design, the origin of the data used for the study, the geographical coverage, population and sample, variable and measures, data preparation and cleaning and the analytical strategies employed in the study.

3.1. Research Design

This study used a cross-sectional ecological design to examine regional-level patterns of telemedicine use among adults aged 75 and older in Finland. Rather than analyzing individual behaviors, the study analyzed wellbeing services counties as the unit of analysis, linking regional telemedicine use with regional digital skills, perceived digital service benefits, and reported challenges. This approach is appropriate for understanding system-level inequalities and contextual digital readiness across Finland's healthcare regions (Park, 2025; Rosenlund et al., 2024). The study employed a quantitative, cross-sectional research design using secondary data obtained from the Finnish Institute for Health and Welfare Digital Services and Transactions 2024 dataset. The aim was to provide answers to the research questions 1. How does telemedicine platform use in Finland by the elderly vary by age and region. 2. What are the most common experiences (benefits and challenges) elderly face in using digital and telemedicine services in Finland and how it affects digital and telemedicine services use among elderly in Finland. 3. How do digital skills, perceived benefits, and reported challenges relate to telemedicine use at the regional level in Finland?

The study focuses on two populations: individuals aged 65+ and 75+, reflecting how Finnish Institute for Health and Welfare structures its age group reporting. Indicators included in the dataset captured descriptive information on digital capabilities, telemedicine use, and experiences with digital health services across all well-being services counties. Artificial intelligence (M365 Copilot based on GPT-5) was used to support writing, structuring, brainstorming and editing of the manuscript. All analytical decisions, interpretations, and final content were reviewed and validated by the author. That is, the tools were used only for language support and structuring; all statistical analysis and interpretation were conducted independently by the author.

3.2. Data Source

3.2.1. Dataset Origin

All data were sourced from the Finnish Institute for Health and Welfare "Digital Services and Transactions – TerveSuomi 2024" survey, exported through the Finnish Institute for Health and Welfare web page that contains the statistics on population health and wellbeing (Sotkanet) and

supplemented with confidence intervals and sample sizes directly from Finnish Institute for Health and Welfare's online reporting interface. The dataset contains indicators such as: Digital skills ≥ fair capability indicator, digital contact with social welfare and healthcare services professional (telemedicine use), perceived convenience benefits of e-service use regardless of time/space, challenges of e-services not accessible and concerns which is e-service data security. Each indicator is provided by region, year (2024), age group, and sex. These variables are self-reported by older residents but aggregated by region, making them suited for ecological analysis

3.2.2. Geographic Coverage

The dataset spans all 23 Finnish wellbeing services counties; this full regional coverage enables robust spatial comparison. Figure 3.1 shows the regional map of Finland.



Figure 3. 1: Finland's regional Map

Adapted from Health services in Finland by Marjukka Turunen 2024.

3.2.3. Population and Sample

Population includes adults aged 65+ and 75+. Sample sizes vary by indicator and region (e.g., n ≈ 9,787 for national 75+ digital skills; n ≈ 8,668 for national 75+ data security concerns), as

reported in the dataset, because regional subsamples differ in size, results are interpreted with consideration for potential sampling variability.

3.3. Variables and Measures:

Regarding our three research questions, which are 1. compare telemedicine use across age groups (65+ and 75+) and regions; 2. identify the most common benefits and challenges encountered when using digital and telemedicine services; and 3. analyse how digital skills, perceived benefits, and reported challenges relate to telemedicine use at the regional level, we have defined that our variables are: telemedicine use, digital capability, perceived benefit, and challenges which were measured based on the data from the Finnish Institute for Health and Welfare(The Finnish Institute for Health and Welfare, 2024) using responses from the questionnaires.

3.3.1 Telemedicine Use (Dependent Variable)

Measured as: Digital contact with social welfare and healthcare services professional (service users), expressed as a percentage of the respective age group. This variable served as the main outcome in the regression and correlation analyses.

3.3.2. Digital Capability

Measured using digital skills ≥ fair (% of 75+) This indicator enabled assessment of regional digital readiness.

3.3.3. Perceived Benefits

Three benefit indicators were used in descriptive analysis; one (“E-services eased use regardless of time/place”) was included in the regression: Eased use regardless of time/place, eased finding/choosing services, helped wellbeing. Values represent the percentage of respondents aged 75+ reporting each benefit.

3.3.4. Challenges and Barriers

Challenge indicators included: Experienced obstacles/concerns with eservices, Concerned about eservice data security, E-services not accessible

Security concerns and accessibility issues were included as predictors in inferential analyses.

3.4. Regional Matching of Indicators

To build the regression dataset, only indicators available for all regions and age 75+ were included. This ensured consistent alignment across counties. The resulting dataset contained 23 regions after excluding “Whole country.”

3.5. Data Preparation and Cleaning

Data preparation was conducted using Python. The steps included:

3.5.1. Column Standardization.

This includes removal of trailing whitespace, ensuring consistent categorical values for age groups, and mapping Finnish age labels (e.g., “75 years old”) into simplified codes (75+). These steps ensured harmonized variable naming for analysis.

3.5.2. Filtering and Indicator Selection

Indicators used in the statistical analysis were selected based on: Relevance to research questions, availability for both national and regional levels and Completeness across all regions in the 75+ subsample.

3.5.3. Reshaping for Analysis

Pivot tables were generated to organize telemedicine use by region × age. Regional datasets were merged to create the regression panel including; telemedicine use (75+), digital skills ≥ fair, security concerns, accessibility issues, time/place benefit.

The final dataset used for correlation and regression contained complete cases only.

3.6. Analytical Strategy

A multistep statistical strategy was employed to address the research questions comprehensively.

3.6.1. Descriptive Statistics

Descriptive statistics (percentages and summary tables) were used to; Compare telemedicine adoption between 65+ and 75+, identify highest and lowest telemedicine use regions and summarize benefits and challenges experienced by older adults. These statistics were drawn directly from the dataset’s value pct fields.

3.6.2. Crosstabulation

Cross tabulated pivot tables were used to compare telemedicine use between 65+ and 75+ within each region and provide differences in availability of benefit/challenge indicators across age groups. This method enabled visually interpretable comparisons and facilitated regional ranking.

3.6.3. Correlation Analysis

Pearson's correlation coefficients were computed at the regional level for the 75+ group to examine linear associations between: Telemedicine use, digital skills, security concerns, accessibility challenges, and perceived convenience (time/place benefit). Correlations were calculated using the merged regional panel dataset and produced a 5×5 matrix.

3.6.4. Multiple Linear Regression

An ordinary least square (OLS) regression model was constructed to examine the combined influence of digital skills, perceived benefits, and challenges on telemedicine use among the 75+.
The content of the model is explained in table 3.1 below;

Table 3. 1: Regression Model Explanation

Variable	Type	Reason for inclusion
Telemedicine use (%)	Dependent	Core outcome (RQ1& RQ2)
Digital skills ≥ fair	Predictor	Measures digital readiness
Security concerns	Predictor	Central challenge indicator
E-services not accessible	Predictor	Barriers to service engagement
Time/place benefit	Predictor	Most reported positive experience

The model achieved $R^2 = 0.34$, meaning predictors explained 34% of regional variation in telemedicine use. Coefficients were interpreted cautiously due to the ecological level of the data. The analysis relied on standard, well-established Python libraries commonly used in quantitative social science and health research which are pandas; used for data import, cleaning, transformation, merging, and aggregation of regional indicators. NumPy is used for numerical operations, matrix algebra, and implementation of ordinary least squares (OLS) regression. Statistical analysis was done in numpy.linalg (numpy.linalg.lstsq, this is the Python library used in solving matrix linear equation using the least square method) which is used to estimate regression coefficients for the regional ordinary least squares (OLS) model. However, because the dataset contained a small number of regional units (wellbeing services counties), a lightweight linear algebra implementation was preferred over more

complex modelling frameworks. The regression is mathematically equivalent to classical ordinary least squares (OLS).

Matplotlib library was used to generate all visual plots including Bar charts (telemedicine use by region), Scatterplots (telemedicine vs skills; telemedicine vs security concerns), and Comparative bar charts (65+ vs 75+) while seaborn library was used to enhance visual styling (e.g., heatmaps of standardized regional profiles). These libraries are widely validated and documented in scientific computing literature (Hunter, 2007; McKinney, 2010). Below is a step-by-step description of the analytical workflow:

Step 1: Data import and preparation

The Finnish Institute for Health and Welfare Digital Services and E-Transactions 2024 dataset was imported into Python using pandas. Indicators were filtered to retain Year: 2024, Age group: 75+, and unit of analysis which is wellbeing services counties. National ("Whole country") aggregates were excluded to ensure that analyses reflected between-region variation only. Each indicator (telemedicine use, digital skills, perceived convenience, security concerns, accessibility problems) was extracted and merged into a single regional-level dataset, where each row represented one wellbeing services county.

Step 2: Descriptive analysis

Descriptive statistics (means, ranges, and regional rankings) were computed to summarize variation across regions. Visualization was used at this stage to: Identify regional disparities, compare age groups (65+ vs 75+) and inspect distributions and potential outliers. These descriptive results directly addressed research question one (variation by age and region).

Step 3: Correlation analysis

Pearson correlation coefficients were calculated between: Telemedicine use (dependent variable), Digital skills, Perceived convenience, Security concerns, accessibility problems. Because all variables were measured at the regional level, correlations represent inter-regional associations, not individual-level relationships. This analysis addressed research question two by examining how regional experiences and challenges align with regional telemedicine use.

Step 4: Regression analysis

Regression analysis was used to examine how multiple regional characteristics jointly relate to telemedicine use among adults aged 75+, beyond what can be observed through descriptive statistics or bivariate correlations. While correlation analysis identifies whether two regional variables are associated, it does not account for the fact that digital skills, perceived benefits, and reported challenges may operate simultaneously and be interrelated at the regional level. The regression model allowed the independent association between each predictor and telemedicine to be assessed while

statistically adjusting for the others, thereby clarifying their relative importance in explaining between-region variations. In addition, regression analysis enabled the estimation of model explanatory power (R^2), showing how much of the regional variation in telemedicine uptake is accounted for by the selected indicators. Consistent with the ecological design, the regression results are interpreted as contextual associations between regions rather than individual-level or causal effects and were used to address research question 3 in a structured and systematic manner.

Step 5: Visual analytics and diagnostic interpretation

Scatterplots and heatmaps (see figures 5.6., 5.7., and 5.8.) were used to visually confirm the direction and strength of correlations, the consistency between bivariate and multivariable results, and the clustering of regions into high- and low-digital-readiness profiles. Visual analytics played a complementary role, supporting interpretation while avoiding over-reliance on numerical output alone.

3.6.5. Methodological transparency and reproducibility

Using Python for the entire analytical process provides several advantages: which includes r*eproducibility* meaning that all steps can be rerun from raw data to final figures,
transparency which means that analytical decisions are explicit and traceable, *consistency* which means that descriptive, inferential, and visual analyses are harmonized within one environment. This approach aligns with contemporary recommendations for open and reproducible research in population health and digital health studies.

Chapter 4 Data Analysis

The data analysis employed the combination of descriptive, correlational and regression method. Data underwent programmatic cleaning, crosstabs, correlations, and a multiple regression (regional panel, 75+) to link experiences/skills with telemedicine use as follows; a moderate positive correlation (r=+0.52) exists between digital skills and telemedicine use which shows that regions with better skills tend to have a higher use. A negative correlation (r=-0.38) exists between security concerns and telemedicine use, and this is associated with lower use. A negative correlation(r=-0.34) also exists for “not accessible" when linked with telemedicine use, which means that accessibility issues link to lower use. A positive correlation (r=+0.55) exists when telemedicine use is linked with the benefit “time/place”. That is, where people perceive time and place as a benefit, telemedicine use is higher.

The Multiple regression (regional, 75+) shows the outcome of telemedicine use (75%) with the predictors: digital skills, security concern, not accessible, benefit: time/place and produced the model $R^2 \approx 0.34$ (explains ~34% of regional variance) which are the estimated effects (pp change in use per pp change in predictor) as; digital skills: +0.24 (positive), security concern: -0.08(negative), not accessible:+ 0.16(small positive likely due to limitations which is explained in the discussion), benefit: time/place:+0.30(positive), the sample size(n=23 regions after matching indicators).

The analysis was based on regional-level indicators from the Finnish Institute for Health and Welfare (THL) Digital Services and E-Transactions 2024 dataset, which provides aggregated percentages for digital service use, skills, benefits, and challenges among older adults.

Data preparation aimed to ensure comparability across regions and alignment with the ecological research design. The analytical focus was restricted to the 75+ age group, as this cohort consistently exhibits the largest digital divide and had the most complete indicator coverage across regions. Limiting the analysis to a single age group avoided confounding age effects with regional differences and ensured that each region contributed one observation per variable. Missing data primarily resulted from indicators not being reported for certain regions due to small sample sizes. No imputation was performed, instead, listwise deletion at the indicator level was applied, meaning that only regions with complete data for all variables included in each analysis were retained. This conservative approach was chosen to avoid introducing artificial values into aggregated regional data and to preserve data validity.

National-level (“Whole country”) aggregates were excluded, as they do not represent independent observational units and would bias estimates of between-region variation. Only indicators directly relevant to telemedicine use, digital skills, perceived benefits, and digital challenges were retained, while variables unrelated to the research questions or inconsistently available across regions were excluded. All variables were kept on their original percentage-point scale to allow direct

substantive interpretation of regional differences. No transformations were applied for regression analysis. However, visual analytics (e.g., heatmaps), variables were temporarily standardized to facilitate comparison across indicators. Underlying assumptions included the comparability of Finnish Institute for Health and Welfare regional indicators, the appropriateness of regional aggregates as representations of contextual digital environments, and the non-causal nature of ecological associations.

Overall, data preparation prioritized transparency, theoretical relevance, and methodological consistency over maximizing sample size. In summary, this study uses a cross-sectional ecological design, analyzing wellbeing services counties as the primary unit of analysis. All data originate from the Finnish Institute for Health and Welfare (THL) Digital Services and E-Transactions 2024 dataset, which reports aggregated digital indicators related to telemedicine use, digital skills, perceived benefits, and digital challenges among older adults.

The analytical dataset focuses on adults aged 75+, as this age group exhibits the largest digital divide and most consistently available Finnish Institute for Health and Welfare indicators. Indicators used include telemedicine use (digital contact with SOTE professionals), digital skills (≥ fair), perceived convenience, data security concerns, and accessibility barriers. Data preparation included filtering, recording age groups, removing national-level rows, and merging indicators by region. Analytical methods comprised descriptive statistics, visual analytics (bar charts, scatterplots, heatmaps), Pearson correlation analysis, and ordinary least squares (OLS) regression at the regional level. All analyses explicitly reflect regional-level (ecological) associations, and causal or individual-level inferences were not made (Laukka et al., 2024; Park, 2025; Rosenlund et al., 2024).

Descriptives summarize regional distributions of telemedicine use and predictor variables. Pearson correlations assessed linear associations between telemedicine use and digital skills, perceived convenience, security concerns, and e-service accessibility at the regional level. A regional OLS model (tele ~ skills + security + not access + benefit time) quantified joint associations. Model performance was assessed via R^2, with ecological interpretation emphasized.

Chapter 5 Results

This chapter presents the empirical findings addressing the study's three research questions which are: 1. Compare telemedicine use across age groups (65+ and 75+) and regions; 2. Identify the most common benefits and challenges encountered when using digital and telemedicine services; and 3. Analyze how digital skills, perceived benefits, and reported challenges relate to telemedicine use at the regional level.

The results draw from the Finnish Institute for Health and Welfare's *Digital Services and E-Transactions 2024 dataset*, which includes indicators on digital health use, digital capabilities, perceived benefits, and barriers among residents aged 65+ and 75+ across Finland's wellbeing services counties and selected municipalities.

5.1. To compare telemedicine, use across age groups (65+ and 75+) and regions.

The variable "telemedicine use" from the dataset was used to provide comparison between the age gradient, likewise, the regional variation.

5.1.1. Systematic age gradient /National Age Differences

At the national level, telemedicine use—measured as *digital contact with a social welfare and healthcare services professional*—was higher among the 65+ age group compared to 75+. The 65+ verses 75+ age telemedicine use comparison chart (see figure 5.1) shows that in every top region, the 65+ years telemedicine usage is greater than the 75+ years usage.

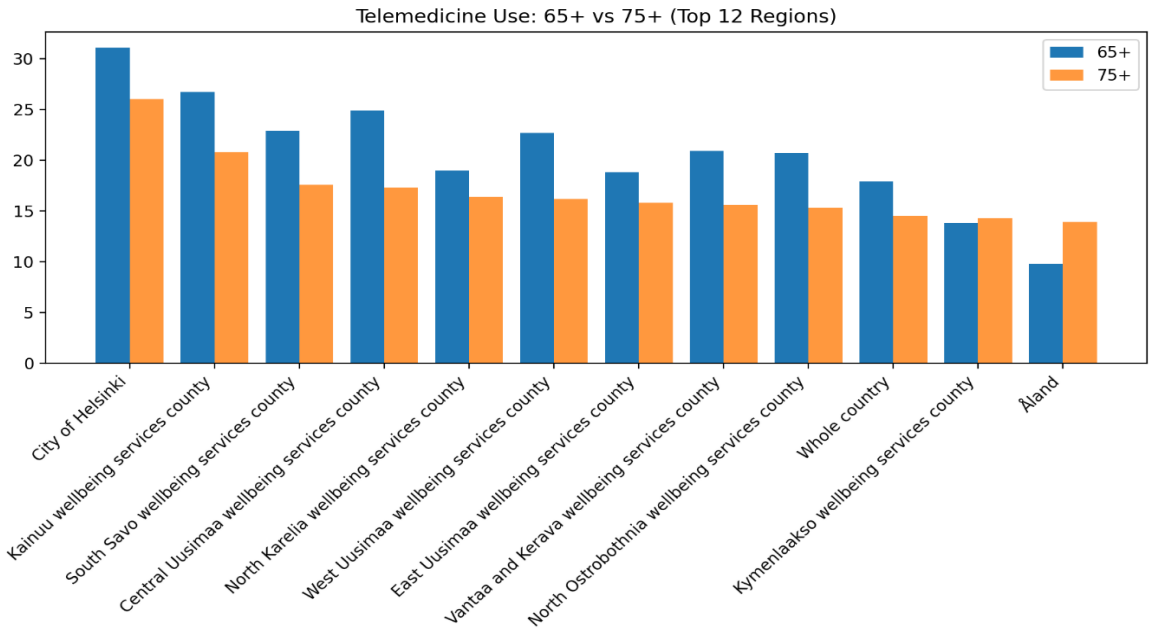


Figure 5. 1: Telemedicine use: 65+ vs 75+ (Top 12 regions); Source: Author's own work 2026

5.1.2. Regional Variation: The figure 3.7. shows the Finland's regional map.

Telemedicine use varies substantially across Finnish wellbeing services counties, the telemedicine use by region bar chart (see figure 5.1 and statistical table 1) which focuses on only the 75+ shows a strong regional variation across the wellbeing counties from high 20-26% (City of Helsinki - 26.0%, Kainuu - 20.8%,) to low 8-10% (for example, South Ostrobothnia-8.4%, KantaHäme- 9.9%, Pirkammaa- 10.3%, Southwest Finland- 10.3%). Other high regions include South Savo - 17.6%, Central Uusimaa - 17.3% and North Karelia - 16.4% while Satakunta has 12.6%. Above average telemedicine use was seen particularly in metropolitan and eastern/northern areas and lower utilization in the western and southwestern regions among the 75+ age groups and describe inter-regional differences, not individual behaviours. This reflects that telemedicine adoption varies sharply by region and declines with age.

Table 5. 1: Final regression data set

Region	Telemedicine	Skills	Security	Not Access	Benefit_Time
Central Finland wellbeing services county	13,4	51	51	35	49
Central Ostrobothnia wellbeing services county	12,7	44	53	36	52
Central Uusimaa wellbeing services county	17,3	54	46	33	53
City of Helsinki	26	65	40	24	59
East Uusimaa wellbeing services county	15,8	55	52	29	51
Kainuu wellbeing services county	20,8	45	57	43	53
Kanta-Häme wellbeing services county	9,9	45	44	38	49
Kymenlaakso wellbeing services county	14,3	45	49	37	51
Lapland wellbeing services county	11,4	45	59	42	50
North Karelia wellbeing services county	16,4	41	51	37	48
North Ostrobothnia wellbeing services county	15,3	45	55	39	47
North Savo wellbeing services county	13	47	50	36	53
Ostrobothnia wellbeing services county	12,7	46	53	30	49
Pirkanmaa wellbeing services county	10,2	46	53	36	45
Päijät-Häme wellbeing services county	12,8	48	50	37	50
Satakunta wellbeing services county	12,6	42	54	44	44
South Karelia wellbeing services county	13,4	46	53	35	49
South Ostrobothnia wellbeing services county	8,4	40	53	37	45
South Savo wellbeing services county	17,6	43	49	34	43
Southwest Finland wellbeing services county	10,3	50	50	33	51
Vantaa and Kerava wellbeing services county	15,6	60	45	28	56
West Uusimaa wellbeing services county	16,2	61	45	24	54
Ã…land	13,9	57	46	23	52

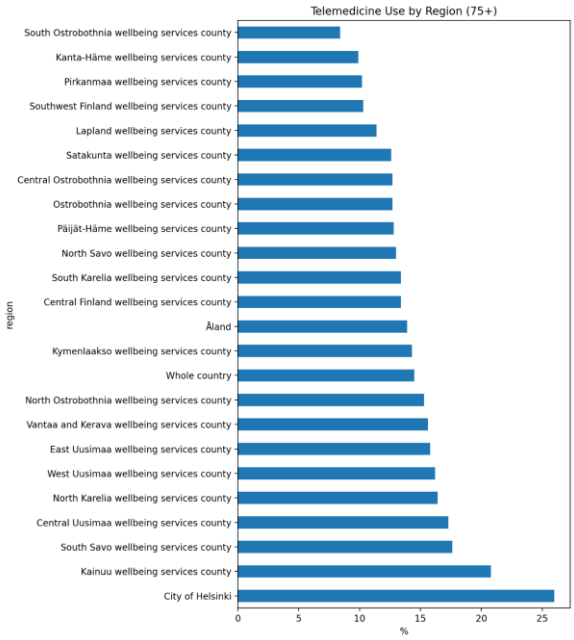


Figure 5. 2: Telemedicine use by region (75+); Source: Author's own work 2026

5.2. To identify the most common benefits and challenges encountered when using digital and telemedicine services.

To understand how experiences (benefits and challenges) affect telemedicine and digital service use, three categories of indicators from the Finnish Institute for Health and Welfare datasets were examined which includes perceived benefits identified as ease of use regardless of time /place, Digital capability identified as digital skill and challenges which is security concerns/accessibility issues. The analysis focused on the 75+ age group and represented visually.

5.2.1. Perceived Benefits

At the national level, the most reported benefits among people aged 75+ were that e-services eased use regardless of time/place with 50% eased finding/choosing services by 47%, and wellbeing by 43%, showing that convenience and information finding are the strongest positive experiences with digital and telemedicine services among older adults. Based on the analysis, telemedicine verses digital convenience (time/place) shows a strong positive association ($r \approx +0.55$). Regions where older adults report that digital services "ease use regardless of time/place" also have higher telemedicine usage (see also Annex E statistical table 2)

5.2.2. Digital Capability

Digital capability was measured through self-reported digital skills being “fair or better”. From the dataset regions digital capabilities were identified, nationally, 49% of people aged 75+ rated their digital skills as at least fair. Regional variation was wide, ranging from 40% for South Ostrobothnia to 65% for Helsinki, showing that higher skill regions tended to correspond with higher telemedicine use. Based on the analysis, the scatterplot (see figure 5.2) Telemedicine vs Digital Skills shows a positive association (r ≈ +0.52), the same pattern as digital convenience(time/place) showing that skills act as a regional enabler.

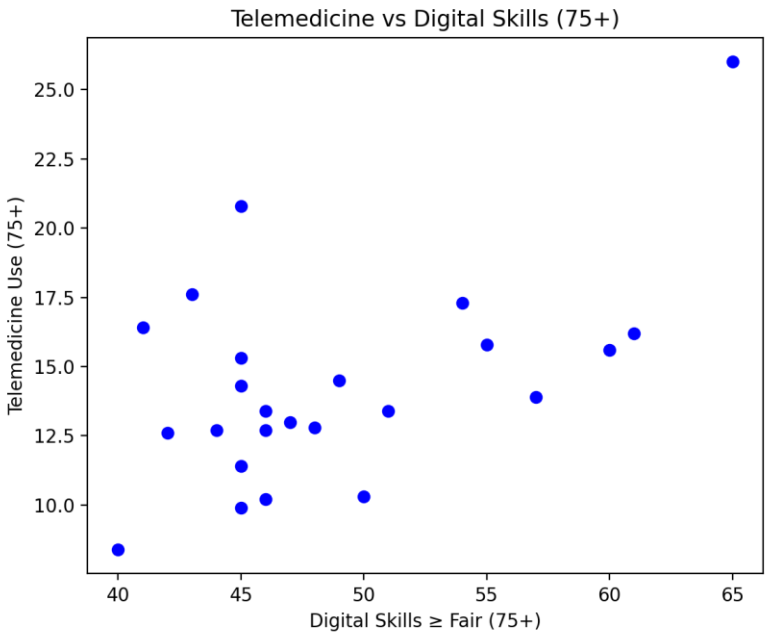


Figure 5. 3: Telemedicine vs digital skills (75+); Source: Author’s own work 2026

5.2.3. Challenges

Challenges, which are security and accessibility issues, were markedly more prevalent than benefits. Nationally among the 75+, 92.8% experienced some obstacles or concerns when using eservices, 50% reported *concerns about e-service data security,* and 34% reported that e- *services were not accessible*. Scatterplot of *Telemedicine vs Security Concerns (*see figure 5.3*)* shows clear negative association (r ≈ –0.38) based on analysis (see also Annex E statistical table 2). Regions reporting more difficulties (“e-services not accessible”) show lower telemedicine uptake. The heatmap of digital profiles (see figure 5.4) shows the regions cluster into high- readiness which are high skill, high benefits, lower challenges and low readiness which are high challenges and lower skills group. These experiences affect telemedicine use at the regional level, not individual behaviors.

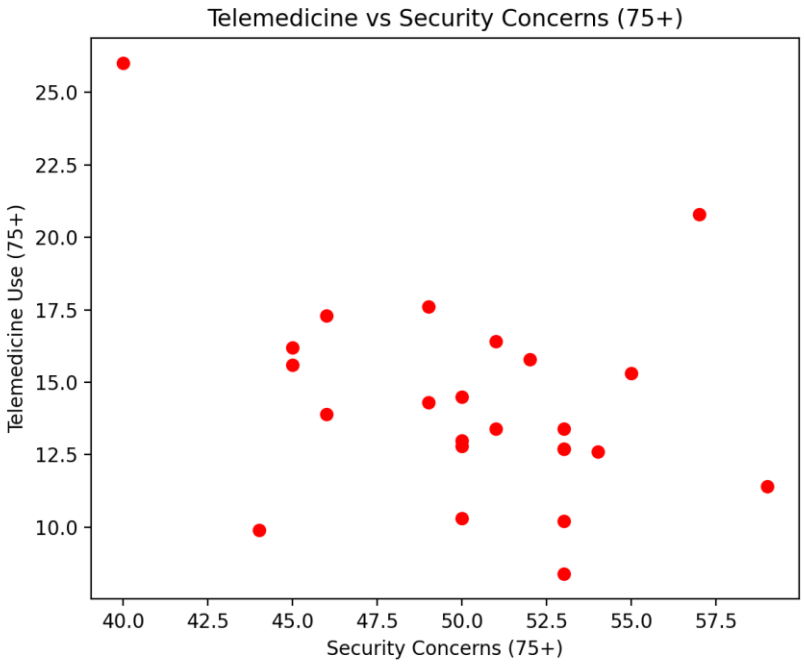


Figure 5. 4: Telemedicine vs security concerns (75+); Source: Author's own work 2026

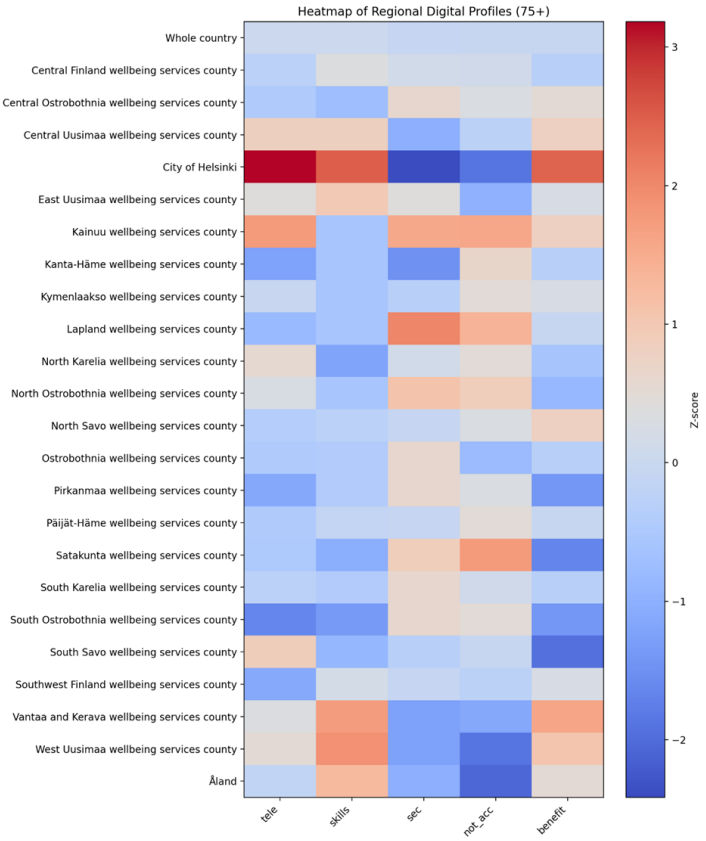


Figure 5. 5: Heatmap of regional profiles (75+). Source: Author's own work 2026

5.3. To Analyze how digital skills, perceived benefits, and reported challenges relate to telemedicine use at the regional level.

To examine how experiences relate to utilization, correlations, and a regional level regression model were estimated using the 75+ panel.

5.3.1. Correlation Analysis

Across regions (n = 23), telemedicine use among the 75+ showed Positive correlation with digital skills r = +0.52 → *moderate association,* Positive correlation with "ease of use regardless of time/place" r = +0.55 → *strongest positive association,* Negative correlation with security concerns r = –0.38, Negative correlation with accessibility problems r = –0.34. These results suggest that higher digital ability and perceived convenience are associated with higher telemedicine uptake, while security worries and accessibility issues correspond to lower use as shown in table 5.2 below (see also Annex E statistical table).

Table 5. 2: Correlation matrix

	Tele	Skills	Security	Not Access	Benefit Time
Tele	1	0,524	-0,376	-0,342	0,548
Skills	0,524	1	-0,697	-0,83	0,777
security	-0,376	-0,697	1	0,712	-0,526
Not_Access	-0,342	-0,83	0,712	1	-0,547
Benefit_Time	0,548	0,777	-0,526	-0,547	1

5.3.2. Regression Model

A multiple regression model was run with telemedicine use (%) as the outcome and four predictors; Digital skills (≥ fair), Security concerns, Accessibility issues, Benefit: ease of use regardless of time/place. The model explained 34% of regional variation in telemedicine use (R^2 = 0.34) among the 75+. Regression result table 5.3 shows the key estimated effects:

Table 5. 3: Regression Result

Predictor	Effect direction	Interpretation
Digital skills	Positive (+0.24)	Higher skill levels correspond to higher use
Time/place benefit	Positive (+0.30)	Convenience perception strongly supports use
Security concerns	Negative (–0.08)	Concern reduces likelihood of use
Accessibility issues	Small positive (+0.16) **	Likely due to confounding/collinearity

These findings reinforce the role of digital skills and perceived convenience as enabling factors, and security concerns as a barrier. The counterintuitive positive sign on “not accessible” arises from overlapping regional characteristics and is discussed as a multicollinearity limitation. Regions with higher digital skills and stronger perceived convenience (time/place) report higher telemedicine use. Regions with more security concerns and inaccessibility report lower telemedicine use in the bivariate view; the negative sign for security persists in the multivariable model, while the inaccessibility sign flips small positive (likely due to multicollinearity and ecological aggregation). Together, these factors account for a meaningful share of the regional differences in telemedicine uptake $R^2 \approx 0.34$. The Remaining ~66% of variance probably reflects regional broadband quality, local social and health care provider digitalization, demographics, socioeconomic status, and regional training/support programs

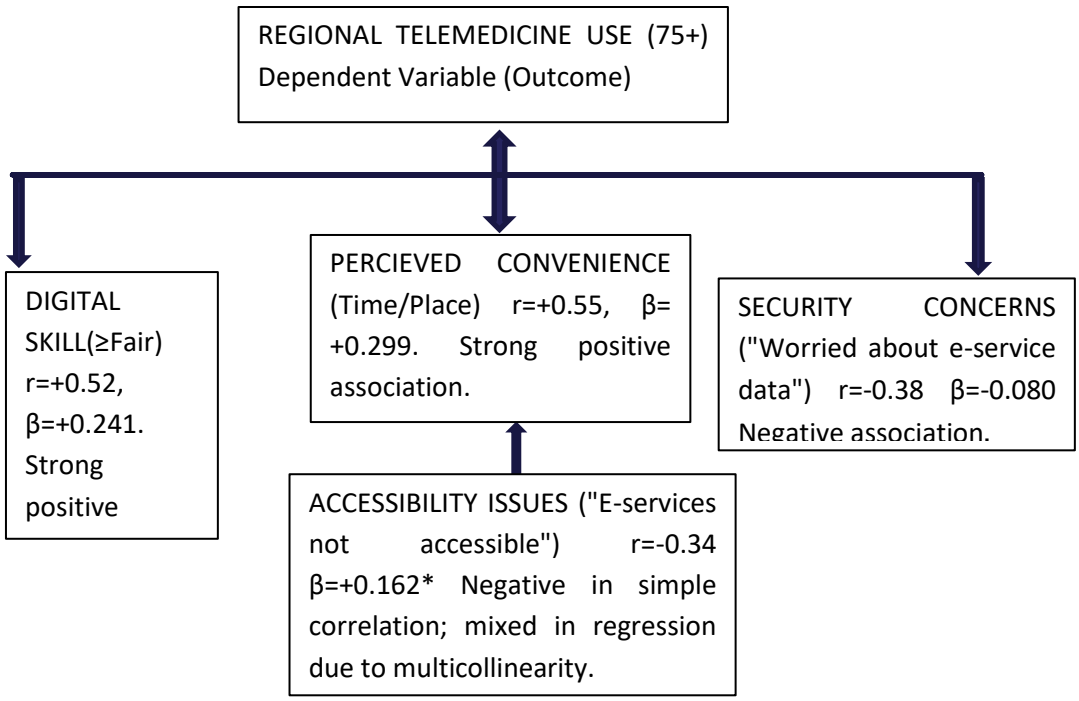


Figure 5. 6: Visual Summary of Research question three (Regional Associations with Telemedicine Use, 75+). Source: Author’s own work 2026

Scatterplots validate the direction of the coefficients, heatmap shows how regions simultaneously differ across multiple digital indicators, bar charts show that regions at the “top” of the heatmap also show the highest telemedicine usage. These visuals are integrated to support the results. These associations are based on the regional level and not individual likelihood. In summary, regional telemedicine use (75+) varied widely: high-use regions included Helsinki and Kainuu, while low-use regions included South Ostrobothnia and Satakunta. In every region examined, the 75+ group reported lower telemedicine use than the 65+ group, confirming an age gradient. Bivariate associations (regional): telemedicine use correlated positively with digital skills ($r \approx .52$) and perceived

convenience (r ≈ .55), and negatively with security concerns (r ≈ −.38) and e-service inaccessibility (r ≈ −.34). In a multivariable regional OLS model, coefficients were positive for skills (≈ +0.241) and convenience (≈ +0.299), negative for security (≈ −0.080), and small/positive for inaccessibility (≈ +0.162), likely reflecting multicollinearity or omitted regional factors. The model explained ≈34% of between-region variance. These results describe associations between regions, not individuals (Laukka et al., 2024; Rosenlund et al., 2024; Park, 2025).

Chapter 6 Ethical Considerations

The dataset is fully anonymized and publicly accessible through Finnish Institute for Health and Welfare. No personal identifiers are present. Analysis was conducted in accordance with principles for ethical use of secondary health data according to new Finnish act (Johanna, 2019) and in accordance with the European health data regulation law (GDPR, 2018) as published in the European health data space on the use of secondary data (European Union, 2025). Regional level aggregates pose minimal risk of reidentification.

Chapter 7 Limitation of the Study

Because the analysis is based on the regional aggregates, the findings reflect differences between service counties rather than individual- level behavioural determinants. As such, associations identified in the correlation and regression models describe ecological relationships, which should not be interpreted as casual or as applying to individuals within the regions. This study may therefore be subject to ecological fallacy.

The positive associations between regional digital skills or perceived convenience and telemedicine use indicate that regions with higher digital readiness tend to report higher telemedicine uptake, but they do not imply that individuals with higher skills necessarily use telemedicine more frequently. Similarly, negative associations with security concerns and service accessibility reflect regional contextual barriers, not individual attitudes. Finally, the model explains approximately one-third of regional variation, suggesting that additional unmeasured regional factors such as service availability, provider digitalization or broadband infrastructure also contribute to telemedicine adoption patters. In summary, ecological design prevents individual-level inference (risk of ecological fallacy). Indicators are self-reported and may contain measurement bias. Unmeasured regional factors (e.g. provider digitalisation, broadband quality, socioeconomic differences) may contribute to observed patterns. Collinearity among challenge indicators can affect coefficient signs and magnitudes (Rabbani et al., 2025). Ecological fallacy occurs when relationships that exist for groups are assumed to be true for individuals and it is a type of surprising situation or confounding specific to ecological studies (Levin, 2003)

Chapter 8 Discussion

This study set out to examine telemedicine use among older adults in Finland through an ecological, regional-level perspective. By linking telemedicine uptake among adults aged 75+ with regional indicators of digital skills, perceived benefits, and reported challenges, the findings provide system-level insight into how digital health adoption is shaped by broader contextual environments. The discussion below integrates the study's results with the existing literature and explicitly addresses each research question, while maintaining appropriate caution in interpretation due to the ecological design.

8.1. Regional and Age-Related Variation in Telemedicine Use (Research Question 1, RQ1)

The findings revealed substantial variation in telemedicine use across Finnish wellbeing services counties, alongside a consistent age gradient in which adults aged 75+ reported lower telemedicine use than those aged 65+ in all regions. This pattern is well aligned with previous research demonstrating that telemedicine adoption declines with increasing age, even in countries with advanced digital infrastructures (Park, 2025; Rosenlund et al., 2024). Age-related differences have been linked in the literature to lower digital literacy, reduced confidence in using technology, and limited prior exposure to digital services among the oldest age groups (Rabbani et al., 2025). What this study adds to the literature is a clear demonstration that these age-related disparities are *not uniform across Finland* but instead vary significantly by region. This supports earlier qualitative and survey-based findings suggesting that older adults' engagement with digital health services depends not only on individual characteristics but also on the surrounding service environment (Laukka et al., 2024; Torkki et al., 2026). Regions with higher telemedicine uptake likely reflect more digitally mature ecosystems, including better service design, stronger local digital support, and more established integration of telemedicine into routine care. Thus, RQ1 is addressed at the population level: telemedicine use varies both by age and by region, highlighting regional digital inequalities that go beyond individual behavior.

8.2. Digital Experiences, Benefits, and Challenges (Research Question 2, RQ2)

The second research question focused on the experiences older adults have when interacting with digital and telemedicine services, and how these experiences relate to usage patterns. The results showed that regions where older adults more frequently reported positive experiences, particularly perceiving E-services as convenient and flexible in terms of time and place also tended to exhibit higher telemedicine use. This finding strongly supports the literature reviewed, which emphasizes perceived usefulness and ease of use as central drivers of digital health adoption among

older adults (Torkki et al., 2026; Rabbani et al., 2025). At the same time, regions with higher levels of reported security concerns and accessibility problems tended to have lower telemedicine uptake. These results are consistent with Finnish studies highlighting concerns about data security, difficulties logging in, unclear instructions, and usability problems as persistent barriers for older users (Laukka et al., 2024; Rosenlund et al., 2024). Importantly, the ecological perspective adopted in this study suggests that such experiences function not only at the individual level but also as *regional digital climate indicators*. Regions where digital challenges are widely reported may create less supportive environments for telemedicine use, even for individuals who might otherwise be capable of engaging with digital services. By confirming these associations at the regional level, the study reinforces arguments in the literature that improving digital health adoption among older adults requires attention to service design, trust, and accessibility and not solely individual skill development.

8.3. Regional Associations Between Digital Skills, Benefits, Challenges, and Telemedicine Use (Research Question 3, RQ3)

The third research question examined how digital skills, perceived benefits, and challenges relate statistically to telemedicine use at the regional level. Both correlation and regression analyses demonstrated that regions with higher proportions of older adults reporting adequate digital skills and perceived convenience also tended to have higher telemedicine use. These findings align closely with prior research identifying digital competence as a key enabler of older adults' engagement with digital health services (Park, 2025; Rosenlund et al., 2024). Security concerns remained negatively associated with telemedicine use in the multivariable analysis, reinforcing earlier evidence that trust and perceptions of data safety are critical for digital health uptake (Laukka et al., 2024). The model explained approximately one-third of regional variation in telemedicine use, indicating that digital skills and experiences capture an important *but not exhaustive* share of the factors shaping adoption. The remaining unexplained variation likely reflects additional regional influences discussed in the literature, such as provider-side digitalization, infrastructure quality, demographic composition, and socioeconomic conditions (BMJ, 2020; Levin, 2003). These results underline a key methodological point emphasized in epidemiological guidance: ecological associations represent contextual population-level patterns and should not be interpreted as individual-level causal relationships (Levin, 2003). Rather than identifying personal determinants of telemedicine use, this study highlights how *regional digital ecosystems* shape the distribution of telemedicine uptake among older adults.

8.4. Synthesis Across Research Questions and Literature

Taken together, the findings across all three research questions align closely with, and extend, the existing literature on digital health and aging. The study confirms well-established patterns of age-related digital inequality (RQ1), demonstrates that perceived benefits and challenges play a significant role in shaping telemedicine engagement (RQ2), and shows that these factors co-vary systematically at the regional level (RQ3). By adopting an ecological design, the study contributes system-level evidence that complements individual-level research and responds directly to calls in the literature for greater attention to contextual and environmental determinants of digital health use (BMJ, 2020; Park, 2025). Overall, the discussion highlights that telemedicine use among older adults in Finland is embedded within broader regional digital environments. Addressing digital inequality therefore requires not only individual-focused interventions, such as digital skills training, but also region-specific strategies aimed at improving service usability, accessibility, and trust in digital systems.

Chapter 9 Conclusion

This ecological study provides evidence of substantial regional variation in telemedicine use among adults aged 75+ in Finland. Telemedicine use varied notably by age and region, with lower uptake among the oldest age groups and significant regional disparities. Positive experiences such as convenience supported adoption, while security concerns and accessibility issues hindered it. Digital skills emerged as a key enabler of telemedicine use, and the regression model showed that both capability and user experience explain variation in adoption.

The study contributes novel insights by demonstrating that telemedicine adoption among older adults is embedded within broader regional digital readiness, influenced by service design, infrastructure, and population-level digital competence. However, because all indicators were aggregated, the results cannot be generalized to individuals, and the study is subject to ecological fallacy. Future research should incorporate individual-level data to further investigate causal pathways and complement these regional findings. Targeted regional measures to strengthen digital competence, improve usability, and address security concerns can support more equitable access to digital healthcare for older Finns (Laukka et al., 2024, Torkki et al., 2026). Policymakers should prioritize digital skill development, user-centered design of digital services, and targeted support for lower-performing regions.

Overall, the study underscores the importance of addressing regional digital inequalities—including targeted digital skills programs, trust-building initiatives, and improved usability—to support equitable telemedicine access for older Finns.

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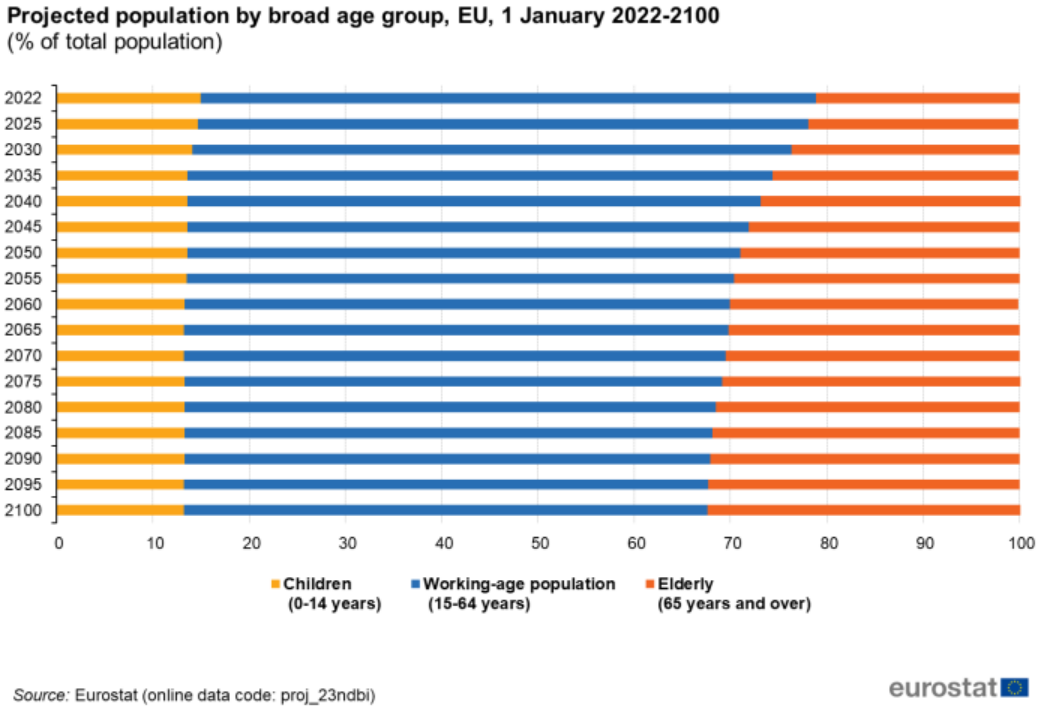
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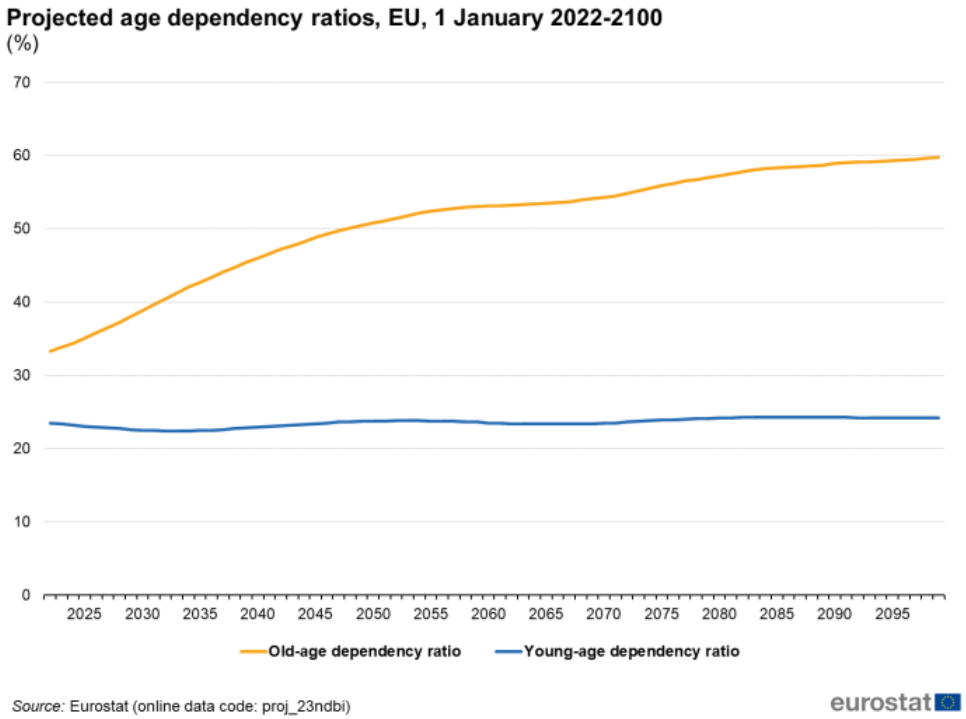
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Annex A Visual Representation of Projected population by broad age group of European union 1 January

2022-2100.

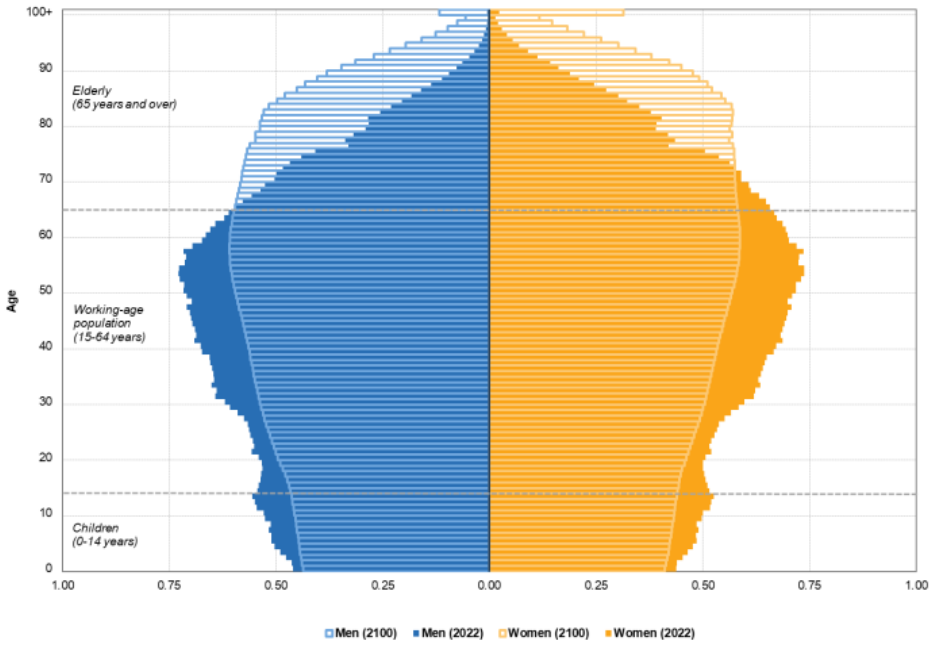


Annex B Visual representation of Projected age dependency ratio of European Union, 1 January



Annex C European union population Pyramids 2022 and 2100.

Population pyramids, EU, 2022 and 2100
(% of total population)



Source: Eurostat (online data code: proj_23np)

eurostat

Annex D Matrix linear equation

Multivariable models used to estimate linear regression at the regional level.
teler = β0+β1 skillsr+β2 securityr+β3 not_accessr+β4 benefit_timer+εr\text{tele}_r\;=\; \beta_0 + \beta_1\,\text{skills}_r + \beta_2\,\text{security}_r + \beta_3\,\text{not_access}_r + \beta_4\,\text{benefit_time}_r+\varepsilon_rteler=β0+β1 skillsr +β2 securityr +β3 not_accessr +β4 benefit_timer +εr

Interpretation:

*β1**beta_1*β1 = change in telemedicine use (pp) for a 1 pp increase in digital skills, holding other factors constant.
*β4**beta_4*β4 = change in telemedicine use (pp) for a 1 pp increase in perceived convenience, ceteris paribus.
*β2**beta_2*β2, *β3**beta_3*β3 = expected (often negative) associations for security concerns and inaccessibility.

Model fit: Report *R2R^2*R2 (share of regional variance explained) and residual plots to check fit.

Caveat: This is ecological (region-level) and cross-sectional (2024), so findings are associational, not causal.

Annex E Statistical tables

Table 3.1: Regression Model Explanation

Variable	Type	Reason for inclusion
Telemedicine use (%)	Dependent	Core outcome (RQ1& RQ2)
Digital skills ≥ fair	Predictor	Measures digital readiness
Security concerns	Predictor	Central challenge indicator
E-services not accessible	Predictor	Barriers to service engagement
Time/place benefit	Predictor	Most reported positive experience

Table 5.1: Final regression data set

Region	Telemedicine	Skills	Security	Not Access	Benefit_Time
Central Finland wellbeing services county	13,4	51	51	35	49
Central Ostrobothnia wellbeing services county	12,7	44	53	36	52
Central Uusimaa wellbeing services county	17,3	54	46	33	53
City of Helsinki	26	65	40	24	59
East Uusimaa wellbeing services county	15,8	55	52	29	51
Kainuu wellbeing services county	20,8	45	57	43	53
Kanta-HÃ¤me wellbeing services county	9,9	45	44	38	49
Kymenlaakso wellbeing services county	14,3	45	49	37	51
Lapland wellbeing services county	11,4	45	59	42	50
North Karelia wellbeing services county	16,4	41	51	37	48
North Ostrobothnia wellbeing services county	15,3	45	55	39	47
North Savo wellbeing services county	13	47	50	36	53
Ostrobothnia wellbeing services county	12,7	46	53	30	49
Pirkanmaa wellbeing services county	10,2	46	53	36	45
PÃ¤ijÃ¤t-HÃ¤me wellbeing services county	12,8	48	50	37	50
Satakunta wellbeing services county	12,6	42	54	44	44
South Karelia wellbeing services county	13,4	46	53	35	49
South Ostrobothnia wellbeing services county	8,4	40	53	37	45
South Savo wellbeing services county	17,6	43	49	34	43
Southwest Finland wellbeing services county	10,3	50	50	33	51
Vantaa and Kerava wellbeing services county	15,6	60	45	28	56
West Uusimaa wellbeing services county	16,2	61	45	24	54
Ã…land	13,9	57	46	23	52

Table 5.2: Correlation Matrix

	Tele	Skills	Security	Not Access	Benefit Time
Tele	1	0,524	-0,376	-0,342	0,548
Skills	0,524	1	-0,697	-0,83	0,777
security	-0,376	-0,697	1	0,712	-0,526
Not_Access	-0,342	-0,83	0,712	1	-0,547
Benefit_Time	0,548	0,777	-0,526	-0,547	1

Table 5.3: Regression Result

Predictor	Effect direction	Interpretation
Digital skills	Positive (+0.24)	Higher skill levels correspond to higher use
Time/place benefit	Positive (+0.30)	Convenience perception strongly supports use
Security concerns	Negative (–0.08)	Concern reduces likelihood of use
Accessibility issues	Small positive (+0.16)**	Likely due to confounding/collinearity