

Research Paper

# Digital integration of older adults in Europe: Linking skills, e-health use and growth patterns

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**Abstract:** This study examines digital health participation among adults aged 65–74 across European Union member states, focusing on the relationship between digital skills and multidimensional e-health use. The research addresses a key gap in the literature, as previous studies have typically analysed single dimensions of e-health use or treated older adults as a homogeneous group. Conceptually, the study builds on competence-based and digital divide frameworks, interpreting digital health use as the outcome of interactions between individual capabilities and structural conditions. Using harmonised Eurostat data, the analysis combines longitudinal trend analysis (2015–2024), a composite e-health indicator, correlation analysis, and cluster analysis. The results show a substantial increase in digital health use among older adults across the EU, particularly after 2019. A strong positive association is observed between digital skills and e-health use, especially for more advanced activities. Cluster analysis reveals persistent cross-national differences, indicating that similar skill levels may lead to different levels of e-health uptake. The findings highlight the need for combined policy approaches targeting both digital skills development and user-centred digital health services.

**Keywords:** Digital health, e-health, ageing, digital inclusion, digital skills, health policy, health inequalities, European Union

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## 1. Introduction

The growing prominence of digital health services is driven by the dual challenge facing healthcare systems: workforce shortages and the increasing burden of ageing populations (OECD, 2023; Socha-Dietrich, 2021). As societies age and multimorbidity becomes more prevalent, demand for healthcare rises, necessitating more sustainable and digitally enabled solutions (Laukka et al., 2024). In parallel, the advancement of digital technologies has enabled several stages of healthcare provision to move online, contributing to the emergence of a more interconnected digital health ecosystem (European Union, 2023). Such an ecosystem can be understood as an integrated system of technological, organisational, and human components supporting the delivery, coordination and governance of healthcare through digital tools and data flows (van de Vijver et al., 2023).

While digital services are transforming everyday life, their success depends not only on technological availability but also on users' competences, motivation, and readiness to adopt digital tools (Heart & Kalderon, 2013; Peek et al., 2016; van Houwelingen et al., 2018). This is particularly relevant for older adults, who face increasing healthcare needs while often encountering barriers to digital participation (Ercsey, 2024; Friemel, 2016; Yang et al., 2024). Digital health tools offer a pathway to more efficient and resilient service delivery by reducing avoidable face-to-face visits and supporting remote care, self-monitoring, and early intervention (Dave, 2024). However, these potential benefits can only be realised if older adults are not excluded from digital services. Reducing digital inequalities is therefore not only a matter of technological access, but also a prerequisite for equitable and socially sustainable healthcare development (van de Vijver et al., 2023).

Within this landscape, adults aged 65–74 represent a particularly important group. They occupy a transitional stage between midlife and older old age: unlike the 55–64 cohort, they are mostly retired and no longer exposed to workplace technologies (OECD, 2023), yet they

typically face fewer functional limitations and greater autonomy than adults aged 75 and over (Kingston et al., 2018). Their health needs increase substantially during this period, while their digital habits remain relatively adaptable, making the 65–74 age cohort particularly relevant for the expansion of digital health use (Friemel, 2016). Despite their strategic importance, adults aged 65–74 remain underrepresented in cross-national research on digital health use, as they are often analysed either together with younger working-age populations or with the oldest-old, thereby obscuring age-specific patterns of digital health engagement.

Despite this growing body of research, several gaps remain in the literature. First, many studies focus on single dimensions of digital health use—most commonly online health information seeking or telemedicine—rather than capturing the multidimensional nature of e-health engagement (Choi et al., 2022; Flodgren et al., 2015). Second, older adults are frequently treated as a homogeneous 65+ group, with limited analytical attention to the transitional 65–74 cohort (Friemel, 2016). Third, although digital health adoption and digital competences have been widely examined, integrated cross-national European analyses that combine multiple e-health indicators with measures of digital skills remain relatively limited (Heart & Kalderon, 2013; Peek et al., 2016; Yang et al., 2024).

Against this background, the aim of the present study is to explore how older adults aged 65–74 participate in digital health services across European Union (EU) countries and to examine the relationship between digital skills and e-health activity. The study addresses two research questions. Firstly: How does participation in digital health services among adults aged 65–74 differ across EU countries? Secondly: To what extent are digital skills associated with e-health activity among older adults?

The analysis compares Hungary's position with the EU27 average and, through cluster analysis, identifies groups of countries characterised by different levels of digital health integration among older adults. By combining trend analysis, a composite e-health indicator, and cross-national clustering, the study contributes to the literature by providing a more differentiated, age-specific understanding of digital health inclusion in later life.

## 2. Literature Review

### **2.1. Digital health adoption among older adults**

Despite the potential benefits of digital health solutions, older adults continue to use digital health developments—such as online appointment booking, teleconsultation, and e-prescription services—far less frequently than younger age groups. Previous studies consistently identify several barriers that limit e-health adoption in later life. These include a lack of digital competence, limited access to the necessary devices (e.g. smartphones or broadband internet), and low levels of trust in digital technologies and online services (Socha-Dietrich, 2021).

Attitudes toward technology play a particularly important role in shaping digital health use among older adults. Individuals who hold more positive views of digital technologies and recognise their potential benefits—such as easier access to healthcare providers, reduced waiting times, or opportunities for self-monitoring—are significantly more likely to engage in e-health activities (Heart & Kalderon, 2013; Peek et al., 2016; van Houwelingen et al., 2018). In addition, social support has been shown to facilitate digital health adoption. Assistance provided by children or grandchildren can help older adults overcome practical and psychological barriers, increasing confidence and willingness to use online health services.

At the same time, empirical evidence highlights substantial heterogeneity in digital health use among older adults across countries and social groups. Differences in institutional settings, healthcare system organisation, and levels of digitalisation contribute to varying patterns of e-health adoption across countries (OECD, 2023). These findings suggest that digital health engagement in later life is shaped not only by individual-level characteristics, but also by broader contextual and structural factors.

## **2.2. Digital divide and cross-national inequalities**

According to recent Eurostat analyses, digital device use among people aged 65–74 has been increasing across the European Union, yet it remains substantially below that of younger cohorts (European Union, 2023; OECD, 2023). The digital divide affecting older adults is multidimensional and closely linked to socio-demographic characteristics. Higher age, lower education and income levels, and rural residence jointly reduce the likelihood of internet use and participation in digital health services (Friemel, 2016; Yang et al., 2024). Although the gap between older and younger age groups has gradually narrowed over time, persistent inequalities remain among socially and geographically disadvantaged groups (European Union, 2023).

Country-level comparisons further reveal marked regional differences within the European Union (European Union, 2023). Northern and Western European countries generally report higher levels of digital competence and e-health use among older adults, while Southern and Eastern European countries tend to lag behind. These disparities reflect differences in digital infrastructure, policy priorities, and the integration of digital solutions into national healthcare systems (OECD, 2023).

Hungarian research points to similar patterns of inequality within the national context. While internet use in the general population has continued to rise (OECD, 2023), digital health literacy and participation in e-health services remain significantly lower among older adults compared to younger cohorts. Education level, income, and settlement type strongly influence digital engagement: older adults with higher education and those living in urban areas are substantially more active users of digital health services (Ercsey, 2024; Girasek et al., 2022; Vajda, 2020). Existing Hungarian studies have primarily relied on cross-sectional surveys and have focused on digital competence or general attitudes toward technology, offering limited insight into cross-national positioning or longer-term trends.

Overall, the literature demonstrates that digital health adoption among older adults is shaped by a complex interaction of individual competences, attitudes, social support, and structural conditions. While digital skills and trust emerge as key enabling factors, cross-national evidence points to substantial variation in how effectively healthcare systems integrate older populations into digital health ecosystems.

## **2.3. Conceptual framework and research hypotheses**

Based on the reviewed literature, digital health use among older adults can be conceptualised as the outcome of an interaction between individual-level digital competences and broader structural and contextual factors. Digital skills enable older adults to access, understand, and use online health services, thereby constituting a key enabling condition for e-health engagement. At the same time, national-level differences in digital infrastructure, healthcare system integration, and policy support shape the opportunities and constraints under which these skills can be translated into actual use.

In this framework, digital skills are assumed to have a direct positive association with e-health use among adults aged 65–74, while country-level contextual and structural conditions provide the setting within which this relationship unfolds. These contextual factors are not treated as independent explanatory variables, but rather as conditions that contribute to cross-national heterogeneity in digital health integration. Building on this conceptualisation, the present study formulates three hypotheses. Across EU member states, higher levels of digital skills among adults aged 65–74 are associated with higher levels of e-health use. Thus, with regard to digital skills and e-health, the first hypothesis (H1) is as follows: Digital skills are more strongly associated with advanced forms of e-health use—such as online appointment booking and access to personal health records—than with basic activities such as online health information seeking among adults aged 65–74. Regarding the multidimensional nature of e-health use, the second hypothesis (H2) is: Substantial cross-national differences exist in the relationship between digital skills and e-health use among adults aged 65–74, reflecting varying levels of digital integration across EU healthcare systems. The third hypothesis (H3) is concerned with cross-national heterogeneity: Country groups exhibit differing levels of digital health integration. Figure 1 summarises the conceptual framework guiding the empirical analysis and visualises the hypothesised relationships between digital skills, multidimensional e-health use, and country-level contextual and structural conditions.

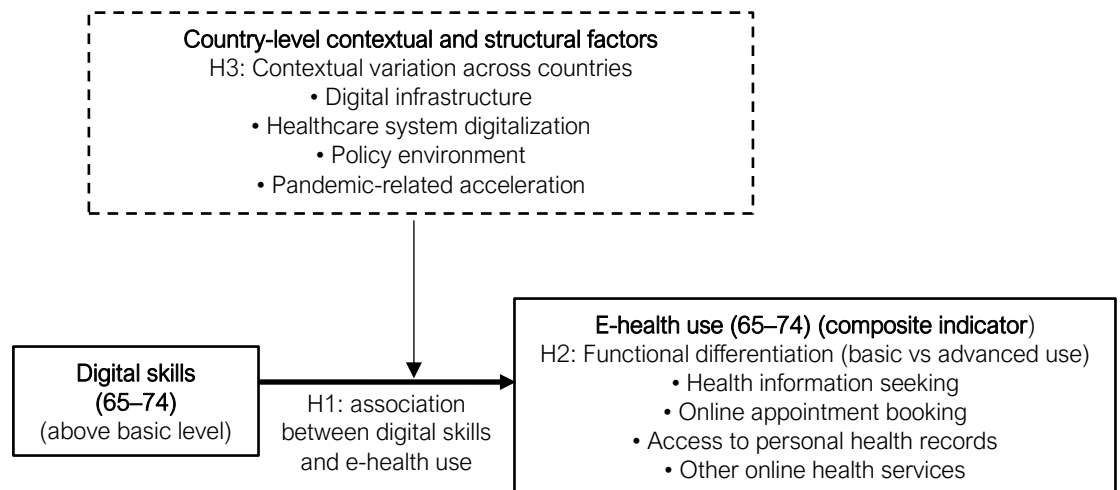


Figure 1. Conceptual framework of digital health use among adults aged 65–74. Source: *author's own*

### 3. Methodology

#### 3.1. Research design

This study is based on a quantitative secondary data analysis of harmonised European Union statistics. A secondary research design was chosen to enable cross-national comparison and longitudinal trend analysis across all EU member states using consistent indicators and methodologies. Eurostat data provide a unique opportunity to examine digital health participation among older adults within a unified statistical framework, making it particularly suitable for analysing age-specific patterns and cross-country differences in digital health integration. The analysis focuses on adults aged 65–74, a transitional age group that is increasingly relevant for digital health policy but remains underrepresented in comparative empirical research, as mentioned in the introduction. The study combines descriptive trend analysis, correlation analysis, and cluster analysis to address the research aims and to test the hypotheses.

#### 3.2. Data sources and sampling

The empirical analysis is based on data published by Eurostat for the period 2013–2024. Data were drawn from the Eurostat database Digital economy and society statistics – households and individuals, which collects information on internet use and digital activities among individuals aged 16–74 across the European Union. The dataset covers all 27 EU member states; the United Kingdom was excluded due to its withdrawal from the EU. The unit of observation in this study is the country. Each EU member state represents one aggregated observation, reflecting the proportion of individuals aged 65–74 engaging in specific digital activities or possessing certain digital competences.

The EU average (EU27) is reported as a population-weighted aggregate of national data, following Eurostat methodology. The study is based on secondary, harmonised Eurostat data; therefore, the data selection strategy focused on a targeted selection of predefined indicators related to digital skills and health-related online activities rather than on a systematic literature search. Inclusion criteria comprised EU member states for which comparable Eurostat data on adults aged 65–74 were available for the analysed period, while countries or observations with missing or non-comparable data were excluded from the analysis.

#### 3.3. Measures and indicators

E-health use was operationalised using four indicators derived from Eurostat's Internet Communication and Technology (ICT) usage by individuals – health-related activities online dataset. These indicators capture different dimensions of digital health engagement: seeking

health information online (e.g. information on diseases, symptoms, self-care, diet, or healthy lifestyles); making medical appointments online via websites or digital platforms; accessing personal health records online; and, using other online health services instead of in-person visits (e.g. teleconsultation or digital self-monitoring tools). The composite e-health index was constructed using indicator-specific min–max normalisation (0–100) and equal weighting across the four dimensions, to ensure balanced contribution and avoid dominance of information seeking. Min–max scaling was preferred to z-scores to preserve interpretability in cross-country comparisons.

Digital skills were measured for individuals with above basic digital skills for the age group 65–74 derived from the Digital Skills indicator (Eurostat, 2024a). Digital competence refers to individuals' proficiency in five areas of digital literacy: information and data literacy, communication, digital content creation, safety, and problem-solving. These competences are measured through the Digital Skills Indicator, which is derived from the European Union's DigComp framework and is based on individuals' reported ability to perform a range of digital tasks across these domains (European Union, 2023). In this study, the indicator represents the proportion of adults aged 65–74 demonstrating above-basic digital competence within each country.

### **3.4. Data analysis**

Several complementary analytical techniques were applied. First, descriptive trend analysis was used to examine changes in e-health use over time for the age groups 55–64 and 65–74 at both EU and national levels. Second, cumulative growth and compound annual growth rates (CAGR) were calculated for the period 2015–2023, and separately for 2019–2023, to assess acceleration effects following the COVID-19 period. The CAGR was calculated using the standard formula  $CAGR = (V_t / V_0)^{1/n} - 1$ , where  $V_t$  denotes the value in the final year,  $V_0$  the value in the initial year, and  $n$  the number of years between the initial and final observations. Third, a bivariate correlation analysis was conducted to assess the association between digital skills and e-health use across EU member states. Pearson's product–moment correlation coefficient ( $r$ ) was used to measure the strength and direction of the linear relationship between the share of individuals aged 65–74 with above-basic digital skills derived from the Digital Skills indicator (Eurostat, 2024a) and the composite e-health use indicator (derived from the Internet activities (Eurostat, 2024b).

Finally, cluster analysis was applied to identify groups of countries with similar digital health integration profiles. Both indicators were standardised and entered into a two-step clustering procedure. Hierarchical cluster analysis using Ward's method and squared Euclidean distance was first employed to determine the optimal number of clusters. The analysis is based on Eurostat datasets by countries, including Individuals with above basic digital skills (age group 65–74) (Eurostat, 2024a) and Individuals using the internet for health-related activities (e-health indicators), (Eurostat, 2024b). Subsequently, a k-means algorithm was used to assign countries to homogeneous clusters. All data preparation and analyses were conducted using Microsoft Excel and Python's pandas library.

### **3.5. Data evaluation and limitations of secondary data**

The use of secondary, self-reported data entails several limitations. Eurostat indicators capture participation in digital activities but do not measure frequency, intensity, or quality of use. Self-reported measures may be affected by recall bias and cross-country differences in response behaviour. In addition, the Digital Skills Indicator relies on activity-based proxies rather than direct assessments of competence, which may lead to over- or underestimation of actual skills among older adults. As the analysis is based on aggregated country-level data, individual-level causal relationships cannot be inferred. Observed associations reflect cross-national correlations rather than within-country or longitudinal causal effects. These limitations were considered in the interpretation of the results. A limitation of the study is the slight temporal mismatch between the digital skills indicator (2023) and the e-health use indicators (2024). However, this sequencing is conceptually justified, as digital competences are assumed to precede and enable subsequent digital health use, including e-health adoption (van Kessel et al. 2023).

## 4. Findings

### 4.1 Sample characteristics and descriptive overview

This section presents a descriptive overview of the country-level sample used in the analysis and introduces the key indicators underlying the subsequent empirical results. As the study is based on secondary, aggregated data, each European Union member state constitutes one unit of observation ( $N = 27$ ). The focus is on adults aged 65–74, a group that is increasingly relevant for digital health policy but remains underrepresented in comparative empirical research. Table 1 summarises the key indicators used in the analysis and presents the EU27 average, the observed country-level range (minimum–maximum), and Hungary's corresponding value. EU27 averages are population-weighted figures published by Eurostat, while the range reflects the lowest and highest proportions observed across member states. This overview provides an initial assessment of cross-national heterogeneity.

**Table 1. Descriptive overview of sample. Source: adapted from Eurostat (2023, 2024)**

Indicator	EU27 average (Eurostat)	Range across EU countries (min–max)	Hungary
Individuals with above basic digital skills (%)	28.19	6.17–66.54	28.43
Health information seeking online (%)	44.93	16.7–78.21	51.82
Online appointment booking (%)	28.19	1.97–57.64	22.38
Access to personal health records (%)	19.21	0.24–59.32	26.18
Internet use for other health services via a website or app (%)	14.66	0.46–65.38	17.87
Composite e-health use indicator	35.5	9.48–60.45	34.85

The descriptive overview highlights substantial variation across EU member states in both digital competences and e-health engagement among older adults. While EU27 averages provide a useful benchmark, the wide range of country-level values underscores the uneven pace of digital health integration across Europe. Hungary's position relative to both the EU average and the observed country range offers an initial indication of its comparative performance, which is examined in greater detail in the subsequent analyses.

### 4.2. Trends in e-health use among older adults (2015–2024)

This section presents the descriptive trend analysis outlined in the Methods section. Based on Eurostat time-series data, and in line with the hypotheses formulated in Section 2.4, the e-health activity of both the younger (55–64) and older (65–74) age groups has steadily increased across the European Union between 2015 and 2024, although at different rates. On average within the EU27, the share of individuals aged 55–64 who searched for health information online rose from 37.6% in 2015 to 56.0% in 2024, while among those aged 65–74 it increased from 24.5% to 44.9%. In Hungary, a similar but even more dynamic growth was observed. Among adults aged 55–64, online health information seeking increased from 43.9% to 63.7%, and among those aged 65–74 from 21.9% to 51.8%. The rise accelerated particularly after 2019, when restrictions on access to in-person healthcare and information during the pandemic significantly stimulated the use of digital tools. This effect is clearly visible in the Hungarian data, where e-health activity among the 65–74 age group grew from 33.8% in 2019 to 46.7% in 2021. In contrast, the EU average showed a steadier but slower increase, from 34.1% to 44.9% over the same period. As a result, by 2024 Hungary had surpassed the EU average: the proportion of older adults (65–74) seeking health information online reached 51.8% in Hungary, compared to 44.9% in the EU27. The gap between the two age groups narrowed in both contexts, though more rapidly in Hungary — from 21.9 percentage points in 2015 to 11.9 percentage points in 2024. These findings indicate that older Hungarian internet users caught up rapidly after the pandemic, suggesting that the use of e-health services has gradually become part of older adults' regular digital practices. The temporal trends in online health information seeking among the two age groups are presented in Figure 2.

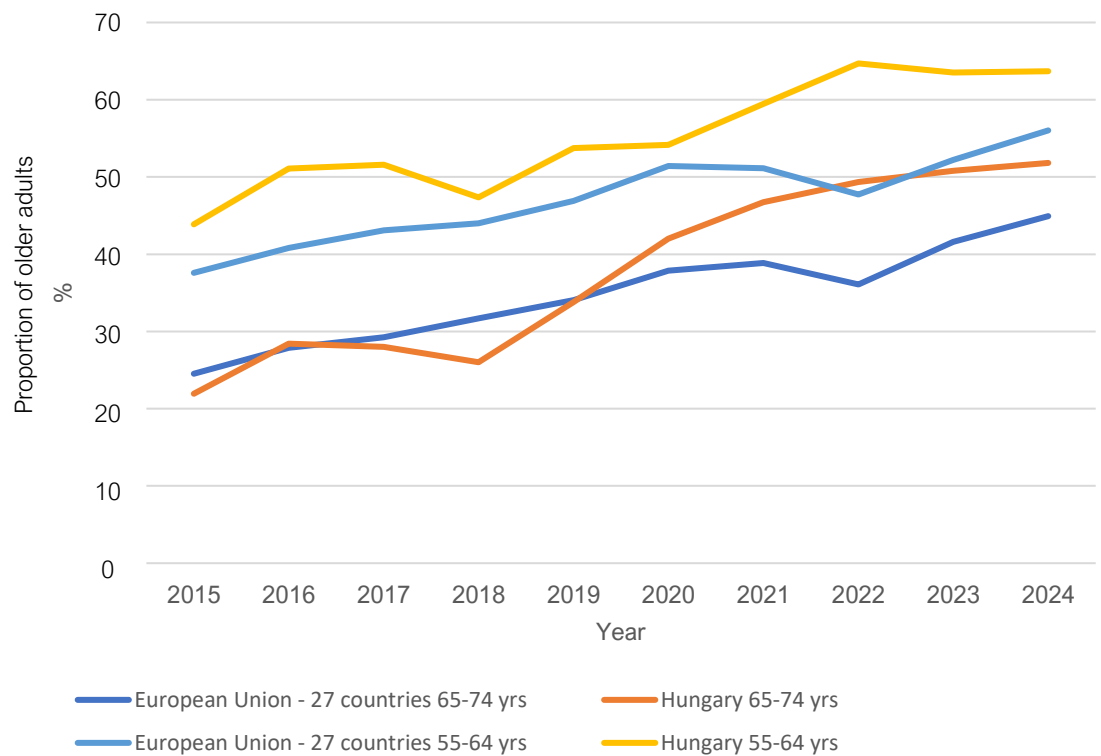
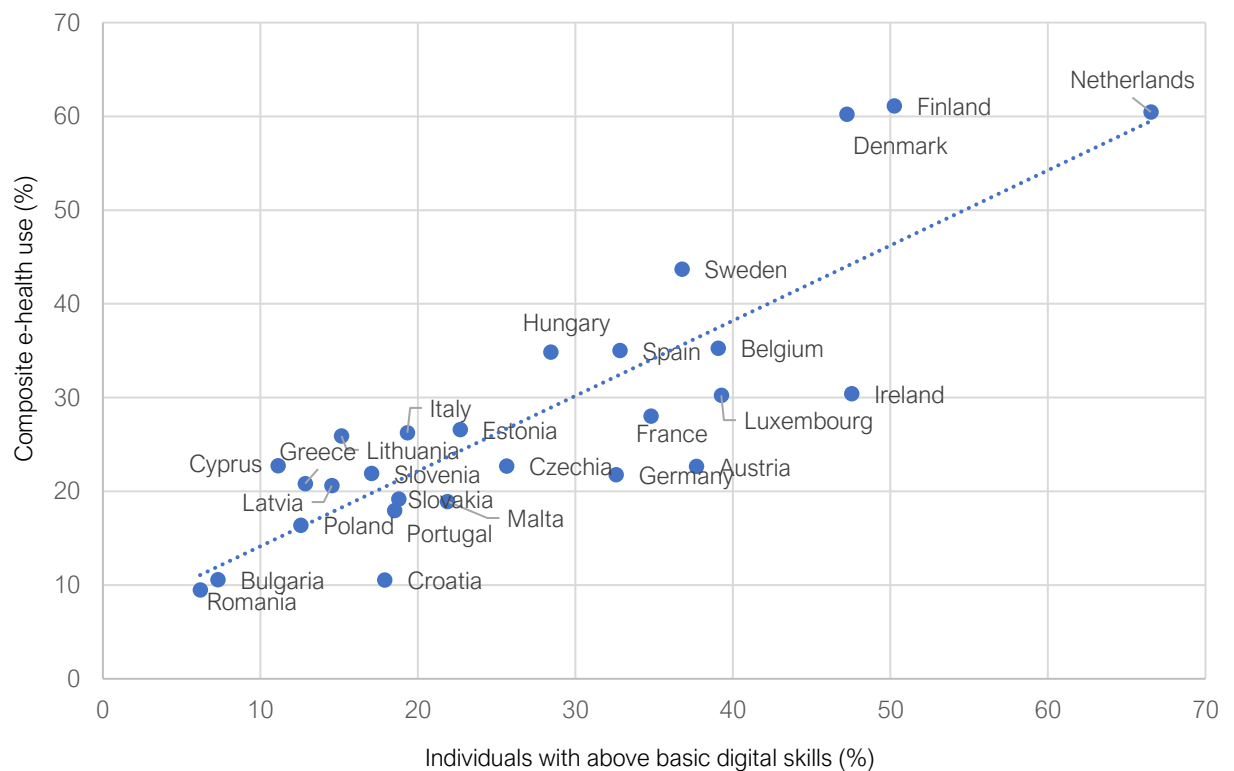


Figure 2. Share of individuals aged 65–74 and 55–64 seeking health information online in Hungary and the EU27, 2015–2024 (%). Source: *adapted from Eurostat (2024)*

#### 4.3. Correlation between digital skills and e-health use

To examine the relationship between general digital competence and health-related internet use, a bivariate correlation analysis was conducted based on Eurostat data for the 65–74 age group across EU member states. The indicator ‘individuals with above basic digital skills’ was compared with the composite e-health use indicator, which integrates multiple dimensions of online health engagement, including information seeking, appointment booking, and access to digital health services. The association between the two variables was measured using Pearson’s product–moment correlation coefficient, a parametric method suitable for assessing the linear relationship between two continuous variables. The analysis covered all EU27 countries (N = 27), with each country representing a single observation pair (digital skills level vs. e-health use rate), illustrated on Figure 3 as a single dot.



**Figure 3. Relationship between digital skills and e-health use among older adults (65–74) for EU27 countries, 2023–2024. Source: adapted from Eurostat (2023, 2024)**

The fitted regression line indicates a strong positive correlation ( $R^2$  value of 0.71,  $r = 0.84$ ,  $p < 0.001$ ), meaning that countries with higher shares of older adults with above-basic digital skills also tend to report higher composite e-health use.  $R^2$  is reported here as a descriptive measure of the strength of the linear relationship and should not be interpreted as causal explanation. Digital skills refer to 2023 data, whereas e-health use is measured for 2024. This one-year difference reflects data availability in the harmonised Eurostat series. Given the relative stability of population-level digital skill distributions over short periods, the 2023 indicator is used as a proxy for the skill environment underlying 2024 e-health participation; the findings therefore represent cross-sectional associations. The observed relationship is consistent with previous research emphasising the importance of digital competence in later-life engagement with technology-based health services. However, the analysis does not allow conclusions about directionality or causality.

Descriptive patterns suggest regional clustering, with several Northern European countries displaying high levels of both digital skills and e-health participation. Hungary's position slightly above the fitted line indicates relatively higher e-health use compared to what would be expected from its digital skills level alone. This pattern is compatible with the presence of additional contextual characteristics (e.g. service availability, institutional arrangements, or support from family members), although these factors are not directly tested in the present analysis. By contrast, countries with similarly moderate digital skills (e.g. Italy, Estonia, Slovenia) show lower levels of e-health use, while highly skilled populations in Northern Europe (e.g. Finland, Denmark, and the Netherlands) show both high competence and high participation levels.

Between 2019 and 2023, growth in both digital skills and e-health use accelerated, particularly in Hungary. The average annual growth rate of above basic digital skills reached 17.2% per year in Hungary, compared to 7.5% in the EU27 average, while seeking health information online increased by 10.7% and 5.1%, respectively. Cumulative growth was visualised in a time series line chart to illustrate changes in growth intensity over time on Figure 4. Both indicators increased substantially between 2015 and 2023, with a marked acceleration in Hungary after 2019. These figures describe temporal co-movement rather than causal linkage. While digital skills increased proportionally more steeply, the simultaneous

expansion of e-health use is compatible with the view that skill development alone does not fully account for cross-country differences in participation levels.

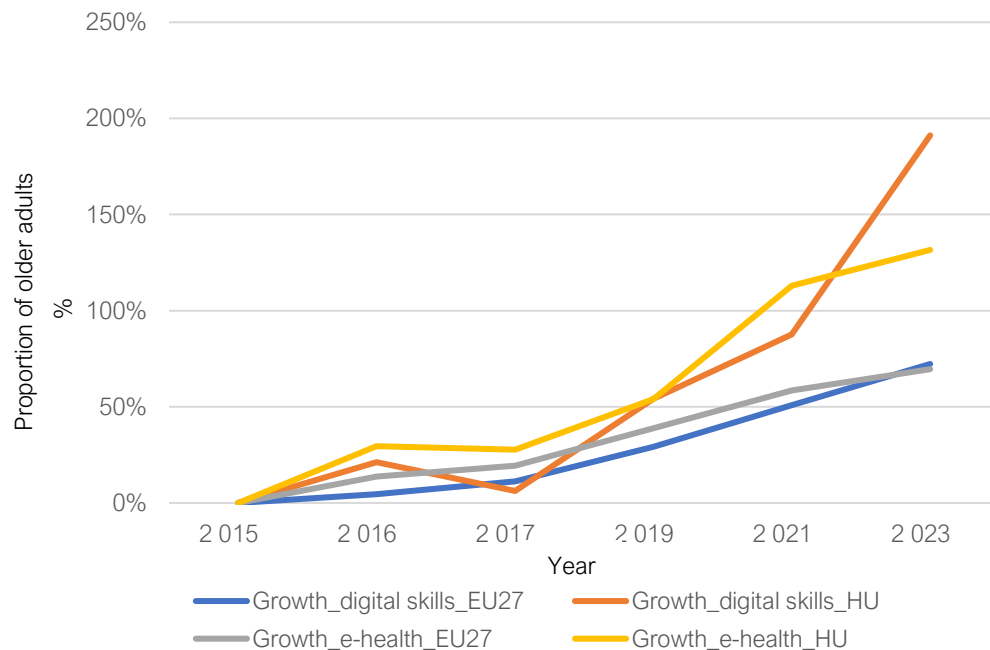


Figure 4. Cumulative growth in digital skills and e-health use among older adults (65–74) in the EU27 and Hungary, 2015–2023. Source: *adapted from Eurostat (2015-2023)*

#### 4.4. Comparative analysis of e-health functions

Beyond health information seeking, Eurostat data available since 2020 allow for the analysis of more advanced e-health activities among older adults, including online appointment booking, access to personal health records, and the use of other digital health services. The expansion of these datasets reflects a shift in the conceptualisation of digital health—from information access toward active service use and self-management. This transition enables a more comprehensive understanding of how older citizens integrate into digitally supported healthcare systems. Analysing these dimensions jointly allows differences to be assessed not only in access or skills, but also in the depth of e-health engagement across countries. Between 2020 and 2024, the scope of e-health participation among older adults expanded considerably in both the EU27 and Hungary. While health information seeking remained the most common digital health activity, more advanced forms of online interaction—such as booking medical appointments or accessing personal health records—showed the most dynamic growth.

Figure 5 compares four dimensions of e-health use among individuals aged 65–74. At the EU level, online appointment booking among elderly individuals more than doubled, from 12.8% in 2020 to 28.2% in 2024, and the share of those accessing their electronic health records increased from 6.9% to 19.2%. In Hungary, the pattern was similar but more pronounced: the proportion of older adults who accessed their health records rose from 8.5% to 26.2%, and the use of other online health services nearly doubled. Hungary exceeds the EU27 average across all indicators, particularly in health information seeking (52% vs. 45%) and access to personal health records (26% vs. 19%).

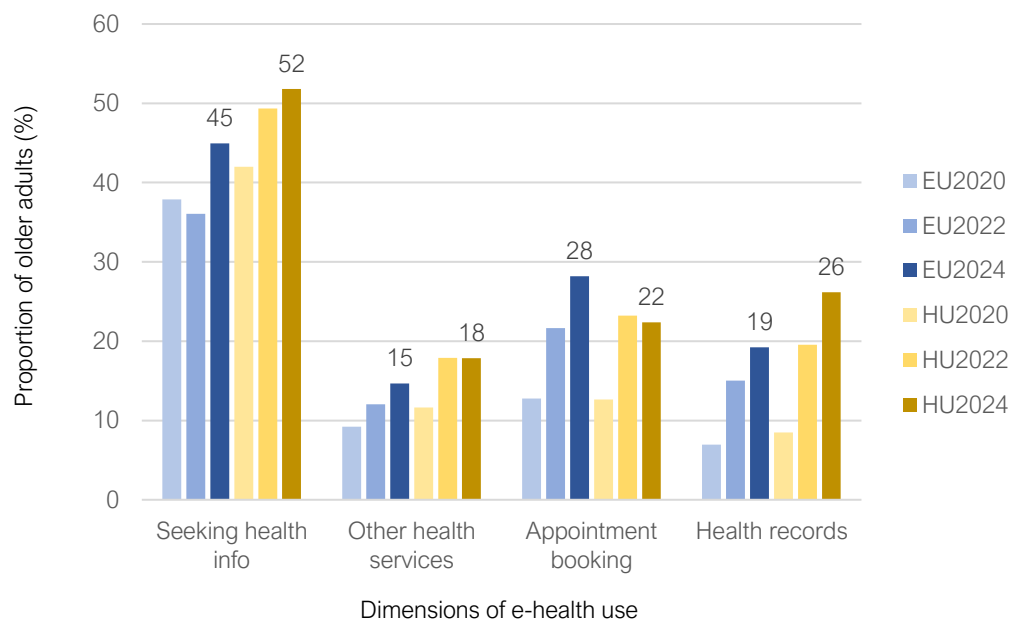


Figure 5. E-health participation by activity type among older adults (65–74) comparing EU27 and Hungary. Source: adapted from Eurostat (2020–2024)

#### 4.5. Digital Integration Profiles of European Countries (65–74)

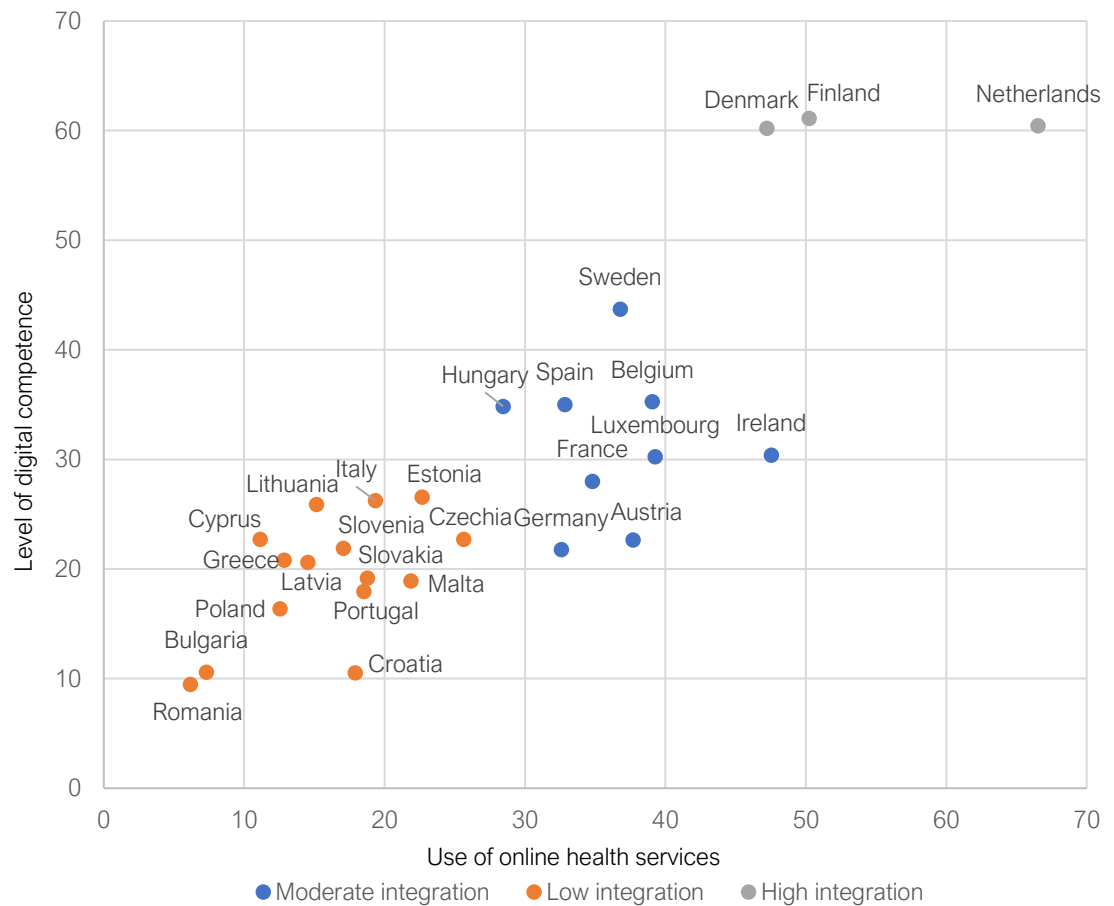
Building on the comparative analysis of the four e-health indicators, the next step focuses on identifying broader patterns in how European countries position themselves regarding digital health engagement among the 65–74 age group. Since Eurostat does not provide a single measure that captures the complexity of e-health use, a composite indicator was calculated in this study based on four dimensions of online health engagement: seeking health information, using other online health services, making appointments with practitioners via digital platforms, and accessing personal health records. Combining these dimensions allows for a more integrated representation of how older adults interact with digital health environments. To further explore country-level similarities and differences, a cluster analysis was conducted using this composite e-health indicator together with the measure of digital skills, in order to map distinct profiles of digital inclusion in later life. The cluster analysis is based on the composite e-health use indicator described in the methods section.

The cluster analysis revealed a clear three-group structure across EU countries, reflecting distinct levels of digital integration in health-related practices. The high integration cluster, comprising Denmark, Finland, and the Netherlands, represents countries where older adults show both advanced digital competence and intensive use of online health services. In these countries, a large share of adults aged 65–74 report above-basic digital skills, and composite e-health use reaches the highest levels in the EU sample.

The moderate integration cluster includes Austria, Belgium, France, Germany, Ireland, Luxembourg, Spain, Sweden, and Hungary. In these countries, digital skills are moderately developed, and between one-fifth and two-fifths of older adults engage in e-health activities. Hungary, although part of the Central and Eastern European region, belongs to this moderate integration group rather than to the low-integration cluster typical of its regional peers. These countries have relatively developed digital infrastructures, and generational differences in online participation are gradually narrowing among older adults.

The low integration cluster covers Bulgaria, Croatia, Cyprus, Czechia, Estonia, Greece, Italy, Latvia, Lithuania, Malta, Poland, Portugal, Romania, Slovakia, and Slovenia, where digital engagement among older adults remains limited. The share of individuals with above-basic digital skills is typically below 20%, and e-health use averages around 10–20% across indicators. This group reflects a persistent digital divide across Southern and Eastern Europe, where lower levels of digital competence among older adults are accompanied by limited engagement in e-health activities. Figure 6 illustrates the clear separation of the country

clusters, with the different colours indicating the low-, moderate-, and high-integration groups based on the composite e-health and digital skills indicators.



**Figure 6.** Distribution of EU countries across three clusters of digital competence and e-health use among adults aged 65–74. Source: *adapted from Eurostat (2024)*

Overall, the three-cluster solution indicates a clear gradient in later-life digital health integration across Europe. Northern countries tend to display higher combined levels of digital skills and e-health participation, while several Southern and Eastern member states are positioned in lower integration clusters. Hungary's placement within the moderate integration group suggests a comparatively more advanced profile than several regional peers. The clustering results are consistent with the correlation findings, highlighting that digital skills are strongly associated with multidimensional e-health use, yet similar competence levels may correspond to different participation levels across countries. This pattern points to the relevance of broader institutional and service-related contexts in shaping cross-national variation, although these contextual dimensions are not directly measured in the present analysis.

## 5. Discussion

The present study examined digital health participation among adults aged 65–74 across EU member states, focusing on the association between digital skills and multidimensional e-health use. By combining harmonised Eurostat data, longitudinal trend analysis, a composite e-health index, correlation analysis, and country-level clustering, the study provides an age-specific comparative perspective extending beyond predominantly cross-sectional and single-indicator approaches. Table 2 summarises the main results of the analysis, linking each analytical step to the applied methods and highlighting the specific contribution of the study beyond existing descriptive evidence.

Table 2. Summary of key findings. Source: *author's own*

Analytical focus	Indicator(s)	Method	Main result	Value added of the present study
<b>Descriptive trends (2015–2024)</b>	Health information seeking (55–64; 65–74)	Time-series analysis	Steady increase in both age groups; faster post-2019 growth among adults aged 65–74, particularly in Hungary	Longitudinal, age-specific comparison over a ten-year period
<b>Growth dynamics</b>	Digital skills; health information seeking	CAGR (own calculation)	Growth rates among adults aged 65–74 exceed EU27 average in Hungary after 2019	Highlights post-pandemic acceleration and catching-up dynamics
<b>Digital skills–e-health link</b>	Composite e-health use indicator	Pearson correlation (r)	Strong positive association across EU member states ( $r = 0.84$ , $p < 0.001$ )	Use of a multidimensional composite indicator instead of single e-health measures
<b>Functional differentiation</b>	Four e-health activities	Comparative analysis	Basic activities more widespread than advanced uses (e.g. records access, online appointments)	Identifies a “digital participation hierarchy” among older adults
<b>Cross-national patterns</b>	Digital skills + composite index	Cluster analysis (Ward + k-means)	Three distinct country clusters (high, moderate, low integration)	Age-specific digital integration profiles across EU countries

Table 2 directly reflects the analytical logic of the study and the hypotheses formulated in Section 2.4. The empirical results also allow for a direct evaluation of the study hypotheses. H1 was supported, as a strong and statistically significant positive association was identified between digital skills and e-health use across EU Member States ( $r = 0.84$ ,  $p < 0.001$ ). This finding reinforces the assumption that higher levels of digital competence are closely linked to more active engagement in digital health activities. H2 was supported, as the comparative analysis confirmed systematic differences between basic and more advanced forms of e-health use. While activities such as health information seeking are widely adopted, more complex services (e.g. access to medical records or online consultations) remain less prevalent, indicating a clear functional hierarchy in digital health participation among older adults. H3 was supported, as the cluster analysis revealed three distinct country groups with differing levels of digital health integration. These clusters highlight substantial cross-national the correlation analysis corresponds to the hypothesised association between digital skills and e-health use (H1), the functional comparison informs differences between basic and advanced forms of engagement (H2), and the cluster analysis captures cross-national heterogeneity in digital health integration (H3). heterogeneity and confirm that digital health participation among older adults follows structured patterns at the country level.

While previous research has often relied on single indicators or cross-sectional snapshots (Heart & Kalderon, 2013; Peek et al. 2016.), the present analysis integrates longitudinal trends, a composite e-health use index, and age-specific cross-national clustering. By synthesising these elements, the table clarifies how the study extends existing evidence and provides a coherent empirical narrative across multiple analytical levels.

The findings of the present study indicate that e-health participation among older adults has increased across Europe, particularly after 2019, in line with previous research (OECD, 2020). While previous research highlighted the catalytic role of the COVID-19 pandemic in accelerating digital health adoption (Choi et al., 2022; Socha-Dietrich, 2021), the present analysis shows that the pace and structure of change differed across age groups and countries. In several cases—including Hungary—adults aged 65–74 exhibited faster relative growth than younger cohorts, coinciding with a narrowing age gap in e-health use. These patterns indicate that later-life digital engagement is responsive to institutional and systemic developments, although the analysis does not imply causality.

A strong positive association was observed between digital skills and multidimensional e-health use. The results further suggest that digital skills are more closely associated with advanced forms of e-health engagement—such as online appointment booking and access to personal health records—than with basic information seeking. This pattern is consistent with previous research indicating that higher levels of digital competence among older adults are associated with more advanced and complex forms of technology use (van Houwelingen

et al., 2018; Friemel, 2016; Yang et al., 2024). At the same time, the present study extends this perspective by identifying a hierarchical structure of digital participation in later life, where more complex interactions are linked to higher competence levels. Cluster analysis reveals persistent cross-national differences in digital health integration. Similar levels of digital competence correspond to differing levels of e-health participation across countries, underscoring the importance of institutional context, service availability, and healthcare system digitalisation.

Beyond confirming established associations, the findings refine digital divide and technology adoption frameworks by showing that later-life inequalities operate along gradients of engagement complexity. The stronger association between digital skills and advanced, system-integrated e-health activities than with information seeking is consistent with a second-level divide, where competence relates to the depth of participation. In addition, the cluster results indicate that similar competence levels may coincide with different uptake levels across countries, suggesting that institutional integration and service design condition how individual competences translate into use. Together, these results support a multidimensional and context-dependent interpretation of digital health inclusion in later life.

## 6. Implications

The findings have both theoretical and practical implications for later-life digital inclusion and digital health policy. From a theoretical perspective, the results support competence-based models of digital participation (Heart & Kalderon, 2013; van Houwelingen et al., 2018) while refining them in two ways. First, the strong association between digital skills and composite e-health use ( $r = 0.84$ ) is consistent with the idea that skills matter particularly for more complex, system-integrated activities (e.g. appointment booking and record access), not only for basic information seeking. Second, the cluster patterns show that similar skill levels can coincide with different uptake levels across countries, suggesting that institutional integration and service design condition how competences translate into use. Together, these findings support a multidimensional and context-sensitive interpretation of digital health inclusion in later life.

From a practical perspective, the results point to differentiated policy needs across the three country clusters identified in the analysis. First, the strong association between digital skills and multidimensional e-health use ( $r = 0.84$ ) indicates that competence development is a key policy lever. In contexts where advanced e-health uptake is low, targeted digital literacy interventions for adults aged 65–74—particularly among groups with lower levels of digital skills and access—should focus on enabling interaction with specific services such as online appointment booking and access to personal health records. Second, in moderate-integration contexts—where relatively high digital skill levels are not matched by comparable levels of e-health uptake—the findings suggest that barriers are not primarily skill-related but linked to service usability, trust, interoperability, and the integration of digital services into routine care. Third, in low-integration countries—characterised by both lower digital skills and limited e-health use—incremental implementation strategies, awareness-raising, and adaptation of practices from higher-integration systems may support gradual adoption, provided that they are aligned with national healthcare capacities and socio-economic conditions.

From a broader societal perspective, these findings highlight that digital health expansion may reinforce existing social and digital inequalities among older adults if competence gaps and structural barriers are not addressed simultaneously. At the same time, they point to the potential of well-designed digital health systems to enhance access, efficiency, and patient empowerment. Overall, the findings suggest that effective strategies must simultaneously address individual competences and structural conditions of access and service integration.

## 7. Conclusions

This study examined digital health participation among adults aged 65–74 across EU member states and explored its association with digital skills. Addressing RQ1, the results

show substantial cross-national variation in multidimensional e-health engagement; addressing RQ2, they indicate a strong positive cross-sectional association between digital skills and composite e-health use. The 65–74 cohort emerges as a strategically important group for digital health expansion and inclusion.

Digital skills refer to 2023 data, whereas e-health use is measured for 2024. This one-year difference reflects data availability. Given the relative stability of population-level skill distributions over short periods, 2023 values are treated as a reasonable proxy for conditions underlying 2024 participation. The results should therefore be interpreted strictly as cross-sectional associations.

Methodologically, the study integrates harmonised Eurostat data, trend analysis, composite indicators, and clustering techniques to provide a comparative perspective. Limitations include reliance on self-reported indicators, activity-based skill proxies, and country-level cross-sectional data, which preclude causal inference. Future research should incorporate longitudinal micro-level data to examine motivational and institutional mechanisms underlying later-life digital health adoption.

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