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# Ensuring Sustainable Digital Inclusion among the Elderly: A Comprehensive Analysis

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**Abstract:** Advancements in digital technologies have transformed the world by providing more opportunities and possibilities. However, elderly persons have several challenges utilizing modern technology, leading to digital exclusion, which can negatively impact sustainable development. This research attempts to address the current digital exclusion by addressing the challenges older people face considering evolving digital technologies, focusing on economic, social, and environmental sustainability. Three distinct goals are pursued in this study: to perform a detailed literature review to identify gaps in the current understanding of digital exclusion among the elderly, to identify the primary factors affecting digital exclusion in the elderly, and to analyze the patterns and trends in different countries, with a focus on differentiating between High-Income Countries (HICs) and Lower Middle-Income Countries (LMICs). The research strategies used in this study involve a combination of a literature review and a quantitative analysis of the digital exclusion data from five cohorts. This study uses statistical analysis, such as PCA, chi-square test, one-way ANOVA, and two-way ANOVA, to present a complete assessment of the digital issues that older persons experience. The expected results include the identification of factors influencing the digital divide and an enhanced awareness of how digital exclusion varies among different socio-economic and cultural settings. The data used in this study were obtained from five separate cohorts over a five-year period from 2019 to 2023. These cohorts include ELSA (UK), SHARE (Austria, Germany, France, Estonia, Bulgaria, and Romania), LASI (India), MHAS (Mexico), and ELSI (Brazil). It was discovered that the digital exclusion rate differs significantly across HICs and LMICs, with the UK having the fewest (11%) and India having the most (91%) digitally excluded people. It was discovered that three primary factors, including socio-economic status, health-related issues, and age-related limitations, are causing digital exclusion among the elderly, irrespective of the income level of the country. Further analysis showed that the country type has a significant influence on the digital exclusion rates among the elderly, and age group plays an important role in digital exclusion. Additionally, significant variations were observed in the life satisfaction of digitally excluded people within HICs and LMICs. The interaction between country type and digital exclusion also showed a major influence on the health rating. This study has a broad impact since it not only contributes to what we know academically about digital exclusion but also has practical applications for communities. By investigating the barriers that prevent older people from adopting digital technologies, this study will assist in developing better policies and community activities to help them make use of the benefits of the digital era, making societies more equitable and connected. This paper provides detailed insight into intergenerational equity, which is vital for the embedding principles of sustainable development. Furthermore, it makes a strong case for digital inclusion to be part of broader efforts (and policies) for creating sustainable societies.

**Keywords:** sustainable development; socio-economic challenges; sustainable societies; digital exclusion; elderly people; digital technologies

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## 1. Introduction

Given how much technology affects modern life in a digital age, the issue of digital inclusion is becoming more and more crucial, especially for the elderly. It is generally acknowledged that technological advancements might raise living conditions for people, encourage social integration, and assist in reducing social disparities [1]. According to Manzoor and Vimarlund (2018), digital inclusion is essential for establishing social justice, encouraging equal development, and eliminating inequality [2].

Understanding the main factors contributing to digital exclusion among elderly people is important to address the present issue. While the systematic review conducted by Lythreatis et al. (2022) discussed the seven factors contributing to digital exclusion by examining 24 different countries [3], a research gap still exists in understanding the common factors contributing to the digital divide across different socio-economic settings. Moreover, recent researchers [4–7] have mainly focused on a specific region or demographic group, which limits the generalization of the findings. Therefore, since related research in this area has not fully explored the primary factors, there is a need to investigate digital exclusion considering different country types (HIC vs. LMIC).

The recent study by Lu et al. (2022) examining 23 countries explained that there is a considerable variation in the digital exclusion rate among HICs and LMICs [8]. However, it was noted that most of the countries were in the HIC category; only 2 countries were LMICs, and all 19 countries from Europe were in the HIC category. It would be beneficial to analyze this variation considering a greater number of LMICs.

The motivation behind this research study is to address the issue of digital exclusion among elderly people. Even though digital technologies are growing rapidly, elderly people are mostly excluded from the digital world, which limits the benefits and new opportunities that modern technology brings. This distinction must be addressed, and therefore, the first objective of this study is to conduct a comprehensive literature review to build foundational knowledge, thereby identifying the research gaps and understanding the challenges faced by elderly people in adopting digital technologies. Moreover, digital technologies can improve the quality of life of elderly people as they can provide access to healthcare and banking services, social connections, and daily activities. This research shows that digital inclusion services and community programs can enhance the social well-being of the elderly, contributing to their overall well-being and social sustainability.

Identifying the primary factors that contribute to digital exclusion is necessary to develop measures to promote digital inclusion. The findings of this paper can potentially be utilized to fabricate policies that make a positive impact on the development of digital inclusion in the elderly. Analyzing the patterns, trends, and variations in digital exclusion across HICs and LMICs is important to understand how the digital divide varies globally. By analyzing different variables, we can explore the similarities and differences between these country types in the context of digital exclusion. This comparative analysis will help us to develop better strategies and services based on geographical location.

This study examines the previous research conducted in this field to determine the status of digital use among the elderly, to identify the research gaps, and to obtain a deeper understanding of the present state of digital exclusion among older people. Individuals above the age of 55 are considered elderly in this study, which primarily focuses on five High-Income Countries (HICs) and five Lower Middle-Income Countries (LMICs). Moreover, the patterns and trends in digital usage by elderly people will be analyzed by utilizing data sources such as SHARE, ELSA, MHAS, ELSI, LASI to obtain a deeper view of the correlation between age and digital activity. This research seeks to give useful insights into the frequently disregarded difficulties faced by older people.

Digital exclusion among the elderly is a sustainability challenge in the context of social sustainability. As societies grow more digitally connected, ensuring that all segments of the population, including the elderly, can participate and benefit from digital technologies is crucial for creating sustainable and inclusive communities. The research explicitly examines socio-economic factors as one of the primary causes of digital exclusion among the elderly.

This paper discusses intergenerational equity, which is crucial for sustainable development. It presents a comprehensive understanding of how economic factors influence digital exclusion and its relationship to socio-economic equity. The research findings are useful for policymakers to work towards equitable, inclusive, and sustainable societies. This study provides a significant contribution by emphasizing why digital inclusion is needed as part of broader sustainable development efforts.

To promote long-term digital inclusion among the elderly, this study attempts to identify the primary variables influencing digital exclusion. Furthermore, this study proposed effective suggestions to authorities to enhance the use of digital technology among the older generation.

The primary objective of this research is to identify and investigate the factors that are detrimental to the elderly in using digital technologies and preventing them from adopting digital technologies. The main objective can be divided into sub-objectives, as listed below:

- To conduct a thorough literature review to discover factors influencing the adoption of digital technologies among the elderly, with a focus on the current state of digital exclusion.
- To explore the causes of the digital divide and identify key contributors that can lead to sustainable digital inclusion.
- To perform in-depth analysis of various data sources to investigate patterns and trends and to obtain a global perspective on socio-economic factors and their link to social sustainability.

The main objective and the sub-objectives address the following research questions:

- RQ1: What is the current state of digital exclusion among the elderly, particularly in terms of competency with devices such as computers, smartphones, and other digital tools?
- RQ2: What are the primary factors affecting the digital divide among elderly people, and how can these factors ensure sustainable digital inclusion among the elderly?
- RQ3: How does the digital exclusion vary among different countries and cultures, and are there any variations in digital exclusion in High-Income Countries (HICs) and Lower Middle-Income Countries (LMICs)?

In searching for answers to the above questions, the research makes the following contributions to this field of study:

- The HICs and LMICs selected for this study were analyzed independently to determine the differences in digital exclusion between them, taking into account how diverse social and economic conditions influence technology usage among older people. It describes how different country features influence digital exclusion.
- The list of factors influencing the digital divide among the elderly includes socio-economic factors, health-related issues, and age-related limitations. By connecting these characteristics to theories such as socio-economic and ecological systems [9], the research provides insights into how they interact and how they affect digital inclusion.
- This study examines the technological challenges faced by elderly people by considering the "Digital Divide Theory" [10] to assess how digital literacy factors influence digital exclusion.
- The analysis of five cohorts from diverse regions to identify how regional and environmental characteristics affect digital exclusion.
- Applying different statistical analyses, such as Principal Component Analysis (PCA), component matrix, and pattern matrix, to understand the major factors affecting digital exclusion. These methods help to analyze how diverse factors contribute to a better understanding of digital exclusion.
- The use of the factor analysis method identified the primary factors influencing digital exclusion among the elderly as socio-economic, age-related limitations and health-related issues. This finding supports the Ecological Systems Theory [9], providing evidence about how these factors affect digital exclusion among the elderly.

- Analyzing the linear trend in the association between digital exclusion and country type.
- The study identifies a linear trend in the relationship between age group and country type and illustrates the interaction between age and socio-economic factors in the context of digital exclusion. This finding supports the Ecological Systems Theory [9] showing how multiple factors like age- and country-specific factors impacts digital exclusion among elderly.

The rest of the paper is structured as follows. Section 2 explores a literature review conducted on this topic to analyze the current state of digital exclusion and examines the factors causing the digital divide and technological challenges faced by elderly people. The literature review also covers the initiatives that have been undertaken to reduce digital exclusion. Section 3 outlines how this study was conducted, providing an outline of the various research and data analysis strategies used in this research. The comprehensive discussion of research findings, which combines both quantitative and comparative analysis to answer the research questions, is discussed in Section 4. Finally, the paper concludes by highlighting the major findings and future directions, as discussed in the last section.

## 2. Research Background

As life expectancy rises globally, the issue of aging has become more prominent [11]. The decreasing mortality rate and dropping birth rates have resulted in an increase in the world's aging population, with Europe experiencing a significant change in the aging population [4]. According to a prediction by Eurostat (2023), the senior citizens in the European Union will reach 500 K in 25 years, and the percentage of older adults between age groups 65 to 74 and 75 to 84 are expected to rise by 16.6% and 56.1%, respectively [12].

Figure 1 depicts the percentage of the elderly population in HICs and LMICs during a period of five years from 2018 to 2022. The result shows a slight increase in the elderly population rate in all these countries [13]. The rate of the older population is above the baseline (black-colored line) for most of the countries except India, Mexico, and Brazil. The highest rate of aging population was observed in Bulgaria (22.5) and Germany (22.1), and the lowest in India (6.8).

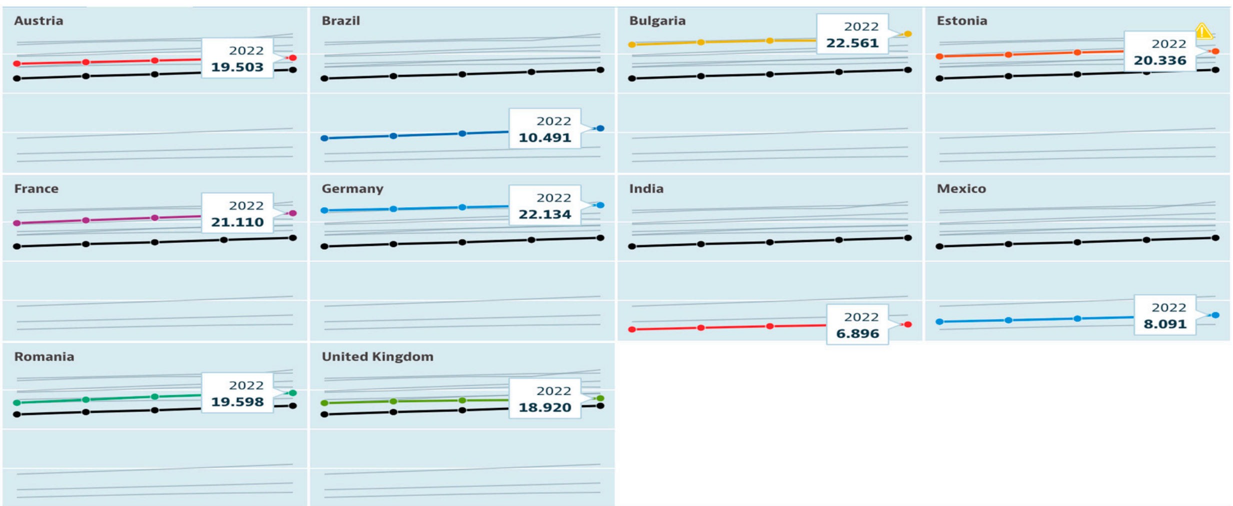


**Figure 1.** Percentage of elderly population in HICs and LMICs between 2018 and 2022 [13].

Moreover, Table 1 indicates the predicted old-age dependency ratio of HICs and LMICs up to the year 2075. Germany and Austria have the highest old-age dependency ratio (63.1). This means that about 63 out of 100 people in these two countries will be 65 years or older by 2075. The old-age dependency ratio of all countries, except India (37), is above 50, which suggests that more than half of the population in these countries will be senior citizens by 2075. Therefore, it is important to prioritize digital inclusion projects for the elderly to provide equitable access to technology and its benefits.

**Table 1.** Expected old-age dependency ratio in HICs and LMICs from 2024 to 2075 [13].

| Country | 2024 | 2025 | 2026 | 2027 | 2050 | 2075 |
|---|---|---|---|---|---|---|
| Austria | 35.5 | 37.1 | 37.7 | 39 | 56 | 63.1 |
| Brazil | 17.7 | 18.3 | 19 | 19.8 | 39.5 | 62.3 |
| Bulgaria | 2.7 | 39.2 | 2.6 | 2.6 | 54.6 | 52.6 |
| Estonia | 35.3 | 39.2 | 36.2 | 36.6 | 54.9 | 59 |
| France | 39 | 40.9 | 40.4 | 41.2 | 54.5 | 55.8 |
| Germany | 42.4 | 41.4 | 45.1 | 46.7 | 58.1 | 63.1 |
| India | 11.9 | 12.7 | 12.4 | 12.7 | 22.5 | 37 |
| Mexico | 15.7 | 14.8 | 16.7 | 17.2 | 28.9 | 53.7 |
| Romania | 3.3 | 35.3 | 3.2 | 3.2 | 52.2 | 58 |
| United Kingdom | 34.8 | 35.9 | 36.2 | 36.9 | 47.1 | 53 |

### *2.1. Current State of Digital Exclusion*

According to Gallistl et al. (2020), digital devices, such as mobile phones, tablets, and computers, have become an important part of everyone's lives, even the elderly [14]. Even though internet access has increased due to the easy availability and mass production of these devices, recent studies reveal that research gaps still exist for different age groups [6,15,16]. Previous studies have identified numerous factors that impact elderly people's internet usage, while initiatives to improve online access have received less attention [6].

Regardless of the growing adoption of Information and Communication Technologies (ICT), digital inclusion among the elderly remains a key issue [7]. A study conducted by Gale et al. (2018) shows that the digital divide among older people can contribute to poor health conditions and greater social isolation [17]. According to the UNFPA (2017) aging report, the depression rate in older adults is increasing drastically, and about 2.90 million senior citizens may experience depression by 2030. The pie chart shown in Figure 2 depicts the global internet users based on different age groups as of February 2024 [18].

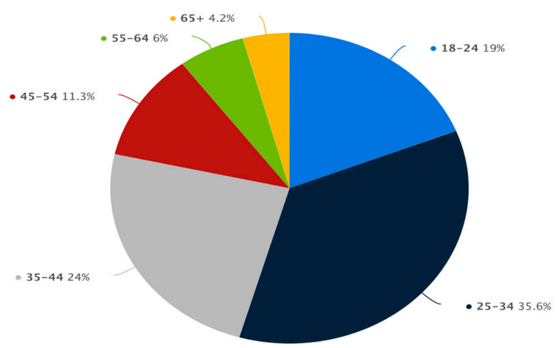


**Figure 2.** Distribution of internet users worldwide as of February 2024 by age group [18].

The older age groups (45–54, 55–64, 65+) have a significantly lower rate of internet users (about <10%) compared to younger age groups. This variation suggests the urgent need for initiatives to support elderly people to be digitally included.

As per the survey conducted by ONS (2020), only 67% of individuals aged over 65 use the internet every day in the UK, while approximately 18% of the elderly people have not used the internet in the last 90 days [19]. The percentage of Facebook users in France ranges between 10 and 11% for the age groups 55–64 and 65+, respectively [20]. Similarly, a research study conducted by the Brazilian Institute of Geography and Statistics suggests that only 45% of senior citizens use the internet regularly [21].

### 2.2. Factors Influencing the Digital Divide

The term "grey digital divide" refers to the digital gap experienced by the elderly due to issues like socio-economic inequities, resource availability, disabilities, and other factors [7]. According to Lythreatis et al. (2022), several reasons lead to digital exclusion among the elderly [3], which may be categorized into three categories: individual, societal, and environmental factors. Table 2 provides an overview of the factors that affect digital exclusion in older people.

**Table 2.** Factors affecting digital divide among elderly.

| Factors | Theoretical Framework | Findings | References |
|---|---|---|---|
| Personal Factors | | | |
| Socio-economic Status | It indicates the social and financial well-being of a person (The Digital Divide Theory) | Individuals with high-income can buy digital gadgets and high-speed internet plans. The difference in income affects the digital adoption rates. | [10,22,23] |
| Level of Education | Refers to the highest level of education completed by an individual, which influences digital usage (Unified Theory of Acceptance and use of Technology) | Older people with higher educational qualifications use digital technologies more efficiently. | [9,24,25] |
| Disabilities | It describes the physical as well as mental ability of a person to use technology (Ecological Systems Theory) | The level of disability among older people has an impact on digital media utilization. | [26–28] |
| Environmental Factors | | | |
| Geographical Location | It refers to the location of a person, such as urban or rural, which can impact on how they use technology (Ecological Systems Theory) | Digital exclusion varies by location, and people from rural areas have less digital proficiency. | [24,28,29] |
| Access to Technologies | It indicates the user's accessibility to digital technologies (Ecological Systems Theory) | Availability of resources is a factor causing digital exclusion. | [28–30] |
| Social Factors | | | |
| Marital Status | Describes whether a person is married, widowed, single, or divorced, which affects social support (Ecological Systems Theory) | Marital status is the main factor defining digital exclusion. | [8,28,31] |
| Social Networks | Having supported social networks helps people in using technology (Ecological Systems Theory) | Elderly individuals with less social networks are more digitally isolated. | [28,32,33] |

### 2.3. Technological Challenges Faced by the Elderly

Many recent research studies have highlighted the challenges faced by the elderly in adopting digital technologies [8,32]. Table 3 lists the main challenges that elderly individuals face when using digital devices.

**Table 3.** Technological challenges faced by older people.

| Challenges | Findings | References |
|---|---|---|
| Lack of expertise | It can cause fear of breaking something or difficulty to follow instructions. | [4,8,32] |
| Privacy concerns | Privacy and security concerns for using digital technologies have a direct impact on digital exclusion. | [34,35] |
| Usability concerns | Designing user interfaces without considering the needs of older people introduces usability concerns. | [34,36] |
| Availability of resources | The availability of ICT devices like mobile phones, tablets, and computers and internet availability have an impact on digital exclusion rates. | [29,30] |

### 2.4. Initiatives to Reduce Digital Divide

The most relevant programs and initiatives conducted in HICs and LMICs to improve digital inclusion among the elderly are presented in Table 4.

**Table 4.** Digital literacy programs for elderly people.

| Country | Initiatives/Programs | Objective | Ref. |
|---|---|---|---|
| Austria | Digital Seniors | Encourage easier access to modern technologies for elderly | [37] |
| | A1 Senior Academy | Provides free courses to seniors to develop digital skills | [38] |
| Germany | Bildung und Lernen im Alter | Provide training and programs to promote digital inclusion among elderly | [39] |
| | The BOOMER project | Reduce digital gap by providing educational resources and courses | [40] |
| France | Digitruck | Provides basic digital skills | [41] |
| UK | One Digital | Provide training to candidates to provide support to elderly in higher digital exclusion areas | [42] |
| Bulgaria and Romania | DIGITOL project | Provide tailored digital literacy for senior citizens | [43] |
| India | Agewell Digital Literacy Program | Conduct digital literacy programs for senior citizens in Delhi | [44] |
| Brazil | MediaWise for Seniors | Improve digital skills among older adults | [45] |
| Mexico | Digital Literacy for Adults and Older Adults | Provide digital media classes for older people | [46] |

Table 4 illustrates that both HICs and LMICs have implemented several initiatives and programs to increase digital inclusion among the elderly, although current research indicates that digital exclusion remains pervasive. The above discussion highlights that while many older people in HICs are using digital technologies, a portion of the population remains digitally excluded. Even though many training programs and seminars are being implemented to increase the digital proficiency of the elderly, a digital gap is still present in those countries [33].

### 2.5. Previous Research Studies

Several studies have been conducted with the intent to reduce the digital divide among older people, and some of the relevant studies are listed in Table 5.

**Table 5.** Previous research studies.

| Factors Contributing to Digital Exclusion | Research Objective | Methodology Used | Results | Limitations | Ref. |
|---|---|---|---|---|---|
| Socio-economic and Functional Dependence | Examine the relationship between digital exclusion and functional dependence | Longitudinal analysis of 23 countries using data from five cohorts, including the UK, USA, Mexico, China, and 19 European countries | - Digital exclusion is linked to functional dependence<br>- There is a considerable variation in digital exclusion among HICs and LMICs | - Considered only 2 countries from LMIC category.<br>- All countries taken from SHARE dataset were under HIC category, which limits the understanding of how digital exclusion varies between HICs and LMICs in Europe | [8] |
| Digital Skills and Literacy | Find the current status of digital exclusion among elderly in Korea | Statistical analysis using Korea Information Society Agency report from 2017 to 2022 | Digital divide is mainly caused by the lack of skills needed to install and use digital devices | - Focused solely on data from Korean data.<br>- Psychological and social factors was not considered | [47] |

**Table 5.** *Cont.*

| Factors Contributing to Digital Exclusion | Research Objective | Methodology Used | Results | Limitations | Ref. |
|---|---|---|---|---|---|
| Cultural and Psychological Constraints | Identify the causes of digital exclusion among elderly people in Poland | Conducting interviews with 30 respondents in Poland who are not from older age group | Fear of digital gadgets, new features, learning mindsets, and economic issues contribute to digital exclusion. | - Small sample size was used for study<br>- Respondents were not chosen from older age groups | [4] |
| Access to Technologies | Identify and analyze the main factors contributing to digital exclusion | Systematic review of 50 articles | - Identified nine factors that cause digital exclusion<br>- Digital revolution has not provided equal access to everyone | - Results may be biased if they are based solely on past research | [3] |
| Social Relationships, Quality of Life | Analyze digital exclusion among elderly | Literature review using articles from the recent five years | Regardless of the adoption of ICT, elderly people still face digital exclusion | - Lacks quantitative data analysis<br>- Limitations with the scope of study due to COVID-19 | [7] |
| Technological Engagements | Examine the technological practices of elderly digital non-users | Qualitative analysis of 15 interviews | Older people who identified themselves as a "non-user" were discovered to be using digital devices in varied ways | - Mainly relies on qualitative data, which limits the generalization of the results<br>- The findings are not transferable due to the limitations of the scope | [6] |
| Peer Influences | Analyze the effect of peer influences on digital use among elderly | Regression model with survey data from China | Older people are more likely to use internet with peer influences | - Considered only the social media data from China<br>- Factors like resource availability were not considered | [48] |
| Digital Health usage Patterns | Examine the health usage habits among elderly in Hungary | Survey | Older people are highly interested in using digital healthcare | - Focused only on Hungary | [49] |
| Artificial Intelligence enabled Digital Transformation | Analyze AI-enabled healthcare transformation among elderly | Comprehensive review of 63 articles | AI helps the elderly in receiving better healthcare | - Ethical and privacy concerns | [50] |
| Healthcare Efficiency | Analyze impact of digital transformation on healthcare quality | Systematic review | Digital technologies can improve the quality and operational efficiency of healthcare | - Relies completely on existing research | [51] |

The literature review revealed that the impact of digital exclusion on the elderly is a growing concern that needs to be addressed. It was able to highlight the digital divide faced by elderly people, with many of the older adults struggling to develop the skills and expertise needed to use digital devices. Various factors, including restricted access to technology, lack of digital skills, and financial difficulties, are contributing to the digital exclusion of the elderly. Digital exclusion has a significant impact on the quality of life of older adults, which limits their access to services, social interaction opportunities, and participation in the digital world. The literature review revealed the need for more research in this area to understand the challenges faced by older people in different age groups.

Despite several research works conducted in this field, there is currently no accepted method for measuring digital exclusion since the datasets utilized in statistical analysis are inconsistent. Ensuring consistency in datasets will enable more accurate analysis and help to find how digital exclusion affects the daily lives of older people. In this research, the digitally excluded people were selected based on criteria such as the frequency of using the internet and other digital devices by the elderly people considered and their engagement in online activities. Furthermore, the most commonly available variables from these five datasets were chosen to ensure consistency between datasets. PCA will be used to identify the major factors influencing digital exclusion, while one-way and two-way ANOVA will be used to measure the variations of digital exclusion among different countries. This provides more detailed and consistent measures of digital exclusion and makes the result comparable.

Many research studies have discussed the variations in digital exclusion between HICs and LMICs, and it is also important to understand how digital inclusion develops and impacts elderly people over time. As per the discussion in previous sections, this study will articulate the following hypotheses to solve the following research questions:

- H1: There is a significant percentage of elderly people who lack the skills to use computers, smartphones, and digital tools.
- H2: Less access to digital devices and the internet, as well as lower education levels, are significantly associated with higher rates of digital exclusion among the elderly.
- H3: Digital exclusion is influenced by cultural settings, and the digital exclusion rate is higher in LMICs compared to HICs.

## 3. Research Strategy

The research methodology consists of a literature analysis, a quantitative analysis of digital usage statistics among the elderly, and a review of the generated results. Each of these strategies is covered in detail here. Figure 3 illustrates the step-by-step research process used in this work.

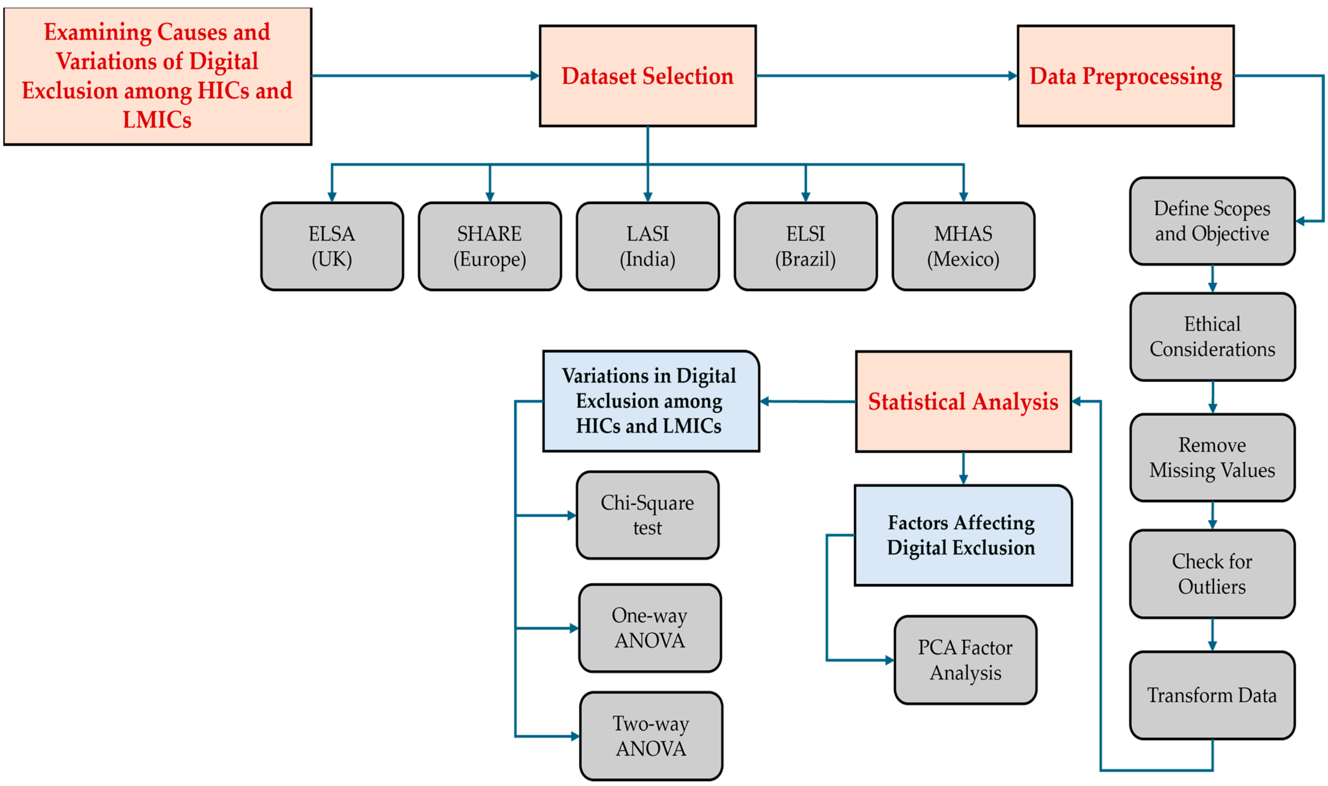


**Figure 3.** Research Process.

### *3.1. Data Collection*

This process involves a comprehensive analysis of data from five different cohorts including SHARE, ELSA, LASI, ELSI, and MHAS. These selected data sources cover the details of digital usage of elderly people in both High-Income Countries (HICs) and Lower Middle-Income Countries (LMICs). This study covered ten countries, five from each category (HICs and LMICs) specified by FCDO [52]. The five HICs considered for this investigation were four from SHARE (Austria, Germany, France, and Estonia) and one from ELSA (UK). The LMICs considered for this study are SHARE (Bulgaria and Romania), LASI (India), ELSI (Brazil), and MHAS (Mexico). These LMICs are located throughout Europe, Asia and America.

The research design applied in the study is quantitative, supported by qualitative insights derived from the literature review. Even though this study has no qualitative data collection methods, the literature review helps to outline the key patterns, trends, and findings of the previous studies by providing a better understanding of the quantitative results. The research methodology allows for a comprehensive understanding of the patterns, trends, and causes that lead to digital exclusion among older people from various countries and cultures.

### *3.2. Type of Research Design*

The research design uses both cross-sectional, longitudinal and comparative analysis. The cross-sectional dataset from five different cohorts (ELSA, SHARE, ELSI, LASI, and MHAS) were examined to find out the present state of digital exclusion among the elderly population. In addition, the comparative analysis is conducted to find the patterns and trends in the digital exclusion among different countries and cultures. The longitudinal data was used to analyze how digital exclusion changes over time. Although this study mainly focused on the comparison of digital exclusion between HICs vs. LMICs, it has also explored the main factors that mediated these differences. This study will look at the primary factors that contribute to digital exclusion in various economic settings, such as socioeconomic level, age, education, health, marital status, and others. This study will not only compare the differences between HICs vs. LMICs but will also attempt to determine what is causing these differences. This research will help in recognizing how digital inclusion might be improved globally by mediating these differences.

For conducting a comprehensive literature review, the following steps were taken:

- Research journals, databases, academic sources and organizational websites, and newspapers were utilized to get the relevant information needed for the research. The Leeds Beckett Online Library, Google Scholar, PubMed, and SCOPUS were mainly considered to identify the research papers.
- The terms like "digital exclusion of the elderly", "digital divide", "older people digital needs", "digital literacy among older adults" were used to search and identify the relevant knowledge.
- The initiatives to reduce digital exclusion in each country was identified through Google search and collecting details from the respective websites.
- The statistical data from government organizations such as Office for National Statistics were collected for providing insights.

### *3.3. Quantitative Analysis*

#### 3.3.1. Data Collection and Transformation

Several factors were considered, and an individual level analysis was performed in this investigation. These variables included age, gender, level of education, marital status, health issues (such as diabetes, hypertension, heart difficulties, lung issues, and malignancies), psychological well-being, family dynamics, and markers of digital activity. as owning a smartphone, accessing the internet, using digital media, and utilizing digital gadgets. The age factor was selected because it has an influence on the ability of people in using technologies [9]. Similarly, level of education has an influence on digital usage [9], and marital status impacts the social support [28]. Furthermore, health issues and psychological well-being can define how easily a person can use digital devices [28]. In addition, the socio-economic status has an impact on the access to the digital devices [10].

The secondary data collected from five cohorts were cleaned and transformed to analysis, and the data cleaning steps involved are given below:

- Some records lacked age information but had year-of-birth information available. So, using Microsoft Excel (v2403), the actual age was calculated based on the year of birth and the year of the interview.
- As the research focused on older adults aged 55 and above, details for those under 55 were omitted.
- Some records with missing gender fields were updated to 'Not known'.
- The null values for health issues (diabetes, high blood pressure, tumor, lungs, heart) were updated as 'NA'.
- The digitally excluded persons were identified by analyzing the different values from each dataset, such as internet, mobile, and social media usage.
- A new field, "digitally excluded", was created to represent people who had not used social media or the internet in over a month.
- After cleaning and transforming the dataset, the commonly available variables from these five datasets were merged.
- The records were then categorized according to different age groups (55–64, 65–74, and 75+) considering the age of each individual and a new field was given for representing the age group of each record. This was helpful to analyze the variations in digital exclusion between the different age groups.
- Finally, we introduced a new field to represent the country type (HICs and LMICs) and updated it according to the country.

### 3.3.2. Descriptive Statistics

Descriptive statistics were used for each country type (HICs vs. LMICs) to compare different variables between countries.

- The details of age (mean, median, and standard deviation (SD)); age groups (55–64, 65–74, 75+); gender (male and female); and fields like age preventing the performance of actions, usually feel left out/lonely, feel lack of control, feel stressed/anxious, completed high school, living with partner, widowed, area lived (rural area or village, town, a big city/the suburbs or outskirts of big city, nursing home or care facility), reported poor health rating, health issues (diabetes, hypertension, tumor, lungs, heart), sight impaired, attended training courses within last 12 months, and digital exclusion rate was added in the descriptive statistics for each country.
- The descriptive analysis included factors such as health, education, family situation, wealth, and psychological well-being.
- The details for the area lived: a big city/the suburbs or outskirts of a big city was not available from the datasets for the UK, India, Brazil, and Mexico. Therefore, it is recorded as blank.
- Similarly, the details of attended training courses within the last 12 months are not recorded for India and Mexico since it was not available from the datasets.

### 3.3.3. Primary Factors Affecting Digital Exclusion

The PCA factor analysis was performed to identify the primary factors contributing to digital exclusion, and the following steps were taken to do PCA using an SPSS Statistics tool.

- All the available variables were taken for factor analysis, and the PCA analysis was conducted with the 'factor' option under Analyze > component reduction in SPSS.
- From the 'Descriptives' tab, KMO and Bartlett's test of sphericity was chosen; we selected 'Principal components' as the extraction method, chose a correlation matrix

for analysis, and selected scree plots, and extraction was performed based on an Eigenvalue > 1.
- The 'Promax' method was chosen for rotation, and the coefficients less than 0.3 were suppressed.
- The variables having commonalities of less than 0.3 were removed from factor analysis to focus on the variables which are more related to the underlying factors and to obtain clear and meaningful results.

### 3.4. Comparative Analysis

Several comparative analyses were performed in this study to measure a combination of multiple factors using SPSS as follows:

- Variations in digital exclusion.
- Variations in life satisfaction among digitally excluded people.
- Impact of health rating by the interaction of digital exclusion and country type.

## 4. Results and Discussion

### 4.1. Statistical Summary

The HICs and LMICs were analyzed separately to determine the differences in digital exclusion. The mean age of HICs and LMICs ranged between 66 and 74, and that for SD was between 8 and 10. The selected variables from these datasets included factors such as health, education, family situation, wealth, and psychological well-being.

#### 4.1.1. HICs

The High-Income Countries selected for this study are from Europe, as shown in Table 6. HICs have an average age of 69 to 74, with a standard deviation of 8 to 10. The female respondents were higher when compared to male respondents in HICs. The age group 55–64 has more respondents from the UK (33.3), with the fewest respondents being from Austria (15.0). The age group 65–74 obtained the highest response rate from France (40.0) and the lowest from Germany (23.1). And when considering the 75+ age group, Austria (43.3) provided the highest response rate and Estonia (21.0) obtained the lowest.

**Table 6.** Descriptive statistics of HICs (source: Austria, Germany, France, and Estonia (SHARE, 2022); UK (ELSA, 2024)).

| | **Austria N = 2821** | **Germany N = 3138** | **France N = 2726** | **Estonia N = 4539** | **United Kingdom N = 6821** |
|---|---|---|---|---|---|
| Age Median (Q1–Q3), Mean, Standard Deviation | 74 (55–102)<br>74<br>8 | 71 (55–99)<br>71<br>9 | 72 (55–104)<br>72<br>10 | 72 (55–101)<br>72<br>10 | 69 (55–89)<br>69<br>9 |
| Age group 55–64 | 411<br>(15.0) | 548<br>(17.5) | 532<br>(20.0) | 1090<br>(24.0) | 2276<br>(33.4) |
| Age group 65–74 | 992<br>(35.2) | 813<br>(26.0) | 1080<br>(40.0) | 1548<br>(34.1) | 2617<br>(38.4) |
| Age group 75+ | 1207<br>(43.0) | 653<br>(21.0) | 999<br>(37.0) | 891<br>(20.0) | 1928<br>(28.3) |
| Gender: Male | 1115<br>(40.0) | 931<br>(30.0) | 1086<br>(40.0) | 1691<br>(37.3) | 3097<br>(45.4) |
| Gender: Female | 1653<br>(59.0) | 1083<br>(35.0) | 1525<br>(56.0) | 2838<br>(63.0) | 3734<br>(55.0) |
| Age preventing performance of actions | 208<br>(7.4) | 351<br>(11.2) | 361<br>(13.2) | 704<br>(16.0) | 791<br>(12.0) |

**Table 6.** *Cont.*

| | Austria N = 2821 | Germany N = 3138 | France N = 2726 | Estonia N = 4539 | United Kingdom N = 6821 |
|---|---|---|---|---|---|
| Usually feel left out/lonely | 17 (1.0) | 65 (2.1) | 136 (5.0) | 194 (4.3) | 304 (5.0) |
| Mostly feel lack of control | 77 (3.0) | 248 (8.0) | 187 (7.0) | 335 (7.4) | 423 (6.2) |
| Feel stressed/anxious | 63 (2.2) | 232 (7.4) | 113 (4.1) | 91 (2.0) | 617 (9.0) |
| Completed high school | 20 (1.0) | 39 (1.2) | 16 (1.0) | 23 (1.0) | 31 (1.0) |
| Living with partner | 30 (1.1) | 96 (3.1) | 53 (2.0) | 47 (1.0) | 4239 (62.1) |
| Widowed | 56 (2.0) | 95 (3.0) | 68 (2.5) | 157 (4.0) | 1560 (22.9) |
| Area lived: Rural area or village | 89 (3.2) | 1023 (33.0) | 1179 (43.3) | 935 (21.0) | 1500 (22.0) |
| Area lived: town | 33 (1.2) | 1051 (33.5) | 932 (34.2) | 1164 (26.0) | 1227 (18.0) |
| Area lived: A big city/the suburbs or outskirts of big city | 60 (2.1) | 705 (22.5) | 298 (11.0) | 642 (14.1) | |
| Living in nursing home/care facility | 31 (1.1) | 43 (1.4) | 41 (2.0) | 29 (1.0) | 29 (0.4) |
| Health rating—poor | 184 (7.0) | 164 (5.2) | 172 (6.3) | 696 (15.3) | 532 (8.0) |
| Health Issues—Diabetes | 352 (12.5) | 357 (11.4) | 253 (9.3) | 653 (14.4) | 884 (13.0) |
| Health Issues—Hypertension | 1103 (39.1) | 973 (31.0) | 719 (26.4) | 2199 (48.4) | 2666 (39.1) |
| Health Issues—Heart problems | 409 (14.5) | 303 (10.0) | 272 (10.0) | 948 (21.0) | 378 (6.0) |
| Health issues—Lungs | 195 (7.0) | 208 (7.0) | 125 (5.0) | 299 (7.0) | 449 (7.0) |
| Health issues—Tumor | 120 (4.3) | 184 (6.0) | 101 (4.0) | 236 (5.2) | 1017 (15.0) |
| Sight impaired | 31 (1.1) | 49 (1.6) | 62 (2.3) | 167 (3.7) | 50 (1.0) |
| Attended training courses within last 12 months | 179 (6.3) | 392 (12.5) | 207 (8.0) | 364 (8.0) | 359 (5.3) |
| Shortage of money | 113 (4.0) | 253 (8.1) | 393 (14.4) | 605 (13.3) | 256 (4.0) |
| Digitally excluded | 619 (22.0) | 875 (28.0) | 848 (31.1) | 1452 (32.0) | 724 (11.0) |

The rate of digital exclusion in HICs ranged below 35%, with Estonia having the most (32.0%) and the UK having the least (11%) digitally excluded older adults. In contrast to other nations, the UK experienced a significant decrease in the percentage of digitally excluded individuals despite slight differences in this category in Austria, Germany, France, and Estonia. Even though all the countries were chosen from Europe, the UK had surprisingly few digitally excluded cases compared to other countries.

#### 4.1.2. LMICs

The Lower Middle-Income Countries chosen for this study include two countries from Europe (Bulgaria and Romania), two countries from America (Brazil and Mexico), and one from Asia (India), as illustrated in Table 7. The mean age of LMICs was between 66 to 70 with a SD ranging between 8 and 10, and the female respondents were higher when compared to male respondents in LMICs. The age group 55–64 has the highest respondent rate in Mexico (51.4), and the lowest is from Bulgaria (20.0). Romania had the highest rate of responders in the 65–74 age group (40.0), followed by Bulgaria (26.0). Among those aged 75 and up, Brazil (25.1%) had the highest rate of respondents, while India (16.4) had the lowest.

**Table 7.** Descriptive statistics of LMICs (source: Bulgaria and Romania (SHARE, 2022); Brazil (ELSI, 2023); India (LASI, 2023); Mexico (MHAS, 2021)).

| | Bulgaria N = 1012 | Romania N = 1582 | Brazil N = 9045 | India N = 42,083 | Mexico N = 10,016 |
|---|---|---|---|---|---|
| Age Median (Q1–Q3), Mean, Standard Deviation | 70 (55–100) 70 9 | 68 (55–98) 69 9 | 66 (55–109) 68 10 | 65 (55–116) 66 8 | 64 (55–105) 66 9 |
| Age group 55–64 | 201 (20.0) | 514 (32.5) | 3850 (43.0) | 20437 (49.0) | 5144 (51.4) |
| Age group 65–74 | 263 (26.0) | 625 (40.0) | 2928 (32.4) | 14763 (35.1) | 3141 (31.4) |
| Age group 75+ | 217 (21.4) | 392 (25.0) | 2267 (25.1) | 6883 (16.4) | 1731 (17.3) |
| Gender: Male | 279 (28.0) | 672 (42.5) | 4952 (55.0) | 19908 (47.3) | 4660 (47.0) |
| Gender: Female | 402 (40.0 | 859 (54.3) | 4093 (45.3) | 22175 (53.0) | 5356 (53.5) |
| Age preventing performance of actions | 197 (19.4) | 344 (22.0) | 1081 (12.0) | 9790 (23.3) | 3580 (36.0) |
| usually feel left out/lonely | 98 (10.0) | 88 (6.0) | 848 (9.4) | 5263 (13.0) | 3307 (33.0) |
| Mostly feel lack of control | 137 (14.0) | 163 (10.3) | 613 (7.0) | 8621 (20.5) | 3595 (36.0) |
| Feel stressed/anxious | 47 (5.0) | 79 (5.0) | 721 (8.0) | 731 (2.0) | 3649 (36.4) |
| Completed high school | 265 (26.2) | 342 (22.0) | 238 (3.0) | 3330 (8.0) | 158 (2.0) |
| Living with spouse | 534 (53.0) | 851 (54.0) | 4785 (53.0) | 28438 (68.0) | 6227 (62.2) |
| Widowed | 265 (26.2) | 280 (18.0) | 1097 (12.1) | 12373 (29.4) | 2313 (23.1) |
| Area lived: Rural area or village | 417 (41.2) | 859 (54.3) | 1492 (16.5) | 27724 (66.0) | 2811 (28.1) |
| Area lived: town | 263 (26.0) | 264 (17.0) | 7553 (84.0) | 14359 (34.1) | 7205 (72.0) |
| Health rating—poor | 78 (8.0) | 243 (15.4) | 1515 (17.0) | 5208 (12.4) | 1730 (17.3) |
| Health Issues—Diabetes | 132 (13.0) | 220 (14.0) | 900 (10.0) | 5197 (12.3) | 1406 (14.0) |
| Health Issues—Hypertension | 416 (41.1) | 720 (46.0) | 2064 (23.0) | 10662 (25.3) | 2917 (29.1) |
| Health Issues—Heart problems | 186 (18.4) | 289 (18.3) | 393 (4.3) | 1446 (3.4) | 276 (3.0) |

**Table 7.** *Cont.*

| | Bulgaria N = 1012 | Romania N = 1582 | Brazil N = 9045 | India N = 42,083 | Mexico N = 10,016 |
|---|---|---|---|---|---|
| Health Issues—Lungs | 83 (8.2) | 55 (3.5) | 301 (3.3) | 1031 (2.4) | 316 (3.2) |
| Health Issues—Tumor | 41 (4.1) | 37 (2.3) | 391 (4.3) | 81 (0.2) | 43 (0.4) |
| Sight impaired | 22 (2.1) | 60 (3.7) | 1574 (17.4) | 7723 (18.4) | 1047 (10.5) |
| Attended training courses within last 12 months | 9 (1.0) | 8 (1.0) | 21 (0.2) | | |
| Currently working | 333 (33.0) | 574 (36.3) | | 16750 (40.0) | 3863 (39.0) |
| Shortage of money | 271 (27.0) | 421 (27.0) | 1823 (20.2) | 7448 (18.0) | 104 (1.0) |
| Digitally excluded | 689 (68.1) | 939 (59.4) | 4256 (47.0) | 38321 (91.1) | 3290 (33.0) |

Compared to HICs, the LMICs had more digitally excluded cases, with most having more than 45% of their population digitally excluded, except for Mexico. Mexico had the lowest rate (33%), while India had the highest (91%). It was surprising to see that Mexico showed the lowest rate in the elderly population who are digitally excluded, which is comparable to HICs. The two LMICs chosen from Europe (Bulgaria and Romania) showed a slight variation in the digital exclusion rate, and the countries chosen from America (Brazil and Mexico) showed a slightly different variation in the exclusion rate. It was unbelievable that in India, most of the older population is digitally excluded even though it is an LMIC, and it showed a rapid growth in digital exclusion rate when compared to other countries in this category.

### *4.2. RQ1: What Is the Current State of Digital Exclusion among the Elderly, Particularly in Terms of Competency with Devices Such as Computers, Smartphones, and Other Digital Tools?*

Understanding the extent of digital exclusion among the elderly will assist in designing strategies for promoting digital inclusion. This investigation aims to explore the digital exclusion among the elderly by analyzing datasets from SHARE, ELSA, MHAS, ELSI, and LASI. Using various charts and graphs, we may gain detailed insights into internet usage trends, device ownership, and variation in digital media usage across HICs and LMICs.

#### 4.2.1. Internet Usage vs. Internet Connection

The bar graph shown in Figure 4 describes internet usage based on the availability of internet connection. The graph clearly shows that elderly people who have an internet connection at home use the internet daily; however, there is very little chance of using the internet if the connection is not present. This suggests that the availability of resources could be a factor influencing digital exclusion among the elderly.

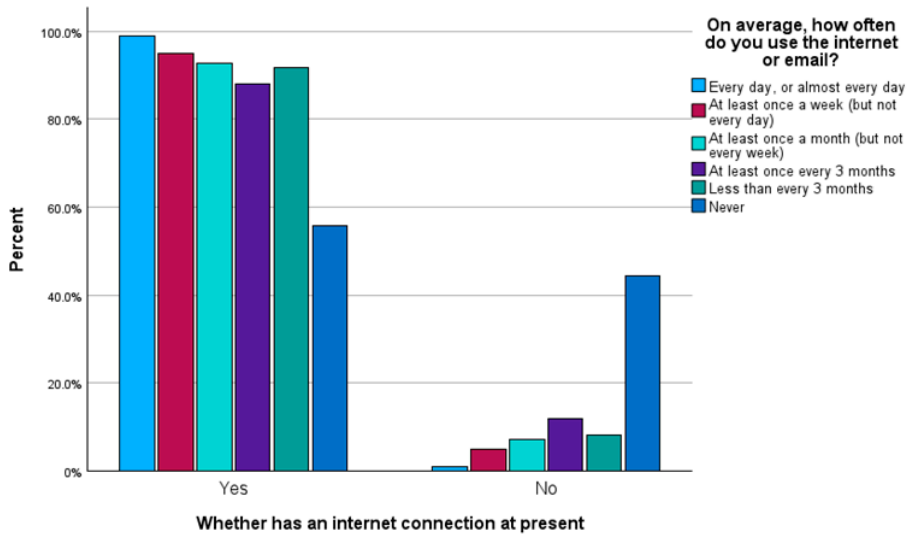


**Figure 4.** Internet usage vs. internet connection.

### 4.2.2. Device Ownership vs. Internet Use

Figure 5 illustrates a bar chart of internet usage based on mobile phone ownership. It is evident that there is very little chance of using the internet if elderly people do not have a mobile phone. Although there are a few older people who do not use the internet despite having a cell phone, fewer than half of the population does. A lack of resources may contribute to digital exclusion among the elderly.

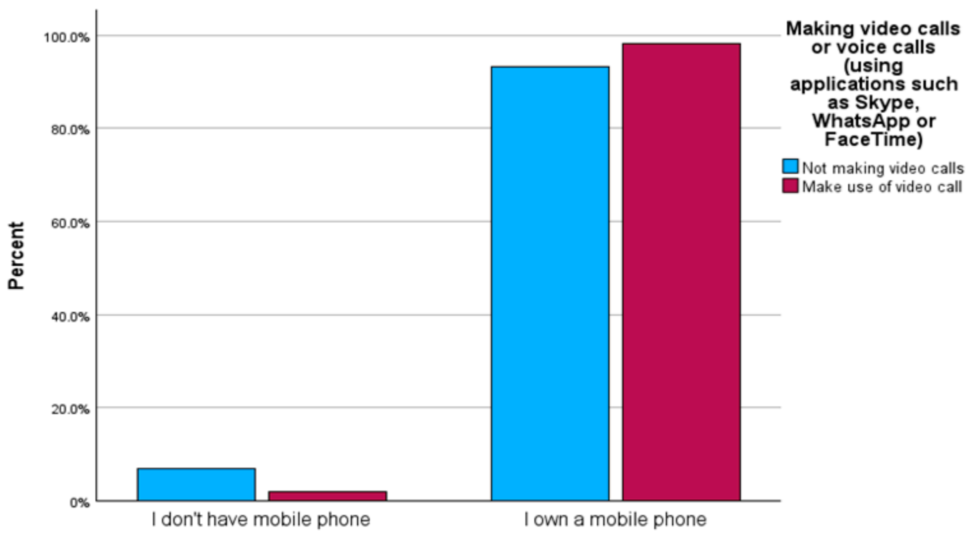


**Figure 5.** Device ownership vs. internet use.

### 4.2.3. Digital Exclusion vs. Age

Figure 6 shows the scatter plot, which highlights the digitally included and excluded elderly based on age, with HICs and LMICs countries not separated. The scatter plot clearly shows that the number of persons who are digitally excluded is slightly lower than the number of people who are digitally included, and this pattern continues throughout age groups. It is important to mention that the majority of digitally excluded people are observed between the ages of 60 and 70, with the number decreasing exponentially as age increases.

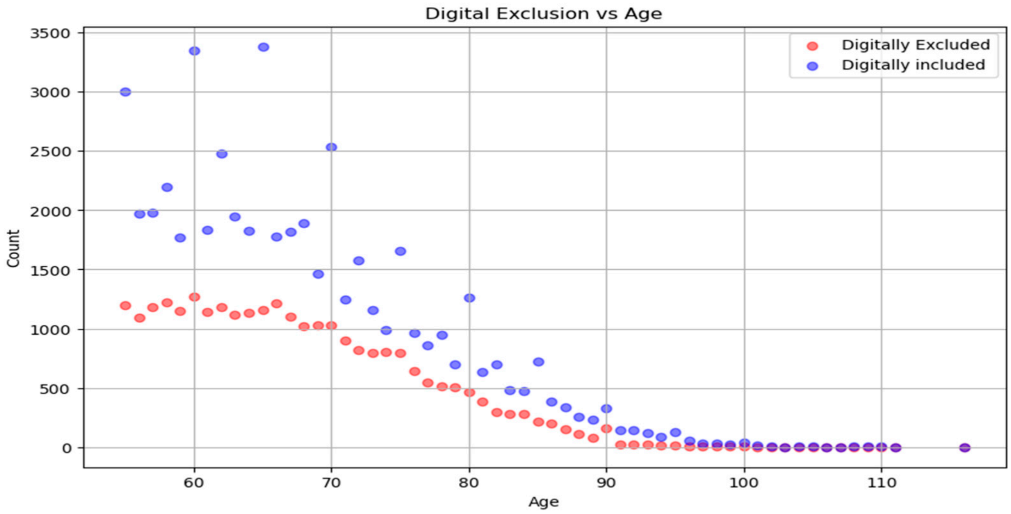


**Figure 6.** Digital exclusion vs. age.

#### 4.2.4. Digital Exclusion vs. Country Type

The graph shown in Figure 7 describes how digital exclusion varies according to age in HICs and LMICs. The digital exclusion rate is much lower in HICs when compared with LMICs, where most of the population is digitally excluded. However, individuals who are over 75 years of age were found to be mostly digitally excluded, regardless of the country type.

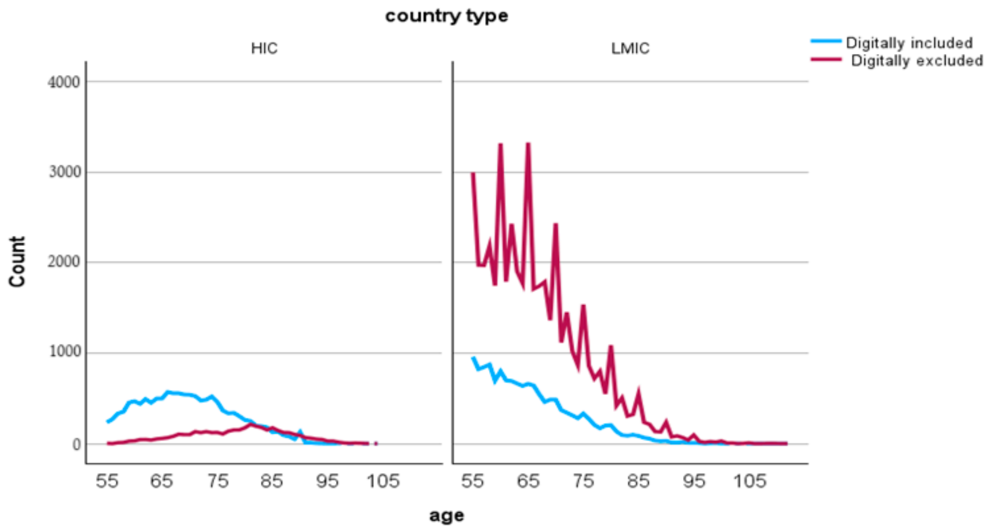


**Figure 7.** Digital exclusion vs. country type.

#### 4.2.5. Digital Exclusion vs. Country Type and Age Group

Figure 8 demonstrates the variation in digital exclusion across age groups in HICs and LMICs. While digital exclusion showed an increasing trend in HICs with higher age groups, the LMICs showed an opposite trend. Although there was a significant variation in digital inclusion rate in both country types, the age group 65–74 showed almost the same rates.

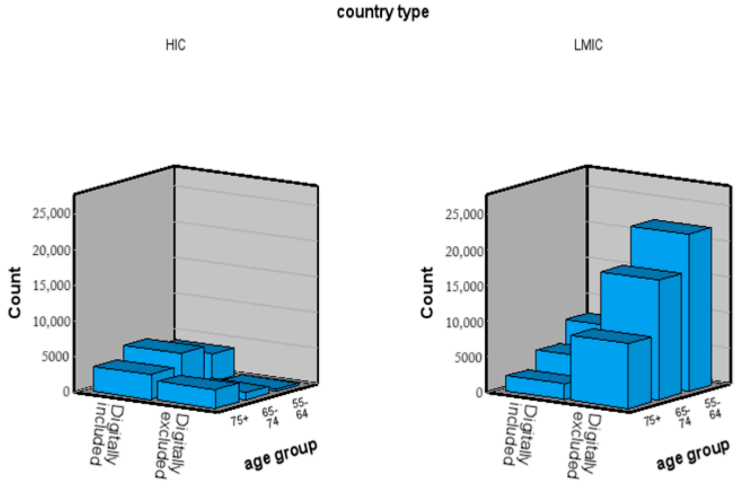


**Figure 8.** Digital exclusion vs. country type and age group.

#### 4.2.6. Digital Exclusion vs. Life Satisfaction

The box plot describes the life satisfaction of digitally excluded people across different country types, as depicted in Figure 9. In HICs, life satisfaction ranges from 2 to 10, and 25% of the digitally excluded population has reported a health rating of 6 or less, and the other quartile indicates 75% of the population has a health rating of 9 and below. In the case of LMIC, it has been observed that a certain amount of the population noted a life satisfaction of 2 or less, but 25% of people have similar life satisfaction to HICs, and 50% and 75% of the population in LMICs are less satisfied with their life compared to HIC.

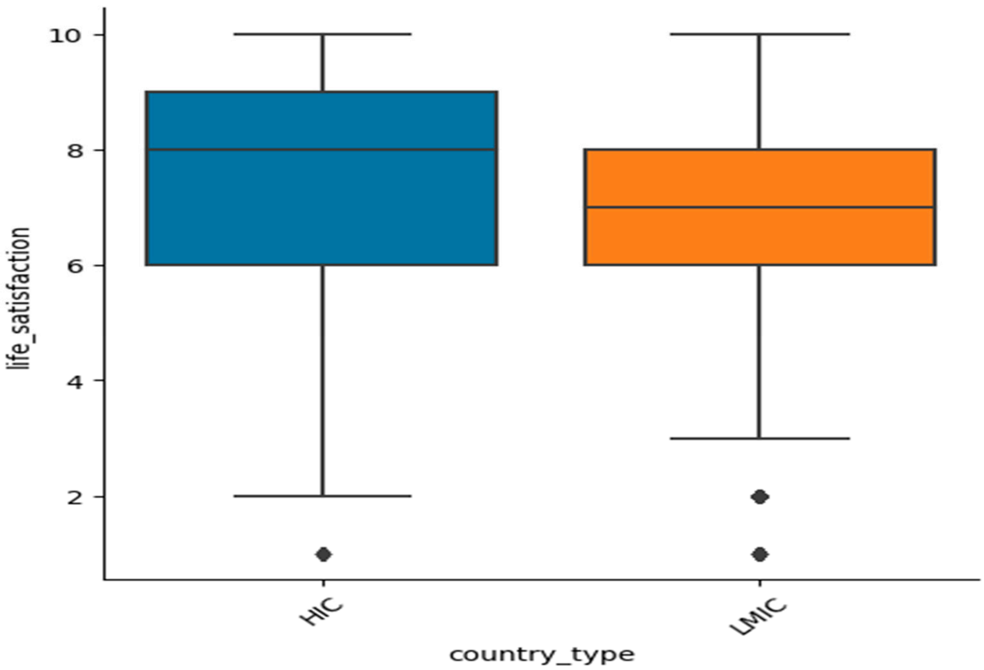


**Figure 9.** Digital exclusion vs. life satisfaction.

### *4.3. RQ2: What Are the Primary Factors Affecting the Digital Divide among the Elderly People, and How These Factors Can Ensure Sustainable Digital Inclusion among the Elderly?*

To understand the factors affecting the digital divide among the elderly, the PCA factor analysis was conducted as it will help us to identify and reduce a large set of variables into primary factors.

#### 4.3.1. Factor Analysis Using PCA (Principal Component Analysis)

The factor analysis was conducted by selecting the commonly available variables from all these countries, and the correlation coefficients less than 0.3 were suppressed as it would not be a primary factor affecting the digital divide [53]. The factors chosen for analysis include life satisfaction; feeling left out from everyone; age preventing the performance of actions; feeling a lack of control in situations; educational qualifications; health ratings; health issues related to the heart, lungs, tumors, hypertension, and diabetes; age group; and country type. These variables include socio-economic, health, demographic, and psychological characteristics, which could impact the digital exclusion of the elderly. The Keiser–Meyer–Olkin Measure (KMO) and Bartlett's sphericity test were used to ensure that the factor analysis was adequate. The test results are shown in Table 8.

**Table 8.** KMO and Bartlett's test.

| **KMO and Bartlett's Test** | | |
|---|---|---|
| Kaiser–Meyer–Olkin Measure of Sampling Adequacy | | 0.541 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 80,283.671 |
| | df | 36 |
| | Sig. | <0.001 |

The KMO value ranges between 0.5 and 0.7, which indicates the moderate suitability of the variables for factor analysis. Bartlett's test checks whether the variables are significantly correlated for factor analysis [53]. Here, the chi-square statistics value is 80,283.671, with a significance level $< 0.001$. This value suggests there are significant relationships among these variables, which supports the decision for factor analysis [54].

#### 4.3.2. Total Variance

Table 9 explains the total variance of each component in factor analysis. The first three components altogether can explain 53.003% of the total variance and have the most significant variability in the dataset. While the remaining components also helped to understand the total variance, their impact will be less significant. This means that the first three components are the most important in determining the main patterns in the dataset, whereas the rest can be considered noisy data or less significant components [55].

**Table 9.** Total variance.

| **Total Variance Explained** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Component** | **Initial Eigenvalues** | | | **Extraction Sums of Squared Loadings** | | | **Rotation Sums of Squared Loadings** [a] |
| | **Total** | **% of Variance** | **Cumulative %** | **Total** | **% of Variance** | **Cumulative %** | **Total** |
| **1** | 1.935 | 21.498 | 21.498 | 1.935 | 21.498 | 21.498 | 1.892 |
| **2** | 1.477 | 16.410 | 37.908 | 1.477 | 16.410 | 37.908 | 1.525 |
| **3** | 1.359 | 15.095 | 53.003 | 1.359 | 15.095 | 53.003 | 1.374 |
| **4** | 0.908 | 10.087 | 63.090 | | | | |
| **5** | 0.824 | 9.160 | 72.250 | | | | |
| **6** | 0.819 | 9.101 | 81.351 | | | | |
| **7** | 0.711 | 7.905 | 89.257 | | | | |
| **8** | 0.633 | 7.029 | 96.286 | | | | |
| **9** | 0.334 | 3.714 | 100.000 | | | | |
| **Extraction Method: Principal Component Analysis.** | | | | | | | |

[a.] When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

#### 4.3.3. Scree Plot

The scree plot helps to determine the number of factors to be considered from these variables by identifying the most important variables [56]. The scree plot shows a number of factors on the x-axis and the eigenvalues on the y-axis [57].

Kaiser's criterion or rule of thumb can be used to determine how many factors should be retained. It explains that we can retain all the factors above an eigenvalue of one. The scree plot in Figure 10 reveals that there are three significant factors with eigenvalues exceeding 1. Retaining these three factors and eliminating the others allows us to conduct a focused and in-depth analysis of the dataset [58].

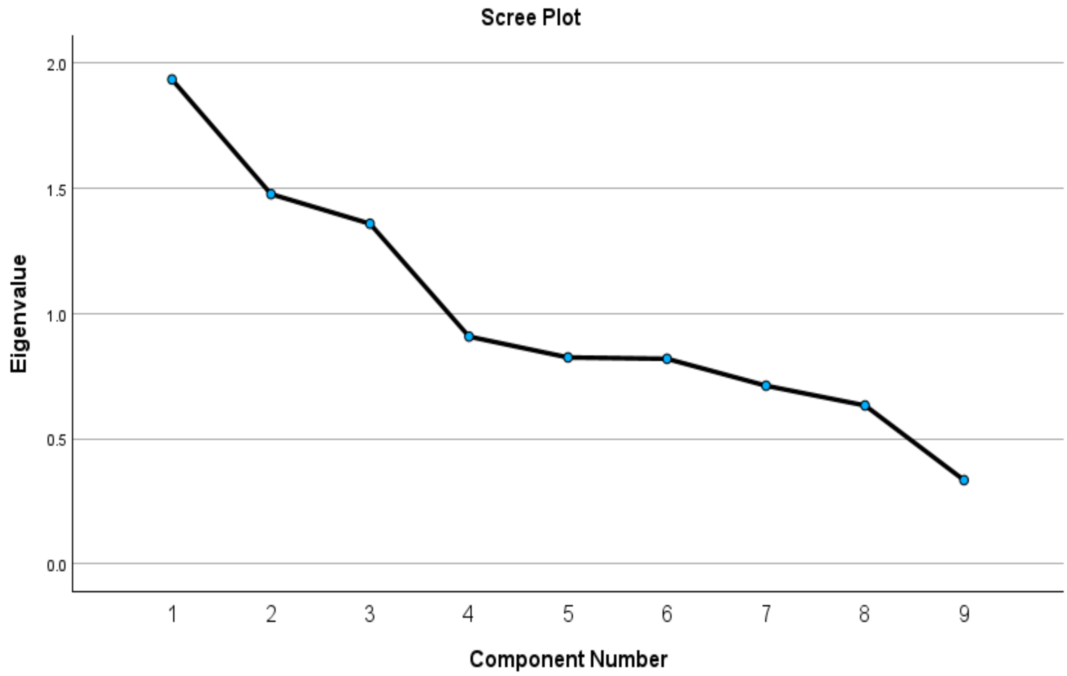


**Figure 10.** Scree plot.

#### 4.3.4. Component Matrices

Table 10 represents the component matrix, which shows the relationships between the variables and components extracted by PCA and displays the loadings of each variable on the principal components [59].

**Table 10.** Component matrix.

| Component Matrix [a] | | | |
|---|---|---|---|
| | Component | | |
| | 1 | 2 | 3 |
| **country_type** | −0.871 | | |
| **matrial_status** | 0.693 | | |
| **education** | 0.596 | −0.315 | |
| **health_issue_sugar** | | 0.615 | |
| **health_issue_bp** | 0.352 | 0.608 | |
| **health_rating** | | 0.607 | |
| **health_issue_heart** | 0.366 | 0.420 | |
| **out_of_control** | | | 0.813 |
| **age_prevents** | | | 0.764 |
| **Extraction Method: Principal Component Analysis.** | | | |

[a.] 3 components extracted.

Furthermore, Table 11 describes the pattern matrix, which helps identify the influence of these variables in each principal component and interpret the results more easily [60].

**Table 11.** Pattern matrix.

| Pattern Matrix [a] | | | |
|---|---|---|---|
| | Component | | |
| | 1 | 2 | 3 |
| **country_type** | −0.889 | | |
| **matrial_status** | 0.709 | | |
| **education** | 0.656 | | |
| **health_issue_bp** | | 0.695 | |
| **health_issue_sugar** | | 0.646 | |
| **health_rating** | | 0.551 | |
| **health_issue_heart** | | 0.520 | |
| **out_of_control** | | | 0.825 |
| **age_prevents** | | | 0.794 |
| **Extraction Method: Principal Component Analysis.**<br>**Rotation Method: Promax with Kaiser Normalization.** | | | |

[a.] Rotation converged in 4 iterations.

Following the loadings in the pattern matrix, the variables "health_issue_bp" and "health_issue_heart", which had loadings of 0.352 and 0.366, respectively, were removed from component 1. Additionally, the variable "education", which had a loading of −0.315 in component 2, was eliminated. The component correlation matrix is shown in Table 12, which describes the correlation between the principal components obtained from Principal Component Analysis [61].

**Table 12.** Component correlation matrix.

| Component Correlation Matrix | | | |
|---|---|---|---|
| **Component** | **1** | **2** | **3** |
| **1** | 1.000 | 0.067 | 0.020 |
| **2** | 0.067 | 1.000 | 0.011 |
| **3** | 0.020 | 0.011 | 1.000 |
| **Extraction Method: Principal Component Analysis.**<br>**Rotation Method: Promax with Kaiser Normalization.** | | | |

### *4.4. Convergent and Discriminant Validity*

#### 4.4.1. Convergent Validity

High loadings of country type, marital status, and education on component 1 in the pattern matrix indicate its relationship to socio-economic status and demographic factors, and when these variables are averaged out, the result is more than 0.7, indicating convergent validity. Similarly, variables in components 2 and 3 have average values of 0.603 and 0.809, respectively. The correlation values are greater than 0.50, indicating strong convergent validity [62].

#### 4.4.2. Discriminant Validity

Table 12 shows that the correlation coefficients between components 1 and 2, 1 and 3, and 2 and 3 are 0.067, 0.020, and 0.011, respectively. The correlation coefficients among these components in the component correlation matrix are significantly low (<0.85). This indicates the existence of high variance between the variables of these components, which suggests good discriminant validity [62].

#### 4.4.3. Factors Affecting Digital Exclusion

Considering the component matrix and rotated component matrix, the following interpretations were made:

**Socio-economic Factors (Component 1):** The “marital status” as well as “education” has high loadings on component 1 with values of 0.709 and 0.656, respectively. Also, the “country type” has a strong negative loading on the same component with a value of -0.889. This suggests that socio-economic factors, such as education and marital status, play an important role in the digital exclusion of the elderly. Having higher levels of education, being married, and living in HICs may be related to a lower rate of digital exclusion among the elderly, most likely due to access to resources and social support.

**Health Issues (Component 2):** The pattern matrix indicates that the health-related variables like “hypertension”, “diabetes”, “health rating”, and “heart problems” have a higher loading on component 2 with values of 0.695, 0.646, 0.551, and 0.520, respectively. This component suggests that elderly people having health problems may experience an influence on their motivation to use digital devices, and higher levels of these health issues may be associated with an increase in digital exclusion among older adults.

**Age-related Limitations (Component 3):** The variables, such as “out of control” and “age prevents from doing things”, show higher loadings on component 3 with values of 0.825 and 0.794, respectively. This component suggests that age-related limitations and feelings of a lack of control can contribute to digital exclusion in the elderly. The social isolation, as well as the lack of control, may hinder the use of digital technologies among older people.

In summary, the digital exclusion of elderly people is influenced by the combination of many factors, such as socio-economic, health-related, and age-related factors. While there may be some other factors that contribute to the digital exclusion rate, these are the primary factors affecting digital exclusion irrespective of the country, region, culture, or income. These variables can have an impact on elderly people’s everyday lives by limiting their access to critical information and services, increasing the risk of social isolation, and lowering their overall quality of life.

### *4.5. RQ3: How Does Digital Exclusion Vary among Different Countries and Cultures, and Are There Any Variations in Digital Exclusion in High-Income Countries (HICs) and Lower Middle-Income Countries (LMICs)?*

Several cases were investigated to understand the variations of digital exclusion between HICs and LMICs, as discussed in the subsequent sections.

#### 4.5.1. Variations of Digital Exclusion between HICs and LMICs

Since digital exclusion and country type (HICs vs. LMICs) were categorical variables, Pearson’s chi-square test was chosen to analyze the variations between them. The result of the chi-square test is presented in Table 13.

**Table 13.** Chi-square test for variations in digital exclusion between HICs and LMICs.

| Chi-Square Tests | | | | | |
|---|---|---|---|---|---|
| | **Value** | **df** | **Asymptotic Significance (2-Sided)** | **Exact Sig. (2-Sided)** | **Exact Sig. (1-Sided)** |
| **Pearson Chi-Square** | 16,601.614 [a] | 1 | 0.000 | | |
| **Continuity Correction [b]** | 16,599.256 | 1 | 0.000 | | |
| **Likelihood Ratio** | 16,091.097 | 1 | 0.000 | | |
| **Fisher’s Exact Test** | | | | 0.000 | 0.000 |
| **Linear-by-Linear Association** | 16,601.405 | 1 | 0.000 | | |
| **No. of Valid Cases** | 79,241 | | | | |

[a] 0 cells (0.0%) have expected count of less than 5. The minimum expected count is 5771.70; [b] computed only for a $2 \times 2$ table.

The following are the major findings achieved through the chi-square test:

- Pearson's chi-square statistics are highly significant ($p < 0.001$), which indicates that there is a strong association between country type and digital exclusion [63].
- Continuity correction is a modification of the chi-square test for 2 × 2 contingency tables, and the *p*-value (<0.001) confirms the strong association found in chi-square tests.
- Likelihood ratio compares how well the observed data fit the null hypothesis to a model in which the variables are independent, and the *p*-value (<0.001) explains that the data fit the model better than the null hypothesis [64].
- Fisher's exact test is used for a small sample size, and it confirms that there is a strong association found in the above tests [65].
- Linear-by-linear association indicates the linear trend in the association between these variables, and the *p*-value is <0.001, indicating a significant linear trend in the association [66].

Furthermore, the bar chart in Figure 11 explains the linear relationship between digital exclusion and country type. There are more digitally excluded people in LMICs than in HICs, and the digital exclusion rate is very low in HICs when compared to the total respondents.

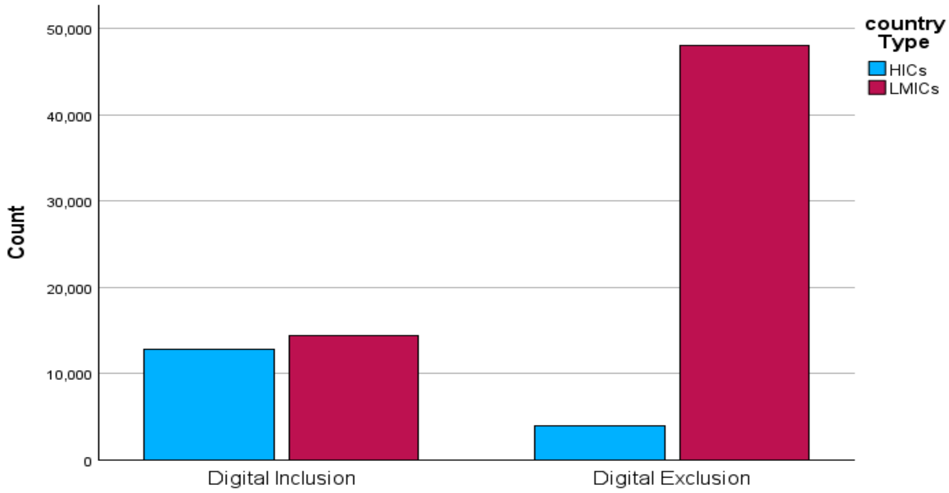


**Figure 11.** Trend in association of digital exclusion between HICs and LMICs.

The null hypothesis (Ho) was rejected because all the above tests suggest that there is a significant association in the variation of digital exclusion between HICs and LMICs.

4.5.2. Variation of Digital Exclusion between Different Age Groups in HICs and LMICs

Since there was a significant association between digital exclusion and country type (HICs vs. LMICs), the association between different age groups was also tested and presented in Table 14. Pearson's chi-square test was selected for analysis because the age groups (55–64, 65–74, 75+) and country types (HICs and LMICs) were categorical variables. Only digitally excluded people were considered for this test.

The following are the major findings achieved through the chi-square test:

- Pearson's chi-square statistics value of 4557.933 with a *p*-value (<0.001) suggests that there is a significant association between the age group and country types [63].
- The likelihood ratio also has a *p*-value (<0.001), which represents a highly significant association [64].
- The linear-by-linear association of chi-square statistics is 4000.725, which indicates there is a linear trend in the association between these variables [66].

**Table 14.** Chi-Square test for variations in digital exclusion between different age groups in HICs and LMICs.

| Chi-Square Tests | | | |
|---|---|---|---|
| | **Value** | **df** | **Asymptotic Significance (2-Sided)** |
| **Pearson's Chi-Square** | 4557.933 [a] | 2 | 0.000 |
| **Likelihood Ratio** | 4043.413 | 2 | 0.000 |
| **Linear-by-Linear Association** | 4000.725 | 1 | 0.000 |
| **No. of Valid Cases** | 51,102 | | |

[a] 0 cells (0.0%) have expected count of less than 5. The minimum expected count is 754.43.

In addition, the bar chart shown in Figure 12 explains the linear trend in the association of age group and country type. The count of digitally excluded people tends to increase with age groups in HICs, which suggests that older people are more digitally excluded compared to younger age groups. On the other hand, the trends in LMICs were opposite, which showed a decrease in the trend in digital exclusion with older age groups.

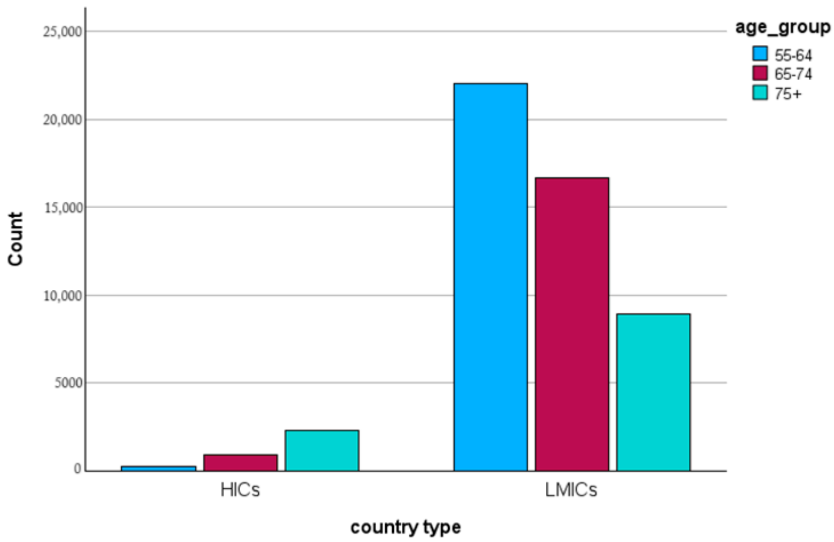


**Figure 12.** Trend in association of digitally excluded people and age groups between different country types.

4.5.3. Variation in Life Satisfaction among HIC and LMIC of Digitally Excluded People

To find the difference in the life satisfaction rate among digitally excluded people in HICs and LMICs, a one-way ANOVA test was performed for these country types. An ANOVA test helps to determine if there is any significant difference in the life satisfaction rates of digitally excluded people in different countries.

i. HICs

The digitally excluded people from HICs (Austria, Germany, France, Estonia, and the UK) were selected for the ANOVA test. The results of the one-way ANOVA test are presented in Table 15. The F statistics value of 46.668 indicates that there is a significant difference in the variation of means across different countries. The $p$-value < 0.001 suggests that the observed differences are statistically significant, supporting the rejection of the null hypothesis (Ho) [67].

**Table 15.** One-way ANOVA test—digital exclusion vs. life satisfaction in HICs.

| **ANOVA** | | | | | |
|---|---|---|---|---|---|
| **life_satisfaction** | | | | | |
| | **Sum of Squares** | **df** | **Mean Square** | **F** | **Sig.** |
| **Between Groups** | 557.299 | 4 | 139.325 | 46.668 | 0.000 |
| **Within Groups** | 7732.226 | 2590 | 2.985 | | |
| **Total** | 8289.524 | 2594 | | | |

ii. LMICs

The digitally excluded people from LMICs (Bulgaria, Romania, India, Mexico, and Brazil) were selected for the ANOVA test, as shown in Table 16. The F statistics value of 256.663 suggests that there is a significant difference in the variation of life satisfaction among elderly people among LMICs. And the $p$-value < 0.001 confirms that these variations are statistically significant [67].

**Table 16.** One-way ANOVA test—digital exclusion vs. life satisfaction in LMICs.

| **ANOVA** | | | | | |
|---|---|---|---|---|---|
| **life_satisfaction** | | | | | |
| | **Sum of Squares** | **df** | **Mean Square** | **F** | **Sig.** |
| **Between Groups** | 3767.305 | 4 | 941.826 | 265.663 | 0.000 |
| **Within Groups** | 216,791.962 | 61,151 | 3.545 | | |
| **Total** | 220,559.267 | 61,155 | | | |

#### 4.5.4. How the Health Rating Is Impacted by the Interaction of Digital Exclusion and HICs and LMICs

To investigate the impact of digital exclusion and its interaction with a country in terms of health rating, the two-way ANOVA test was performed, as illustrated in Table 17.

**Table 17.** Two-way ANOVA test.

| **Tests of Between-Subject Effects** | | | | | |
|---|---|---|---|---|---|
| **Dependent Variable:** | | | | | |
| **Source** | **Type III Sum of Squares** | **df** | **Mean Square** | **F** | **Sig.** |
| **Corrected Model** | 6616.012 [a] | 19 | 348.211 | 350.383 | 0.000 |
| **Intercept** | 76,513.696 | 1 | 76,513.696 | 76,990.914 | 0.000 |
| **country** | 3345.504 | 9 | 371.723 | 374.041 | 0.000 |
| **digitaly_excluded** | 437.557 | 1 | 437.557 | 440.286 | 0.000 |
| **country * digitaly_excluded** | 185.155 | 9 | 20.573 | 20.701 | 0.000 |
| **Error** | 67,900.503 | 68,324 | 0.994 | | |
| **Total** | 538,597.000 | 68,344 | | | |
| **Corrected Total** | 74,516.515 | 68,343 | | | |

[a.] R Squared = 0.089 (adjusted R squared = 0.089).

The sum of squares for digital exclusion is 437.557, indicating that it has a significant impact on the health rating of elderly people. The interaction between country and digital exclusion has a value of 185.155, indicating that it has a considerable impact on health rating. The F- and *p*-values of 20.701 and <0.001, respectively, show that the effect of the interaction is statistically significant [68].

## 5. Conclusions and Future Work

This research is linked with social sustainability and attempts to address the current digital exclusion by investigating the challenges that older people face as digital technologies evolve. It was understood that various factors contribute to the digital exclusion rate, such as insufficient digital literacy, limited access to digital media, and socio-economic factors, and this has been clearly demonstrated in this paper. Table 5 summarizes key findings from the literature review, such as the link between digital exclusion and functional dependence [8], as well as a summary of the current investigation on digital exclusion [7]. Factor analysis identified the primary factors influencing digital exclusion among the elderly: socio-economics, age-related limitations, and health-related issues. Table 3 outlines the technological challenges that elderly people face, such as a lack of experience [4,8,32] and privacy concerns [34,35]. These factors have a direct impact on the daily life of the elderly because they significantly decrease access to essential services, socializing, and even banking in this digital age. Therefore, it is important to strengthen and enhance policies and programs to address the digital gap that affects the elderly, which directly improves their quality of life.

This research work makes a key contribution by emphasizing why digital inclusion is needed as part of broader sustainable development efforts. This study helps to identify the variation of life satisfaction and health rating of digitally excluded elderly people across different cultures and countriesand reveals that there is a significant difference between High-Income Countries (HICs) and Lower Middle-Income Countries (LMICs). Further analysis to identify if these country types impact the digital exclusion of older people concluded that there is a significant variation in their numbers, and even age group plays a vital role in digital exclusion. The numbers of digitally excluded elderly people in HICs, such as the UK (11%), and in LMICs, such as India (91%), demonstrate the importance of taking action to increase digital inclusion, which has a direct impact on their social standards. These findings will assist authorities in taking steps to enhance digital inclusion across countries and communities.

The analysis shows that while digital literacy programs such as Austria's "Digital Seniors", Brazil's "MediaWise for Seniors", and Mexico's digital literacy programs have helped the elderly people in improving their digital skills, challenges such as socio-economic factors and limited access to rural areas affect their efficiency. While India's "Agewell Digital Literacy Program" has been successful in cities, it still must be expanded to rural areas to have a wider impact. To address these issues, this study suggests expanding digital literacy programs to the remote regions in HICs. In LMICs, programs should be tailored to meet the specific needs of elderly people in rural areas by integrating digital literacy programs with assistance in buying resources such as low-cost digital devices and internet access. In addition, programs such as the UK's "One Digital" should be introduced in LMICs. Similarly, in HICs, the age group composed of those 75 and above is more digitally excluded, and in LMICs, the lower elderly age groups are more digitally excluded. Therefore, the programs should focus more on these categories in different countries to reduce the exclusion rate. Additionally, community activities such as teaching and collaborations between public and private sectors can encourage older people to use technologies, thereby reducing the digital exclusion rate.

Digital isolation is a growing concern among the elderly, and it is very important to address these challenges effectively because it affects mental health, social connections, and the overall standard of living. Future research should investigate other aspects of digital exclusion, such as the influence of cultural settings, living standards, and access to healthcare services. Furthermore, longitudinal studies that track how digital exclusion changes over time, as well as research on the effectiveness of digital inclusion programs and efforts, would be valuable. Additionally, collaboration with researchers, policymakers, and organizations is required to develop and implement broad initiatives for bridging these gaps and helping the elderly become more digitally inclusive.

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