MEASURING DIGITAL INEQUALITY ACROSS THE LIFE CYCLE: AGE, GENDER, AND EDUCATION EFFECTS IN TÜRKIYE

Yaşam Döngüsü Boyunca Dijital Eşitsizliğin Ölçülmesi: Türkiye'de Yaş, Cinsiyet ve Eğitim Etkileri

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Abstract

Rapid technological developments have forced economic actors to adapt to the digital world, revealing the economic significance of digital inequalities. This study investigates digital inequality dynamics throughout the life cycle in Türkiye by creating a multidimensional digital welfare indicator. This indicator encompasses access to digital tools, usage frequency, purposes, and digital experience, using TURKSTAT's Household Information Technology Usage Surveys. Digital inequality is measured via the Gini coefficient across age, gender, and education. Findings show that digital inequality in Türkiye decreased significantly in the last decade, with the Gini coefficient falling from 0.539 in 2015 to 0.285 in 2023. Digital inequality increases steadily across age groups after youth and is significantly higher among elderly individuals, women, and those with low education. While digital inequalities among women exceed those among men, this gap has widened over the last decade. Digital welfare follows an inverted U-shape throughout the life cycle, peaking in middle age. Education significantly reduces age and gender-based digital inequalities. Policy recommendations include digital literacy programs for the elderly, gender-sensitive support strategies, and integration of digital skills into lifelong learning frameworks.

Öz

Hızlı teknolojik gelişmeler ekonomik aktörleri dijital dünyaya uyum sağlamaya zorlamaktadır. Öte yandan, dijital erişimden yoksun bireyler ile dijital teknolojileri etkin biçimde deneyimleyenler arasındaki uçurumun ve dijital eşitsizliklerin ekonomik önemini ortaya çıkarmıştır. Bu çalışma, çok boyutlu bir dijital refah göstergesi oluşturarak Türkiye'de yaşam döngüsü boyunca dijital eşitsizliğin dinamiklerini araştırmaktadır. Dijital refah göstergesi; dijital araçlara erişimi, kullanım sıklığını, amaçlarını ve dijital deneyimi içerecek geniş bir çerçevede ele alınırken, TÜİK'in Hanehalkı Bilişim Teknolojileri Kullanım Araştırmaları verileri kullanılmıştır. Çalışmada dijital eşitsizlik Gini katsayısıyla ölçülmekte ve yaş, cinsiyet ve eğitim seviyesine göre dijital eşitsizliğin değişimi incelenmektedir. Bulgular, Türkiye'de dijital eşitsizliğin son on yılda önemli ölçüde azaldığını, 2015'te 0,539 olan Gini katsayısının 2023'te 0,285'e düştüğünü göstermektedir. Yaşam döngüsü boyunca dijital eşitsizlik yetişkin ve yaşlılarda istikrarlı biçimde artmaktadır. Bunula birlikte dijital eşitsizlik yaşlı bireyler, kadınlar ve düşük eğitim seviyesine sahip bireyler arasında önemli ölçüde daha yüksektir. Kadınlar arasında dijital eşitsizlikler erkeklerden daha yüksek olmakla birlikte, aradaki fark son on yılda büyük ölçüde artmıştır. Dijital refah, yaşam döngüsü boyunca ters U şeklindeyken orta yaşlarda zirveye ulaşmaktadır. Eğitim; yaş ve cinsiyete dayalı dijital eşitsizlikleri önemli ölçüde azaltmaktadır. Politika önerileri arasında, yaşlılara yönelik dijital okuryazarlık programları, toplumsal cinsiyete duyarlı destek stratejileri ve dijital becerilerin yaşam boyu eğitim çerçevelerine entegre edilmesi ifade edilebilir.

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1. Introduction

The proliferation of personal computers and the World Wide Web (www) in the early 1990s marked the initial steps of digitalization, accelerating and necessitating all economic agents, regardless of size, into the digital realm. Although at that time, concerns regarding the inequalities that access to computers and the internet might generate were often dismissed as "problems of the future", rapid technological advancements brought that future much closer than anticipated. The issue, initially framed as the "digital divide" in the early 2000s, was comprehensively theorized by Van Dijk (2002), who identified four successive stages of access: mental access, material access, skills access, and usage access. The first stage refers to an individual's psychological and cognitive readiness to use digital technologies. This is followed by ownership of digital devices, acquisition of relevant skills and education, and finally, opportunities and patterns of actual use. As the first two stages have become more easily realizable, disparities emerging from the latter two stages have grown more critical. Notably, the gap between individuals who lack even basic digital access and those experiencing more advanced stages has made it increasingly important to measure the digital divide, digital inequality, and digital gap, as well as to understand the factors driving these differences.

The concepts of digital divide and digital inequality, both gaining relevance with the rise and widespread use of the internet, are often used interchangeably. However, seminal studies such as DiMaggio and Hargittai (2001) and Hargittai (2003) clarify that the digital divide reflects a binary distinction between those who have or do not have access to digital technologies. In measuring the digital divide, studies frequently rely on indicators such as the proportion of the population using the internet or possessing digital devices like computers or mobile phones (see Vehovar et al., 2006; Srinuan and Bohlin, 2011; Lythreatis et al., 2022). By contrast, Hargittai (2003) defines digital inequality as the disparities in the quality and depth of access and use, spanning several dimensions within society. Moreover, according to Hargittai (2003), digital inequality can be categorized into four dimensions: technical means, autonomy of use, social support networks, and experience. In sum, digital divide and digital inequality are distinct phenomena, and digital inequality represents a multidimensional condition with more complex outcomes that necessitate closer investigation. This study offers a novel approach to measuring digital inequality by a composite digital welfare measure and analyzes digital inequality across the life cycle.

According to Imran (2023), although information and communication technologies (ICTs) offer considerable potential for development and productivity, they also entail substantial costs. Moreover, the so-called digital revolution remains incomplete. Therefore, the socio-economic structures and effects of these technologies must be carefully examined by economists, social scientists, and policymakers. In this regard, Imran (2023) argues that the implications of digital inequality on development, intergenerational gaps, social exclusion, polarization, the post-COVID era, and ongoing trends in digital transformation must all be taken into account.

Building on these earlier approaches, Robinson et al. (2015) conceptualize digital inequality at two levels: access and skills on one hand, and participation and activity on the other. They emphasize that individuals' integration into digital society and their digital abilities can significantly affect a wide range of outcomes, such as academic performance, labor market matching, entrepreneurship, and access to healthcare services. Moreover, given the increasing

proportionality of digital resources over time, differences in the use and access to digital technologies from childhood to old age may become even more pronounced.

Digitalization has been strongly emphasized with the advent of Industry 4.0, while its environmental, cultural, and social fragmenting effects are often overlooked, particularly in developed economies. In parallel, digital inequality and inequality of all kinds can act together. Just as other inequalities differ between groups with different characteristics, such as income, age, and gender, digital inequality can be significant for groups disadvantaged in terms of access, knowledge, competence, and costs (Martin et al., 2016). Therefore, it is essential to conduct situational analyses and formulate policies addressing digital inequality throughout the life cycle in response to the accelerating digital transformation. For example, Cotten et al. (2014) note that the digital inabilities faced by older adults are mitigated by higher levels of education and income. Also, according to Robinson et al. (2015), while children and adolescents may not differ significantly in terms of internet access, they have considerable differences in usage patterns and skills.

Within this context, the aim of this study is to examine digital inequality and digital welfare throughout the life cycle. Additionally, it explores how changes in digital inequality across age groups are influenced by gender and educational attainment. For this purpose, data from the Turkish Statistical Institute's Household Information and Communication Technologies Usage Survey (ICT-Household Survey) for the years 2015, 2019, and 2023 have been utilized. This enables both a current analysis and a historical comparison of digital inequality across the life cycle. Also, the study seeks to contribute to the literature in two ways. First, it develops a novel digital welfare indicator for Türkiye, categorized according to Hargittai's (2003) classification of digital use and access, and calculates its Gini index to measure inequality. Previous studies have primarily focused on internet and computer access when calculating digital inequality through Gini coefficients (e.g., Ono and Zavodny, 2007; Li, 2023). By contrast, this study incorporates usage frequency, purpose, and digital experience, offering a more comprehensive and realistic perspective on digital inequality in Türkiye.

Second, this is the first study in the international literature to analyze digital inequality across the life cycle according to our best knowledge. Although the digital divide between young and elderly is frequently emphasized in the literature, there is a lack of studies that address these differences with digital welfare indicators. Therefore, it is possible to provide a comprehensive framework for Türkiye on how digital inequality changes at different stages of life.

Following the introduction, the paper is structured as follows: the second section reviews the relevant literature, followed by the data and methodology section. The fourth section presents findings and assessments related to digital inequality, digital welfare indicators, and their variation across the life cycle. The paper concludes with a discussion and policy recommendations in the final section.

2. Literature Review

Digital inequality, as one of the key indicators of individuals' digital integration, has appeared in the literature under various terms (e.g., digital divide, digital gap, etc.). Early studies primarily examined digital inequality through the relationship between individuals'

access to and/or use of digital tools or internet ownership and income inequality. For example, Martin (2003) and Chakraborty and Bosman (2005), using data from the U.S. Current Population Survey, investigated the relationship between computer and internet ownership and income inequality. Both studies used data from 1994 to 2001. Martin (2003) calculated income Gini coefficients for households with and without computers, focusing on how computer ownership was distributed across income levels, drawing on data from 1994 to 2001. The results showed that income inequality among computer-owned households decreased over time, while inequality among non-owned households increased. Chakraborty and Bosman (2005) performed a similar analysis using different breakdowns. They calculated a Gini coefficient of 0.197 based on annual income among households that owned computers. However, they noted that fewer than 30% of the bottom 45% of income earners in the U.S. owned a computer, revealing a clear digital divide between middle- and low-income households. In both studies, the findings consistently suggested that as household income increased, digital inequality decreased.

While many studies have examined the relationship between income inequality and digitalization, fewer have directly measured digital inequality or the digital divide. Following Hargittai's (2003) work on differentiating digital divide from digital inequality, there has been a growing tendency to move beyond the binary measurement of the presence or absence of digital tools or infrastructure, and instead adopt the broader concept of digital inequality, which includes access to digital tools and intermediaries and their qualitative dimensions. In this context, for example, Ho and Tseng (2006) used World Bank and International Telecommunication Union (ITU) data for 2002 to measure global digital inequality. Their study took internet usage intensity as the main indicator for digital inequality. They found a global Gini coefficient of 0.70 for digital inequality and described this as extremely unequal. Although internet penetration was high in advanced economies such as Northern Europe, North America, and the Asia-Pacific in 2002, it remained significantly low in regions such as Latin America, North Africa, Central Asia, and other less developed countries. In short, while internet usage became widespread in certain regions, the top 20% countries according to income accounted for 80% of global internet activity. Since greater wealth and income are associated with broader diffusion of information technologies, Ho and Tseng (2006) emphasized that reducing or eliminating economic and digital inequalities between developed and developing countries may only be possible through technology diffusion and leapfrogging effects.

Ono and Zavodny (2007) examined the structure and inequalities of information technologies in the United States, Sweden, Japan, South Korea, and Singapore, using country-level microdata from the year 2000. Their analysis focused on gender, education, and income groups. They measured digital inequality based on computer ownership and usage, internet usage, and the timing of acquiring the first computer. The study used the gap between the top and bottom 10% of the distribution as the main inequality metric. According to their findings, the largest inequality was observed in Singapore, particularly regarding education. In other countries as well, the greatest digital divide was between higher education and secondary education groups. Ono and Zavodny (2007) argued that digital inequalities often reflect prior economic or social inequalities, and to address digital inequality effectively, one must tackle the underlying sources of those broader inequalities.

In recent years, a limited number of studies have attempted to measure digital inequality at the micro level using inequality indicators such as the Gini coefficient. For example, Li (2023), using household finance survey data from rural China for the years 2013–2019, divided

digital inequality into two main categories: digital access and digital use. To measure digital access, the study used indicators such as the number of smartphones in the household, the types of internet-accessible devices, and whether or not the household had an internet connection. For digital use, it considers variables such as barriers to smartphone usage (e.g., availability of 4G/5G), the ability to access desired information at any time, the use of the internet to meet daily needs, and the use of WeChat. Li (2023) calculated using a composite digitalization index derived through iterative principal factor analysis for digital inequality. Then, the maximum and minimum values of this index were used to calculate a digital inequality indicator. Rather than drawing broad inferences based on this index, the study focused on the relationship between digital inequality and income distribution. The results showed that digital inequality had a significant negative impact on household income. This negative impact was particularly more pronounced among low-income households. Moreover, it is reported that digital inequality contributed to increased income inequality among households and that middle-income households were the most affected. While middle- and high-income households could potentially mitigate the negative effects of digital inequality by increasing their digital capital, this is much more difficult for low-income households.

Another study that calculated digital inequality and examined its economic impacts, similar to Li (2023), was conducted by Yue et al. (2024). They calculated a digital divide index, which they interpreted as a digital inequality indicator, for 59 middle- and low-income countries between 2005 and 2020. Although their methodology was similar to Li (2023), they defined the digital divide indicators differently. In their framework, four main components were identified: infrastructure, social impact, digital trade, and social support. Infrastructure included fixed broadband and landline; social impact was measured by individual internet usage; digital trade included the value added by medium- and high-tech manufacturing and ICT exports; and social support was calculated based on capital value added in the service sector per capita. Their analysis examined the effect of digital inequality on energy poverty while also accounting for income inequality. The results showed that high levels of digital inequality further exacerbated energy poverty, and being both digitally and energy poor led to even deeper income poverty.

Chamwong et al. (2024) also calculated a Gini coefficient for digital inequality using household data from Thailand. They used five components similar to Li (2023) and broadly categorized them as internet access and internet usage, while using comparable indicators. These five components included: whether the household had internet access, the share of income allocated to both home and mobile internet expenditures, the quality of the internet connection, the presence of digital devices in the household, and the flexibility and convenience of internet usage. For each of these components, they created an index and then calculated the Gini coefficient for different household groups. The national digital inequality Gini coefficient was reported as 0.2713, while it was 0.2928 in rural areas and 0.2539 in urban areas. When examining different income groups, the highest level of inequality (0.6008) was observed among the lowest-income group, whereas the lowest levels of inequality were among wage earners and the top-income group (0.1852 and 0.1102, respectively). Additionally, while inequality remained low and stable among the top three income groups, it increased significantly between the bottom two income groups. The fact that the Gini coefficients of these groups are 0.3207 and 0.6008 expresses this situation.

In Türkiye, there are very few studies using the Gini coefficient to measure digital inequality with microdata from the ICT-Household Survey. One such study, conducted by Fidan

and Şen (2015), approached digital inequality as a form of digital divide and calculated Gini coefficients for computer, internet, mobile phone, and internet banking access using data from the 2007–2013 surveys. Their results showed that the lowest level of inequality (0.410) existed in mobile phone ownership, while the highest (0.425) occurred in internet banking usage. Furthermore, in terms of gender disparities, they found that the Gini coefficient for rural areas was 0.957, indicating that computer ownership was almost entirely concentrated in one gender. Similar results emerged for internet access. Based on these findings, Fidan and Şen (2015) concluded that specific projects and policies should be developed to reduce digital inequality, particularly among individuals living in rural areas. A similar study by Fidan (2017), using microdata from the 2011–2014 ICT-Household Surveys, calculated Gini coefficients for digital inequality by NUTS-1 regions. This study considered computer usage, internet usage, and gender-based differences. The findings indicated that inequality in computer usage was lower than inequality in internet usage. Among the regions, the highest inequality levels were found in TR9 (Trabzon, Ordu, Giresun, Rize, Artvin, Gümüşhane) and TR10 (Erzurum, Erzincan, Bayburt, Ağrı, Kars, Iğdır, Ardahan). Additionally, the gender-based inequality in computer and internet usage declined over time in almost all regions, except for TR9.

In recent years, some studies using the ICT-Household Survey in Türkiye have addressed digital inequality without calculating Gini coefficients. Among these, studies emphasizing intergenerational digital inequality—also addressed in this study—are particularly noteworthy. For instance, Görgün Baran and Erdem (2017) examined the use of digital technologies by older adults using the 2016 dataset, focusing on individuals aged 60–74. The findings showed that older adults most commonly owned mobile phones and that their internet usage rate stood at 42%. The most frequently cited reason for not using the internet was a perceived lack of necessity. Among those who did use the internet, the primary activities included reading news, using social media, and accessing health-related information. Görgün Baran and Erdem (2017) argued that older individuals, often described as "digital immigrants" due to their low internet adoption and limited engagement with e-learning and information-seeking, should be supported to overcome their disadvantages compared to younger generations.

A different perspective on the role of age was presented by Canatan et al. (2023), who analyzed the socioeconomic determinants of digital technology ownership using the 2021 survey data. They found that as age increased, so did the probability of owning medium- and high-tech digital tools—this was also true for income. Additionally, individuals who used e-government services, possessed digital skills, and engaged in e-commerce were more likely to own medium- or high-tech devices. A striking finding from the study was that if the increase in the share of digital technologies in total household expenditures exceeded the increase in income, digital poverty intensified. Canatan et al. (2023) concluded that improving digital ownership among low-income households is a critical tool for reducing digital inequality.

3. Data and Methodology

This study examines how digital inequality changes throughout the life cycle in Türkiye. Life cycle models describe how a welfare indicator changes across different stages of life. The life cycle model, which is frequently used in inequality literature, is adapted for digital inequality in this study. In this framework, the study first constructs an individual-level digital welfare indicator and then measures the distribution of this indicator across different age groups

using various inequality metrics. In the first step, the constructed digital welfare indicator reflects individuals' levels of access to and use of digital technologies.

The literature on digital access and adaptation proposes several criteria for assessing individuals' digital welfare. Hargittai (2003) suggests four categories to assess individuals' digital welfare: the first category, technological quality level, encompasses the digital devices owned by individuals; the second, autonomy of use, measures the frequency with which individuals use their technological devices and the internet; the third category, social support network, evaluates how individuals use the internet for socialization, networking, and information retrieval; and the final category, experience, assesses electronic skills such as job searching, conducting banking transactions, and accessing online services via internet technologies. This study adopts Hargittai's (2003) classification, which considers digital inequality in a gradual manner beyond mere ownership of internet access or a computer.

Data for measuring digital welfare in Türkiye was sourced from the Turkish Statistical Institute's ICT-Household Survey for the years 2015, 2019, and 2023. This survey is the primary data source on ICT usage in Türkiye and has been conducted continuously since 2004. It collects information at the household and individual levels regarding ownership and use of ICTs, barriers to ICT use, e-commerce, e-government usage, and cybersecurity. The survey is based on a nationally representative sample that covers all geographical regions of Türkiye and includes individuals aged 16–74 living in households.

The population of the ICT-Household Survey data consists of individuals within the borders of Türkiye. According to the metadata published by the Turkish Statistical Institute (TURKSTAT), a representative sample for the ICT-Household Survey was determined by using a multi-stage stratification method. In this way, the ICT-Household Survey uses Level 1 of the Classification of Statistical Regional Units as the stratification criterion, and the sample is determined in such a way that reliable estimates can be produced at this level. The data is geographically comparable between regions within the country and between countries. At the same time, it is also comparable within years, as no revision was made in any year to create a break.

Table 1 lists the questions considered for constructing the digital welfare indicator under each digital welfare category. In the questions listed in Table 1, each "yes" answer adds one point to the individual's welfare score, while each "no" answer adds zero points. In calculating the total welfare score, all the criteria listed in Table 1 were equally weighted.

Table 1. Digital Welfare Categories and Indicators

Digital Welfare Category	Digital Welfare Indicator
Technological Quality	Ownership of a desktop computer in the household
	Ownership of a laptop in the household
	Ownership of other smart devices in the household
Autonomy of Use	Availability of internet access in the household
	Individual internet access
	Frequency of internet usage
	Use of email via the internet
Social Support Network	Using the internet for search purposes
	Using the internet for participation in social media
	Using the internet for reading news
	Using the internet to obtain information about goods and services
	Using the internet for search purposes
Experience	Using the internet to seek health-related information
	Using the internet for job searching
	Using the internet for selling goods and services
	Using the internet for conducting banking transactions
	Using the internet for attending education or training
	Using the internet to access educational materials
	Using the internet to access educational websites

Note: Since all other sub-items are Yes-No type questions, one point is added to the indicator for those who answer yes. However, the answer options for the question on the frequency of internet use are 'Several times a day', 'Almost every day', 'At least once a week', and 'Less than once a week'. For this sub-item, one point is added to the answers 'A few times a day' or 'Almost every day', indicating that the Internet is used every day.

In the second step, the distribution of the calculated digital welfare indicator by age was examined. In recent years, dynamic inequality analyses have been preferred in the literature instead of static, year-on-year analyses. Life cycle analysis is one of the methods used for this. Instead of comparing inequality between two countries or two years statistically, life cycle analysis examines whether inequality changes across different periods of an individual's life. Accordingly, individuals in the sample were divided into six groups that represent different stages of the life cycle. To distinguish the younger population, who tend to have a high tendency for digital technologies, the first age group was defined as 16–20 years. Then, four additional groups were formed in ten-year intervals: 21–30, 31–40, 41–50, and 51–60. Finally, individuals aged 61 and over were categorized as representing the retirement period.

Digital inequality was measured using the Gini coefficient for both the overall sample and each life cycle age group. The Gini coefficient is a widely used measure of inequality based on the Lorenz curve approach (Atkinson and Bourguignon, 2015). It measures the area between the Lorenz curve, which shows the actual distribution of a welfare indicator, and the line of perfect equality. The Gini coefficient ranges from zero (0) to one (1). A value of one (1) indicates total concentration of the welfare indicator in the hands of a single individual, while a value of zero (0) indicates perfect equality. Therefore, a Gini coefficient closer to one (1) signifies higher inequality in the distribution of the welfare indicator across the sample.

4. Findings

In this study, a digital welfare indicator was constructed by taking into account access to and usage habits of digital technologies. This indicator aims to reflect the digital wealth of

individuals in Türkiye. The digital welfare indicator was measured for all individuals included in the ICT-Household Survey, which has a nationally representative sample. Thus, it provides significant insights into the level of digital infrastructure and adaptation in Türkiye during the current era of technological advancement.

Table 2 presents the results of inequality measurements regarding the distribution of digital welfare at the individual level across the population. The table includes the Gini coefficients and their standard errors for the years 2023, 2019, and 2015. The fact that the standard errors are very close to zero indicates that the inequality measure and the welfare indicator underlying the measure are consistent and statistically reliable. This further confirms that the digital welfare indicator developed in this study is both reliable and compatible with the data used.

According to Table 2, the Gini coefficient for the distribution of digital welfare was 0.285 in 2023. This value indicates that digital inequality in society was quite low in 2023. Notably, the Gini index of income distribution in the Turkish economy in the same year was 0.431, making Türkiye one of the countries with the highest inequality among OECD countries. When these two indicators are considered together, it becomes evident that digital welfare in Türkiye is distributed more equitably than income. This suggests that digital technology adoption has become relatively widespread across Turkish society.

One striking finding is the trend in the distribution of digital welfare over the past decade. As can be seen from Table 2, while the Gini index for digital inequality was 0.539 in 2015, it decreased to 0.469 in 2019 and to 0.285 in 2023, despite the pandemic period when inequalities increased worldwide. First, it is important to note that the past measurements of digital inequality are consistent with the literature. Among the few studies conducted for Türkiye, Fidan and Şen (2015) estimated the highest level of digital inequality at approximately 0.4 for the 2007–2013 period. By contrast, Ho and Tseng (2006), although using a simpler indicator, reported a digital inequality level of around 0.7 for a developing country like Thailand. Given that the digital welfare indicator used in this study is more comprehensive, the differences are considered consistent within an acceptable range.

**Table 2. Digital Inequality for the Overall Sample**

	2023	2019	2015
Gini coefficient	0.285	0.469	0.539
Standard Error	0.002	0.001	0.002

Source: Author's own calculations based on ICT-Household Survey data.

The decline in digital inequality for Türkiye is quite remarkable. Over the past decade, the Gini coefficient for digital inequality fell by 0.254 points, corresponding to a 50% decrease. In other words, digital inequality in Türkiye has halved since 2015. This finding clearly shows that access to and usage of digital technologies have spread across broader segments of society.

The focus of this study is to examine how digital inequality changes across different age groups throughout the life cycle in Türkiye. Accordingly, the distribution of the digital welfare indicator within each age group is also measured using the Gini coefficient. Figure 1 presents the Gini coefficients representing digital inequality within six different age groups. Several important findings emerge from the figure. First, excluding the youngest age group, the Gini

coefficient increases steadily as the age groups progress. For instance, the Gini coefficient is 0.174 for the 21–30 age group, 0.187 for the 31–40 group, 0.228 for the 41–50 group, and 0.325 for the 51–60 group. Finally, it reaches 0.509 for the 60+ group.
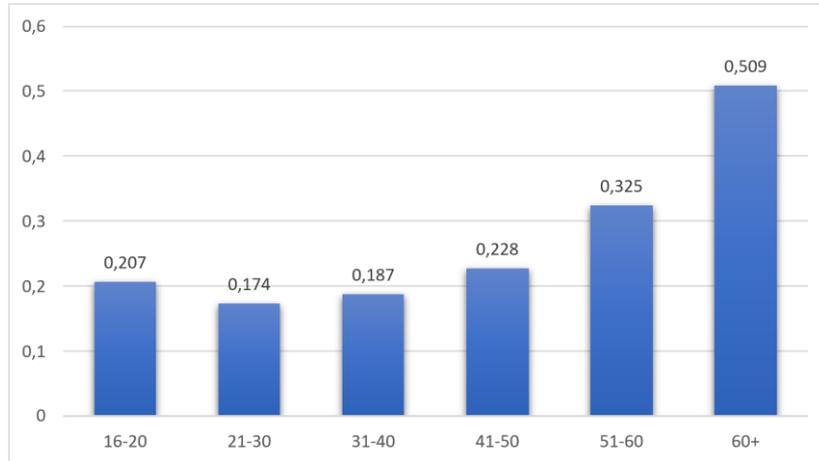
Figure 1. Digital Inequality by Age Groups
Source: Author's own calculations based on ICT-Household Survey data.

This finding demonstrates that digital inequality in Türkiye increases consistently with age. In summary, individuals encounter increasing digital inequality as they grow older. Additionally, the sharpest increase in inequality occurs within the 60+ age group. The level of digital inequality within this group is 1.33 times higher than the average inequality level across the other age groups (which is 0.22). Lastly, the level of digital inequality among the 16–20 age group, which generally represents the pre-employment educational period, is comparable to that of the middle age groups and is slightly higher than that of individuals in their twenties and thirties. This result may reflect the fact that the digital welfare indicator includes not only digital technology usage but also ownership, where parental control over technology access and usage habits could still play a significant role for younger individuals.
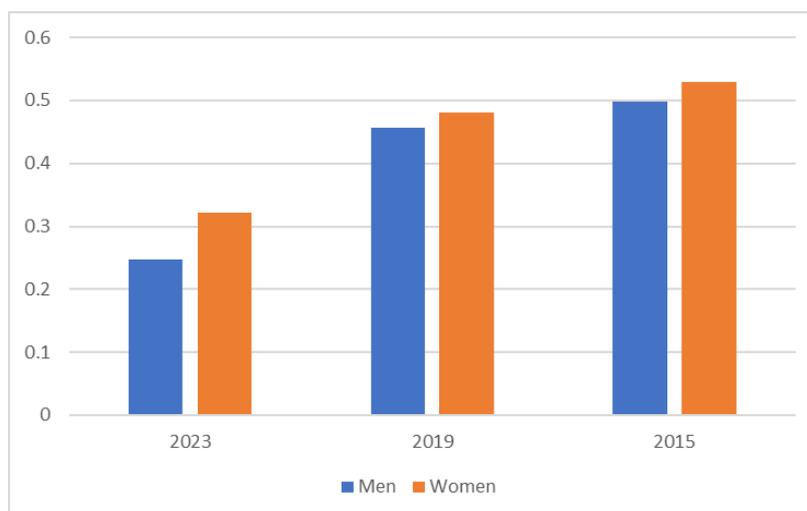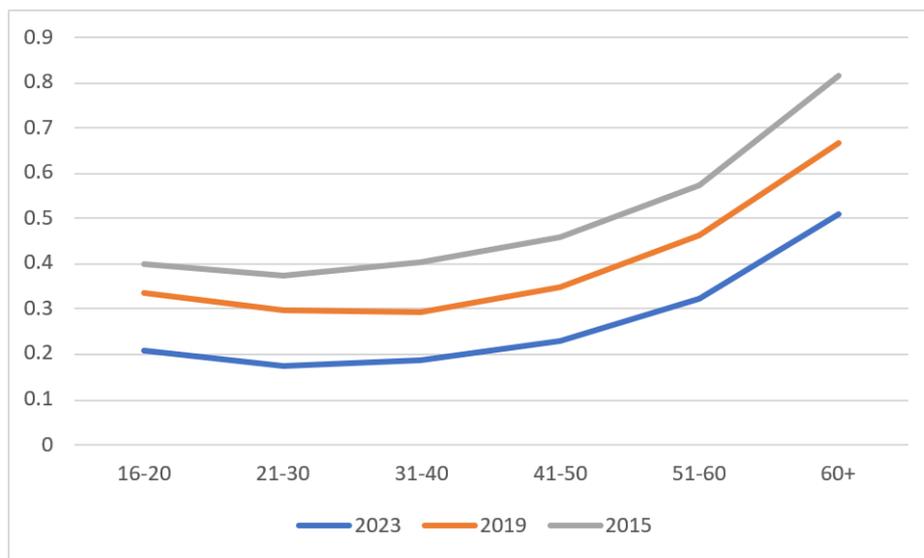

Figure 2. Digital Inequality by Gender Across Different Years
Source: Author's own calculations based on ICT-Household Survey data.

Figure 2 summarizes the trends in digital inequality among men and women over the past eight years. According to the figure, digital inequality varies by gender. In all three observed years (2015, 2019, and 2023), digital inequality was consistently higher among women. However, a particularly important finding is that the gap between men and women has widened over time. Despite the overall sharp decline in average inequality, gender-based inequality has increased. Although heterogeneity among women in terms of access to and usage of digital technologies has decreased over time, the increase in equality among men has been significantly greater. From 2015 to 2023, the Gini coefficient among women decreased by 0.21 points, whereas among men, it fell by 0.25 points.

The significant decline in overall digital inequality over the past decade has raised the question of how age-related digital inequality evolved during the same period. Figure 3 presents the trends in digital inequality across different age groups at four-year intervals. According to the figure, although digital inequality decreased over time within each age group, the pattern of inequality among the groups remained similar across all years. This suggests that digital inequality across the life cycle is a persistent phenomenon: even as inequality diminishes, it continues to exist. Furthermore, the rate of decline in digital inequality appears to be relatively similar across all age groups.
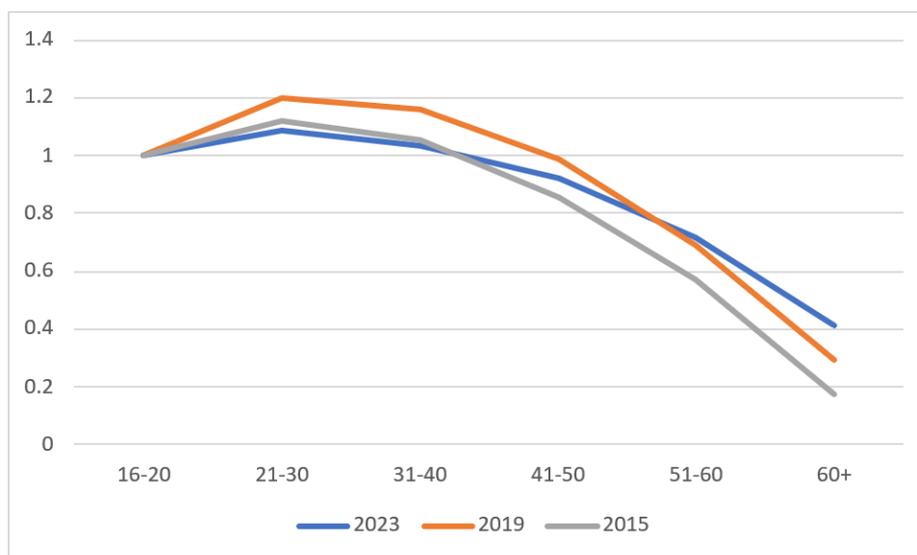

Figure 3. Digital Inequality by Age Groups Across Different Years
Source: Author's own calculations based on ICT-Household Survey data.

Digital inequality rises after individuals complete their education and enter the labor market. However, Figure 4 shows how average digital welfare changes across age groups. Instead of measuring inequality, Figure 4 presents the average level of digital welfare for each age group relative to the 16–20 group, which is set to 1.

According to the figure, the average digital welfare of the 21–30 age group is 1.09, meaning that their digital welfare is 9% higher than that of the 16–20 age group. Similarly, the average digital welfare of the 31–40 group is 3% higher than that of the youngest group. However, from the age of 40 onward, it declines below the 16–20 age group's level. For instance, the digital welfare of the 41–50 group is 0.92, while it is 0.71 for the 51–60 group. In

the 60+ group, the average digital welfare falls to 0.41, representing a 59% decline compared to the 16–20 age group.


Figure 4. Digital Welfare by Age Groups
Source: Author's own calculations based on ICT-Household Survey data.

Overall, the movement of digital welfare across age groups is in the form of an inverted U (or hump). In the literature on income inequality, inequality across age groups is mostly in the inverted U-shape. However, the situation is found to be different in terms of digital technologies. While digital inequalities increase with age, digital wealth takes the inverted U shape depending on the inverted age. Therefore, owning and using digital technologies, which is measured as digital welfare, peaks in the middle-aged period in society, while it reaches its lowest value at the age of 60 and above, which refers to the retirement period. When evaluated together with inequalities, it is possible to say that the age group of 60 and above has both the least adaptation in terms of digital technologies and faces the highest inequality. On the other side of the coin, individuals in the 21-30 age group are both the group with the highest adaptation to digital technologies and the group with the lowest digital inequality within the age group.

After analyzing the life cycle profile of digital welfare and digital inequality in Türkiye, an important question is whether the relationship between digital inequality and age varies with the other demographic variables. At this point, within-group inequalities are calculated separately for different demographic and socioeconomic subgroups. The first of these is the education variable, which is considered to have a high impact on digital technology adaptation. Figure 5 traces digital inequalities at different education levels in different age groups for 2023. It is first observed that education level has an impact on digital inequality regardless of age. Accordingly, for each age group, digital inequality decreases sharply as the level of education increases. Here, it is determined that graduating from primary and secondary school makes the biggest difference in reducing digital inequality. Although the increase in education level after high school reduces inequality, this effect is quite limited compared to lower education levels.

The relationship between digital inequality and age differs across education groups. In the analysis made for the whole society, the continuous increase starting from the second age group is much more evident in low education groups, while it becomes insignificant and disappears as the level of education increases. For university graduates and above, digital inequality remains nearly flat across all age groups, except for the 60+ group. This indicates that higher education eliminates the age-related rise in digital inequality. In sum, education not only reduces digital inequality across all age groups but also prevents digital inequality from increasing with age.
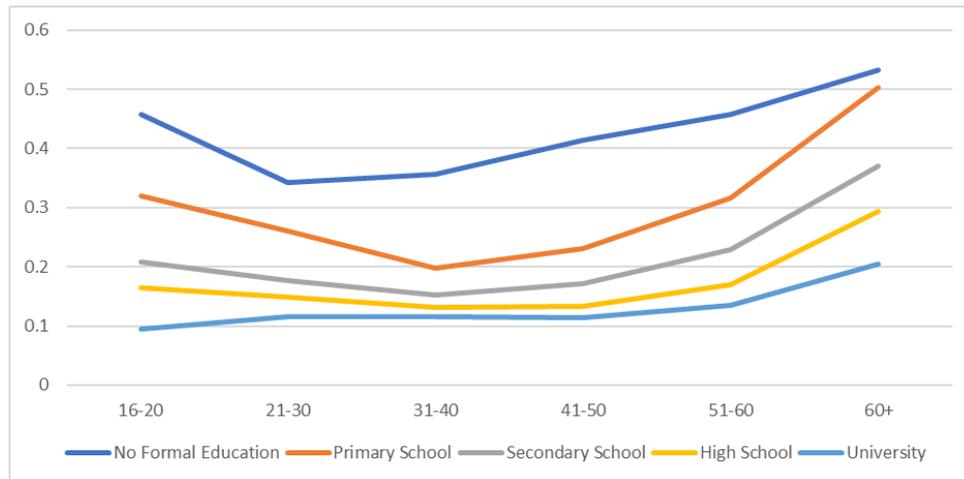
Figure 5. Digital Inequality by Educational Attainment and Age Groups (2023)
Source: Author's own calculations based on ICT-Household Survey data.

A similar analysis was conducted by gender. Figure 6 presents digital inequality across age groups separately for men and women. The figure clearly shows that digital inequality is higher among women across all age groups. However, gender does not appear to play a major role in the age-related changes in digital inequality. Among men, inequality continues to decline until middle age, while inequality increases after middle age among women. Therefore, the lowest digital inequality occurs in the 31–40 group (representing the middle working age) among men, whereas it occurs earlier, in the 21–30 group among women, which corresponds to the early labor market entry period.
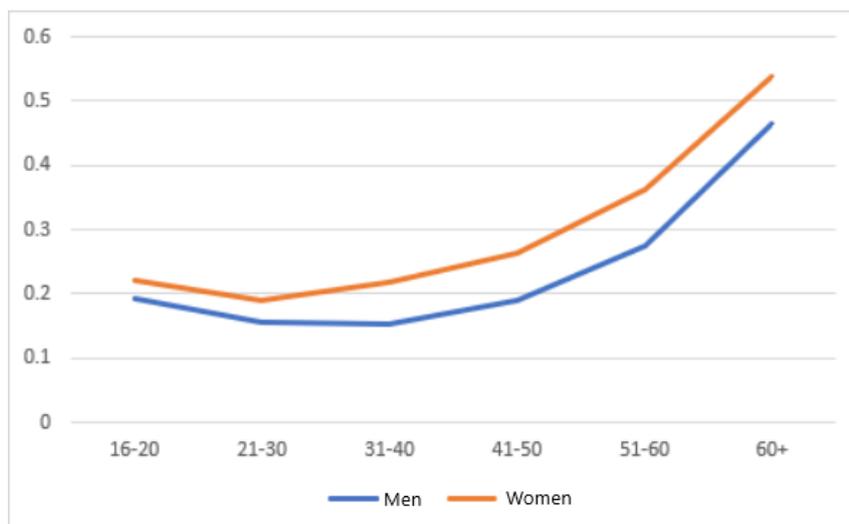
Figure 6. Digital Inequality by Gender and Age Groups
Source: Author's own calculations based on ICT-Household Survey data.

5. Conclusion and Discussion

This study developed an original digital welfare indicator to examine how digital inequality evolves throughout the life cycle in Türkiye. Based on Hargittai's (2003) classification, which highlights the multidimensional nature of digital access and use, the digital welfare indicator is designed to encompass not only access to digital devices but also usage frequency, usage purposes, and digital experience. By analyzing digital inequality from a life cycle perspective, this study provides one of the first applications that emphasize the dynamic aspects of digital inequality within the Turkish context.

Whereas the literature often treats digital inequality as a static phenomenon, this study tracks how digital welfare varies over time, incorporating variables such as age, gender, and education. Thus, the study offers a more comprehensive and inclusive framework for measuring digital inequality and contributes new insights for policy development. Using microdata from the TURKSTAT ICT-Household Surveys for the years 2015, 2019, and 2023, the study analyzed the distribution of digital welfare across socio-demographic variables, thereby uncovering the structural dimensions of digital inequalities.

The findings show that digital inequality in Türkiye has significantly declined since 2015, with the Gini coefficient decreasing from 0.539 to 0.285. These results, which are consistent with the literature, indicate that digital technologies have become accessible to broader segments of society and that overall digital adaptation has improved. Furthermore, according to the TURKSTAT, internet usage among individuals aged 16–74 has continuously increased over time, reaching 87.1% in 2023 and 88.8% in 2024. This figure is significantly higher than the global average of approximately 67.5% for the same period.

However, despite this positive trend, digital inequality shows significant differences across age groups. Digital inequality rises with age, and particularly among individuals aged 60 and above, a sharp increase is observed. These finding highlights that the elderly population faces pronounced disadvantages in accessing and using digital technologies. As Cotten et al.

(2014) also emphasize, although internet connectivity is relatively high among both children and the elderly, a digital gap persists in terms of the quality and purpose of internet usage. This situation also has important implications for the so-called "sandwich generation," who are responsible for caring for both their children and elderly parents. As children's digital competencies improve over time, enhancing digital skills among the elderly could help alleviate the digital caregiving burden placed on the middle-aged generation. Additionally, reducing digital exclusion among older adults may also help mitigate negative outcomes such as depression, loneliness, and financial hardship.

Gender-based analyses reveal that digital inequality is consistently higher among women compared to men and that this gap has widened over time. Educational attainment emerges as a critical factor in reducing digital inequality. As the education level increases, digital inequality decreases, and the age-related effect on inequality weakens. Especially from the level of higher education onwards, the impact of age on digital inequality becomes markedly limited. Thus, education not only enhances individuals' digital skills but also mitigates the digital disadvantages associated with aging. When gender and educational differences are considered together, it becomes apparent that improving women's educational attainment and digital literacy would be a key solution to reducing social inequalities (Antonio and Tuffley, 2014). Moreover, Avanesian et al. (2024) argue that in addition to gender and education, age-related differences must also be taken into account, suggesting that policymakers should design gender-sensitive policies to improve young people's acquisition of digital skills relevant to employment opportunities.

Also, there are some good examples of digitalization policies. For example, in terms of basic digital skills, including components such as data literacy and communication, Finland and the Netherlands have the highest rates in Europe at 79% (World Economic Forum, 2022). Across Europe, the rate of those experiencing a basic digital skills gap is 32% (Mancino, 2023). In particular, Finland's success is an important guide, as citizens' digital access is very high and policies have been implemented based on a strategic plan. Prepared in 2022, Finland's Digital Compass Strategy Report addresses the country's digitalization path with a focus on improving the digital competencies of sectors and citizens.

In addition, there are many successful examples of training programs. According to the Canadian Evaluation of the Digital Literacy Exchange Program (DLEP) final report (Innovation, Science and Economic Development Canada, 2021), the results of the training implemented for target groups lacking basic digital literacy skills indicated positive results exceeding the aimed expectations. These target groups, the underrepresented groups that are being targeted by the DLEP, are: seniors (65 years and older), persons with disabilities, indigenous persons, newcomers to Canada, language minorities, low-income people, people with low levels of education, and people living in rural and remote areas. For example, according to the answers of the target groups, their use of the internet in life, their ability to use the internet, confidence when using the internet, and their ability to understand the digital world and make informed decisions when online were enhanced within one year. Besides, as pointed out in a case study in the project, the life of a woman over 65 years was reported to have changed and improved tremendously as a result of this DLEP program.

Based on these findings, several policy recommendations can be made regarding digital inequality. First, special digital literacy programs targeting the elderly population should be

developed to enhance digital inclusion. E-services training and digital guidance programs organized through public and local administrations could facilitate the digital integration of this group. Second, gender-focused digital support policies should be designed to eliminate the structural barriers faced by women in accessing digital tools, particularly for those living in rural areas. Programs supporting digital equipment ownership and skill acquisition should be prioritized. Third, digital skills should be integrated into the education system from an early age and promoted through a lifelong learning perspective. Although various projects and policies have been implemented in Türkiye in recent years in this area, their continuity and widespread impacts must be ensured and monitored at both micro and macro levels.

In conclusion, while this study shows that digital inequality has declined over time in Türkiye, it also reveals that variables such as age, gender, and education still create significant disparities in access to digital welfare. Addressing these differences is critical for ensuring that digital transformation progresses in a manner consistent with the broader goals of social cohesion.

Declaration of Research and Publication Ethics
This study, which does not require ethics committee approval and/or legal/specific permission complies with the research and publication ethics.

Researcher's Contribution Rate Statement
I am a single author of this paper. My contribution is 100%.

Declaration of Researcher's Conflict of Interest
There is no potential conflict of interest in this study.

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