Review Article

A decadal review of the role of communication-mobile technologies in promoting digital inclusion: Digital divide

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ARTICLE INFO	ABSTRACT
	Advancements in communication-mobile technologies have transformed the digital landscape, creating new opportunities while also exposing disparities in access and usage. This phenomenon of unequal digital participation, often termed the "digital divide", can exacerbate inequalities. Bridging this divide through innovative technological solutions and policy interventions is critical for empowerment. This study investigates the role communication-mobile technologies have played in promoting digital inclusion over the past decade through a systematic review of academic literature. Fourteen studies published between 2012 and 2023 were analyzed following a rigorous selection process. A conceptual framework was developed to examine the layers of the digital divide, variety of divides, intervention types, and tools used. The analysis reveals the multifaceted nature of the divide across geographical, socioeconomic, and demographic dimensions. Communication and access emerge as pivotal elements, with studies emphasizing approaches like leveraging libraries as community hubs. The importance of multi-tiered interventions, from grassroots to policy-level, is pronounced. Arts, libraries, training, and mobile platforms are identified as key tools. While the findings largely align with the topics highlighted in the preliminary sections, gaps exist concerning insufficiently addressed divides and groups. Expanding the discourse to incorporate these areas can enrich the conceptualization of communication technologies' role in digital inclusion. This timely systematic review provides a foundation for continued interrogation of digital participation challenges facing diverse global populations. **Keywords:** digital divide, communication technologies, mobile technologies, rural areas, digital inclusion

INTRODUCTION

The digital age, marked by rapid advancements in information and communication technologies (ICTs), has created a new paradigm, where access to digital tools and the internet is paramount. This transformation has heralded myriad opportunities, from bridging geographical divides to offering instant access to global knowledge repositories (Castells, 2000). Central to this paradigm shift is the proliferation of communication-mobile technologies, which have played an instrumental role in shaping the contours of the digital landscape (Donner, 2008; Drydakis, 2021).

However, while communication-mobile technologies have brought about immense benefits and conveniences, they have also exposed stark disparities in digital access and usage (Dalgic-Tetikol et al., 2022; Tan & Chan, 2018). This phenomenon, often referred to as the "digital divide", underscores the inequalities between individuals, households, businesses, and geographic regions at various socio-economic levels with both access and usage of information and communication tools (Ragnedda & Muschert, 2013; van Dijk, 2020; Vassilakopoulou & Hustad, 2023). For over a decade, scholars and policymakers alike have expressed concern about these disparities, viewing them as more than just a technological issue but also a socio-economic one with profound implications on social inclusion and development (Asmar et al., 2020; Buthelezi et al., 2021).

This study delves into a decadal review of how communication-mobile technologies have influenced digital inclusion. It interrogates the dual role of these technologies as both enablers and potential perpetuators of the digital divide. In doing so, we aim to provide a comprehensive understanding of the interplay between mobile technologies and digital inclusivity over the past 10 years.

Literature Review

The digital divide refers to the gap or bridge between different segments of society in terms of access to and skills in using ICTs (Gunkel, 2003). It encompasses inequalities in access to ICTs, such as computers and the internet, as well as disparities in the ability to effectively use these technologies (Jetha et al., 2023). The digital divide can manifest in various forms, including differences based on income, location (rural vs. urban), gender, age, ethnicity, and socioeconomic status (Abu-Shanab & Al-Jamal, 2015; Gu, 2021; Mendoza-Lozano et al., 2021). It is a multifaceted problem that can have social, economic, and educational implications (Chang et al., 2016). The divide can hinder individuals' ability to participate fully in society and take advantage of the benefits offered by ICTs. Efforts to bridge the digital divide involve addressing both access to ICTs and the development of digital skills (Lediga & Fombad, 2018; Zhao et al., 2023).

Classification of Digital Divide

The digital divide refers to the gap or disparity between individuals or groups who have access to and effectively use ICTs and those who do not (OECD, 2001). It encompasses various dimensions, including access to ICT infrastructure, such as computers and the internet, as well as the possession of skills and knowledge required to use these technologies effectively (Lameijer et al., 2017).

The digital divide can manifest at different levels, such as the first level, which focuses on access to ICT hardware and connectivity, and the second level, which highlights inequalities in digital skills and competencies (Dalgic-Tetikol et al., 2022). Additionally, the third level of the digital divide addresses aspects such as data literacy, data governance, and trust in data quality, which can impact individuals' ability to collect, interpret, and make informed decisions based on data (Jauhiainen et al., 2022). Bridging the digital divide is crucial for promoting digital inclusion, ensuring equal opportunities, and reducing inequalities in access to information, education, employment, and social participation (Asmar et al., 2020; Neves & Mead, 2021).

The digital divide, which highlights disparities in digital access and literacy, is significantly influenced by demographic factors such as age, income, and education level. Academic research underscores these disparities, showing that older individuals in the USA often face a larger digital divide due to barriers like unfamiliarity with technology (Sanders & Scanlon, 2021). Income levels further accentuate this divide; a study across the 28 EU member states revealed that income was a critical determinant in digital access, particularly regarding e-Services and social networks (Elena-Bucea et al., 2021). Education level also plays a pivotal role in digital literacy and access. Higher education often equips individuals with necessary digital navigation skills, a notion supported by a study, which identified education as a significant predictor of individual internet use

patterns for news-related activities (Ogbo et al., 2021). These academic insights collectively reveal the multifaceted nature of the digital divide, heavily dictated by age, income, and education level, thus outlining the pervasive digital disparities across different demographic segments.

The geographical digital divide is significantly marked by disparities between urban and rural areas, and between developed and less developed countries. Academic studies highlight that urban areas in European Union countries tend to have better digital infrastructure compared to rural areas, emphasizing the need for best practices to bridge this divide (Feurich et al., 2023). This urban-rural divide extends to income disparities exacerbated by digital economy growth, particularly noted in developing countries, where digital resources are heavily concentrated in urban centers (Deng et al., 2023; Furuholt & Kristiansen, 2007). On a global scale, developed countries exhibit higher levels of digital access with around 87% of individuals having internet access in 2019, contrasted sharply with only 19% in the least developed countries (Vassilakopoulou & Hustad, 2023). This global divide mirrors the national urban-rural divide, further complexifying the digital access landscape across geographical and socio-economic dimensions (Aruleba & Jere, 2022).

The digital divide notably impacts individuals with disabilities and patients, creating a "disability divide" due to insufficient financial resources or the lack of necessary skills and tools for leveraging internet access, as elaborated in a study analyzing this divide among people with disabilities (Duplaga, 2017). In healthcare, the accessibility, readability, and mobility of health-related websites pose challenges for these individuals, further widening the digital divide (Mason et al., 2021). The surge in telehealth, particularly during the COVID-19 pandemic, has exacerbated health inequities among these populations, reflecting a broader digital disparity (Valdez et al., 2021). Furthermore, technological advances have led to a digital dependency, excluding vulnerable individuals lacking essential digital skills, a concern echoed in a study assessing the digital divide in patients concerning the healthcare environment (Croicu & Kreutz, 2017). This divide amplifies health inequalities, especially for people with severe mental illnesses, indicating the pervasive impact of digital disparities across different health conditions and patient demographics (Spanakis et al., 2021).

Several academic studies have delved into interventions aimed at bridging the digital divide, as follows.

A study examined the impact of access to distance learning and educational technology in shaping student learning experiences, drawing from an initiative termed "disrupted classes, undisrupted learning" to propose policy takeaways for fostering an undivided future for remote distance learning (Liu, 2021). Another study focused on the educational digital divide exacerbated by the COVID-19 pandemic, suggesting that various strategies have been employed to cater to the digital needs of vulnerable students, although there's a recognition of the need for more comprehensive solutions (Norman et al., 2022). A systematic scoping review aimed to identify research on the design and deployment of digital health interventions to reduce the digital divide and increase digital health literacy at various levels (national policy, national program, and localized or individual levels) (Jenkins et al., 2022). Another article proposed a model using a community-based participatory research framework based on principles of community media and the promotors model to bridge the digital divide and enhance the effectiveness of e-health interventions for underserved populations (Ginossar & Nelson, 2010).

A study explored a digital media literacy intervention, finding that randomized exposure to the intervention led to a decrease in the perceived accuracy of false news articles, hinting at the potential of media literacy interventions in addressing aspects of the digital divide (Guess et al., 2020). A literature review outlined a research agenda that includes extending established models of digital inequalities, examining the effects of digital divide interventions critically, and better linking digital divide research with sustainability research, hinting at a multi-dimensional approach towards bridging digital divides (Vassilakopoulou & Hustad, 2023). Bridging the age-based digital divide has also been a subject of scholarly interest. A study delved into the digital communications divide, particularly focusing on the lack of access to digital infrastructure due to physical location, which is often termed as the urban-rural divide (Flynn, 2022). These studies illustrate a range of interventions and approaches aimed at addressing the digital divide, spanning educational, healthcare, and media literacy domains. They underscore the importance of multi-dimensional approaches and policy interventions in mitigating digital inequalities.

The literature reviewed underscores the multifaceted and pervasive nature of the digital divide across geographical, socioeconomic, demographic, and health dimensions. Communication-mobile technologies
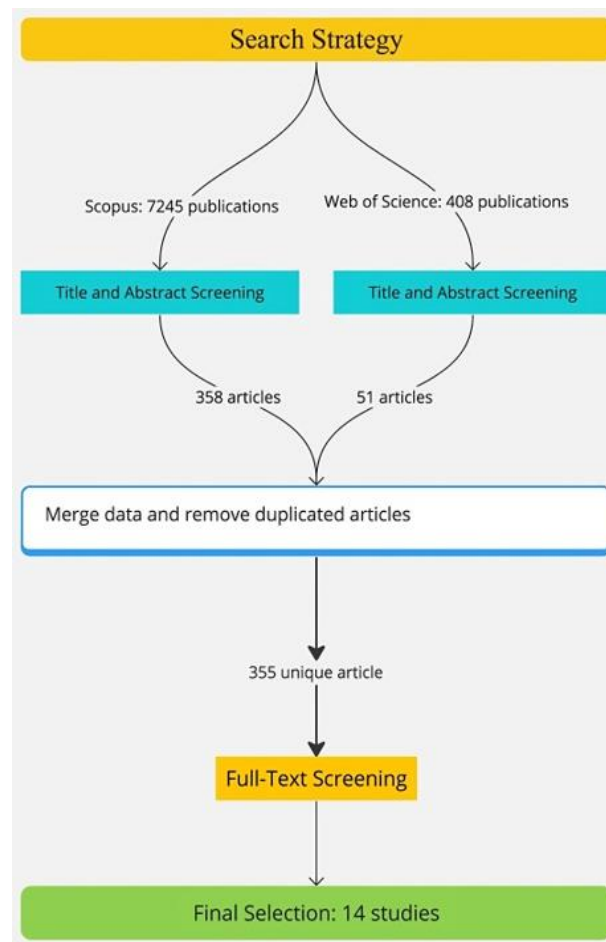
Figure 1. Publication selectin process (Source: Authors)

have played a pivotal dual role, both enabling and potentially exacerbating digital inclusion. Bridging these divides through comprehensive policy interventions and grassroots approaches is critical for promoting equitable digital participation and realizing the developmental potential of these technologies. As the world grows increasingly reliant on digital access, skills, and participation, this study aims to provide a timely decadal analysis on the interplay between mobile technologies and digital inclusion. The insights garnered can inform policymakers, technology companies, educators, healthcare providers, and other stakeholders seeking to close digital gaps and build a more digitally inclusive future. Given the centrality of mobile technologies in shaping the digital landscape, this research hopes to further the discourse on leveraging their potential to empower diverse populations rather than perpetuate disparities.

METHODOLOGY

A systematic review, unlike a traditional narrative review, adheres to a structured approach in identifying, appraising, and synthesizing research evidence (Bearman et al., 2012). This approach is analogous to experimental research and offers replicability, transparency, and an exhaustive exploration of the chosen topic. Given the extensive number of studies published on the subject, especially in the era of rapid technological advancement, a systematic review offers a lens to sift through the vast amount of information, filtering out noise and emphasizing the most rigorous and pertinent findings.

The process involves several stages, each meticulously planned and executed (**Figure 1**). These stages range from determining precise search strings to ensure a comprehensive retrieval of articles, through to detailed assessments of each potential study against predefined eligibility criteria. The aim throughout is to distill a vast body of literature into a cohesive, evidence-based narrative on how communication-mobile technologies have been, or can be, deployed to decrease the digital divide (Rethlefsen et al., 2021).

Search Strategy

To identify potentially relevant studies, we conducted a comprehensive search in two major electronic databases: Scopus and Web of Science. The search was restricted to articles published between 2012 and 2023, and in the English language. Additionally, we limited our search to documents classified as articles.

Scopus search query

(("communication technologies" OR "mobile technologies" OR "digital accessibility" OR "digital divide") AND ("rural areas" OR "remote areas")) AND PUBYEAR>2011 AND PUBYEAR<2024 AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (DOCTYPE, "ar"))

7,245 publications are returned from this search query.

Web of Science search query

(("communication technologies" OR "mobile technologies" OR "digital accessibility" OR "digital divide") AND ("rural areas" OR "remote areas"))

408 publications are returned from Web of Science search query.

Title & abstract screening

Using predefined eligibility criteria, we conducted an initial screen of titles and abstracts from the identified articles. From Scopus, out of 7,245 articles, 358 articles were considered potentially relevant after title and abstract analysis. From Web of Science, out of 408 articles, 51 articles were considered potentially relevant after title and abstract analysis.

Removal of duplicates

After merging data from both sources, duplicates were removed. The combined total came to 355 unique articles.

Full-text screening

We then undertook a thorough examination of the full text of these articles. The focus was primarily on studies with interventions aimed at reducing the digital divide. During full-text screening, special attention was paid to the following:

(1) whether the study prioritized communication or mobile technology,

(2) whether the study addressed the digital divide, and

(3) selecting studies that aim to compensate for and address the digital divide.

Final selection

Following the full-text review, 14 studies were selected for detailed analysis, as they met all the specified criteria. Selected articles are listed in **Table 1**.

Table 1 presents a selection of scholarly articles focused on various aspects of the digital divide, with an emphasis on communication technologies and their role in promoting digital inclusion. The articles span from the year 2015 to 2023, and their publication sources include a diverse range of journals, such as "Information and Learning Science," "Information Research," and "Journal of Librarianship and Information Science," among others. The diversity in the topics is evident from titles discussing library connectivity, public libraries facilitating older people's digital inclusion, and the application of advanced workplace technologies. The number of citations each article has received, as recorded by both Scopus and Web of Science, provides an indication of their relative influence or importance in the academic community. Notably, the article titled "Old and afraid of new communication technologies? Reconceptualizing and contesting the 'age-based digital divide'" by Neves et al., published in the Journal of Sociology in 2018, stands out with a substantial number of citations in both databases, suggesting it might be a pivotal piece in this realm of research. The databases column indicates that most articles were sourced from both Scopus (S) and Web of Science (W), ensuring comprehensive coverage in the review.

Table 1. Selected articles for systematic review

ID-1	ID-2	Authors	Title	Journal	n1	n2	D
sc_27	st_01	Ayoung et al. (2020)	An evaluation of the library connectivity project through the lens of the digital inclusion model	Information and Learning Science	1	1	S & W
art_8	st_02	Brown (2023)	Identifying potential barriers to community participation and use of telecentres: A Philippines case study	Information Research	0	0	S & W
sc_23	st_03	Casselden (2023)	Not like riding a bike: How public libraries facilitate older people's digital inclusion during the COVID-19 pandemic	Journal of Librarianship and Information Science	4	3	S & W
dd_10	st_04	ChanLin et al. (2015)	Bridging volunteer services and mobile teaching in the tablet reading community	Libri-International Journal of Libraries and Information Studies	6	5	S & W
dd_7	st_05	Cheng et al. (2022)	Bridging the digital divide for rural older adults by family intergenerational learning: A classroom case in a rural primary school in China	International Journal of Environmental Research and Public Health	9	8	S & W
sc_18	st_06	Choudrie et al. (2022)	Bridging the digital divide in ethnic minority older adults: An organizational qualitative study	Information Systems Frontiers	8	9	S & W
sc_15	st_07	Jetha et al. (2023)	Divided in a digital economy: Understanding disability employment inequities stemming from the application of advanced workplace technologies	SSM-Qualitative Research in Health	2	-	S
art_5	st_08	Kosurko et al. (2022)	Dance wherever you are: The evolution of multimodal delivery for social inclusion of rural older adults	Innovation in Aging	1	2	S & W
sc_21	st_09	Lediga and Fombad (2018)	The use of information and communication technologies in public libraries in South Africa as tools for bridging the digital divide: The case of the Kempton Park public library	Public Library Quarterly	8	5	S & W
sc_16	st_10	Neves et al. (2018)	Old and afraid of new communication technologies? Reconceptualizing and contesting the 'age-based digital divide'	Journal of Sociology	74	59	S & W
sc_33	st_11	Suwana and Lily (2017)	Empowering Indonesian women through building digital media literacy	Kasetsart Journal of Social Sciences	35	-	S
dd_47	st_12	Vong et al. (2017)	Investigating the roles of knowledge management practices in empowering rural youth to bridge the digital divide in rural Sarawak	Journal of Integrated Design and Process Science	8	6	S & W
sc_34	St_13	Wilkin et al. (2017)	Addressing digital inequalities amongst young people: Conflicting discourses and complex outcomes	Oxford Review of Education	21	14	S & W
sc_6	st_14	Zhao et al. (2023)	Narrowing the age-based digital divide: Developing digital capability through social activities	Information Systems Journal	8	4	S & W

Note. n1: Number of citations by Scopus; n2: Number of citations by Web of Sciences; D: Database; S: Scopus; & W: Web of Sciences

Data Analysis

Initially, each of the selected publications was read thoroughly. Special attention was devoted to sections of the studies that addressed the 'digital divide' and their respective conclusions. This focus was instrumental in understanding the nuances and overarching themes prevalent in the discourse on the digital divide. To streamline the review and ensure objectivity, a rigorous analytical framework was developed specifically for the 'digital divide' section of each paper.

The framework was constructed based on the foundational principles emphasizing the importance of adopting systematic review methods to ensure clarity, transparency, and replicability in the assessment of literature (Asmar et al., 2020; Dalgic-Tetikol et al., 2022; Duplaga, 2017; Feurich et al., 2023; Lameijer et al., 2017; Neves & Mead, 2021). By adhering to such a structured approach, potential biases in the selection and interpretation of studies were minimized.

Once individual analyses were completed, the findings were collaboratively discussed by the team of authors. Collaborative discussion is a critical component of systematic reviews to ensure consistency in interpretations and reduce the risk of individual biases, as supported by Moher et al. (2015). Through these discussions, any discrepancies or variations in interpretations were reconciled, ensuring a harmonized understanding of the research landscape. The analyses were then finalized based on collective decisions, reinforcing the integrity and reliability of the review's findings.

Conceptual Framework for Digital Divide Studies

Dimensions & levels

First level: Infrastructure and access: Examination of the presence of physical devices and individuals' access to digital networks (van Dijk, 2020).

Second level: Digital skills and competencies: Evaluates the capacities, knowledge, and skills of individuals to effectively use digital tools.

Third level: Inequalities in capacities: Investigates the unequal distribution of abilities and capacities among individuals to benefit from digital resources (Dalgic-Tetikol et al., 2022).

Divide varieties

Geographical differences: Investigates the digital divide among individuals living in different geographical regions (Feurich et al., 2023).

Personal characteristics: Factors like gender, age, and disability status that influence the digital divide are analyzed in this category (Ogbo et al., 2021; Sanders & Scanlon, 2021).

Intervention types

Policy-level interventions: Approaches, where national or international bodies, such as governments and other organizations, develop general principles and solution strategies to reduce the digital divide (Jenkins et al., 2022).

Macro projects: Large-scale projects targeting broad audiences, typically conducted by the government or large organizations.

Micro projects: More specialized projects targeting a specific audience or local group (Ginossar & Nelson, 2010).

For gender-based digital divide, collaborative efforts by governments and NGOs to address physical infrastructure deficiencies can be considered policy-level interventions. Distributing tablets to female students in a school to promote digital reading habits, or providing free internet access, is an example of a micro-level project. A large-scale initiative by the health department to facilitate access to mobile health tools for the elderly represents a macro-level project. **Figure 2** shows conceptual framework.

FINDINGS

The in-depth analysis of the 14 selected studies on communication-mobile technologies and digital inclusion provides rich, multi-faceted insights into the roles these technologies play in promoting participation among underserved communities. The following sections will systematically elucidate the vital findings concerning each of these central aspects of the studies analyzed–their aims, digital divide frameworks implemented, intervention approaches adopted, tools leveraged, and outcomes achieved.

Aim of Studies

Focus on age-based digital divide

Several studies (e.g., st_14, st_10, st_06, st_05, and st_08) address the digital divide concerning older adults. This research investigates the challenges older individuals face in adopting technology and suggest interventions, like digital capability development and intergenerational learning projects, to mitigate the divide.
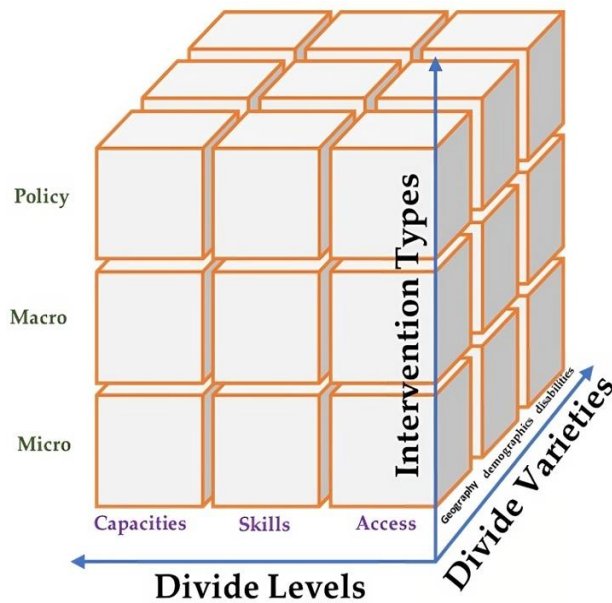
Figure 2. Conceptual framework (Source: Authors)

Digital divide & socio-economic factors

Some studies (e.g., st_10 and st_13) have considered socioeconomic, educational backgrounds, or specific conditions like frailty and care-dependency when discussing the digital divide. This highlights the multifaceted nature of the divide, with factors beyond just age playing a role.

Empowerment through digital literacy

Empowerment is a recurring theme. For example, st_11 seeks to empower Indonesian women through digital media literacy, while st_12 explores how knowledge management practices can empower rural youth in Malaysia.

Digital divide in specific geographies

Many studies are location-specific. For instance, st_06 focuses on older Indian adults at a Punjabi radio station, st_09 investigates ICTs in South African public libraries, and st_02 considers rural telecentre projects in the Philippines.

Digital divide & institutions

Some studies delve into the role of institutions like public libraries (st_09 and st_01) and schools (st_04) in addressing the digital divide. The involvement of these institutions suggests community-based solutions to the digital divide challenge.

Diverse populations & digital divide

A couple of studies (st_07 and st_13) specifically focus on groups like persons living with disabilities and digitally disadvantaged young people. This highlights that the digital divide affects various sub-groups within society differently.

Evaluation of specific programs

Some studies, like st_03, aim to evaluate specific programs, like the Housing Plus Pilot, to measure their success in addressing the digital divide. This underlines the importance of continuous assessment of intervention measures.

Table 2 shows the aims of the studies.

Figure 3 depicts the code and categories for aim the studies.

Table 2. Aims of studies

| ID	Aims of the studies
st_01	It aimed to collect primary data from staff of public libraries, pupils, school librarians, and ICT teachers to determine if the library connectivity project has achieved its desired results.
st_02	The aim of the study was to reframe the problem of information and communication technology usage and consider factors influencing rural telecentre projects in the Philippines.
st_03	The aim of the study was to evaluate the success of the Housing Plus Pilot, which provided remote digital skills training and support to older people living in sheltered housing in Newcastle upon Tyne during 2021.
st_04	The aim of the study was to promote teachers' adaptation of tablet reading and teaching among remote schools and to bridge the digital divide for children in remote areas.
st_05	The aim of the study is to investigate the effectiveness of a family intergenerational learning (FIL) project in bridging the digital divide for rural older adults in China.
st_06	Its aim is to explore & understand digital divide in older adults when accepting & using smart devices within an organization focusing on a group of educated, older Indian adult volunteers at a local Punjabi radio station.
st_07	The study sought to examine the implications of the digital transformation of the economy for the employment participation of persons living with disabilities.
st_08	The study aims to understand the experiences of older adults in rural areas in the context of the digital divide and how technology can be used to enhance social inclusion for this population.
st_09	The aim of the study is to investigate the use of information and communication technologies (ICTs) in public libraries in South Africa as a tool for bridging the digital divide.
st_10	The aim of the study was to challenge the notion of an age-based digital divide and explore the dynamics of technology adoption and use/non-use among older adults, specifically those with frailty, care-dependency, and low socioeconomic/educational backgrounds.
st_11	The aim of the study is to empower Indonesian women by developing their digital media literacy skills, enabling them to effectively use the Internet and improve their quality of life.
st_12	The aim of the study was to investigate the roles of knowledge management practices in empowering rural youth to bridge the rural-urban digital divide in Sarawak, Malaysia.
st_13	The aim of the study is to explore the experiences of digitally disadvantaged young people, parents, and teachers who were part of a digital inclusion scheme in England, and to examine how the discourses around 'digital youth' and determinist ideas of technology and social change inform the perception and outcomes of such schemes.
st_14	Its aim is to narrow the age-based digital divide by developing digital capability through social activities.
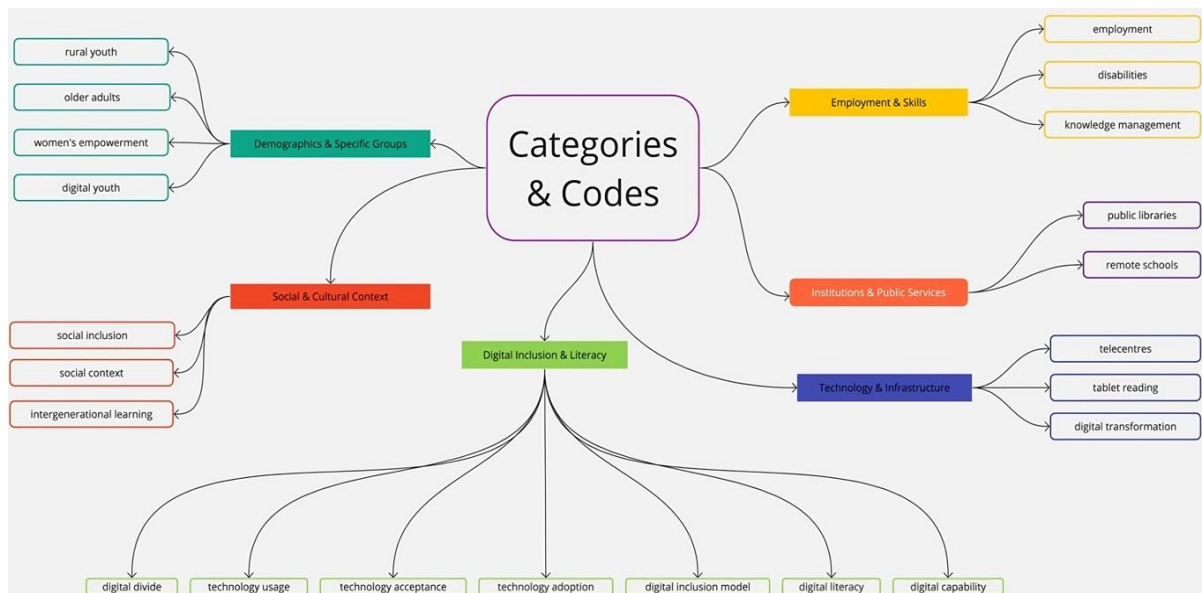
Figure 3. Code & categories for aim studies (Source: Authors)

Analysis for Digital Divide Framework

In an attempt to understand the layers and complexities of the digital divide across different nations, it's insightful to consider the "divide level" addressed in various studies.

At the most foundational level lies the "access level" divide, which primarily concerns itself with ensuring that individuals and communities have the essential infrastructure and means to connect digitally. Studies such as those conducted in South Africa (st_09), Ghana (st_01), Indonesia (st_11), the UK (st_13), Taiwan (st_04),

and the Philippines (st_02) emphasize this fundamental divide, showcasing the paramount need to ensure basic digital access across diverse geographical landscapes. However, access alone does not ensure effective use. This leads us to the "skills level" divide, which delves deeper into the competencies required to utilize digital platforms efficiently. Studies from China (st_14), Canada (st_07 and st_08), both Canada and Australia (st_10), India (st_06), the UK (st_03 and st_13), Indonesia (st_11), China again (st_05), Taiwan (st_04), Malaysia (st_12), and the Philippines (st_02) emphasize this divide. The repeated mention of the skills level across multiple countries, ranging from developed nations like the UK to developing ones like India, reinforces the universal importance of digital literacy and the challenges in ensuring it. Beyond basic skills lies the "capacities level" divide, a more nuanced layer emphasizing the full utilization of digital tools for advanced tasks. Notably, studies from China (st_14), India (st_06), and both Canada and Australia (st_10) focus on this aspect. It is evident from these studies that it's not just about harnessing technology, but more about leveraging it to its fullest potential, something that becomes especially salient as nations and their populations become more digitally entrenched. Lastly, there are studies such as the one from Canada (st_07) that holistically address all these layers, underscoring the multi-faceted nature of the digital divide and the importance of a comprehensive approach. In essence, these studies, identifiable by their unique IDs, offer a rich tapestry of insights into the digital divide's varying dimensions, reinforcing the idea that addressing this divide requires strategies tailored to specific needs and contexts.

A significant portion of the studies underscore the "age divide" as a primary factor in the digital disparity. Studies from China (st_14), both Canada and Australia (st_10), India (st_06), the UK (st_03), and Canada again (st_08) underline the challenges faced by the elderly population in adapting to digital transformations. The frequency with which this demographic is highlighted across various countries, irrespective of their development status, emphasizes the universal challenges senior citizens face in adapting to the digital age. It underscores the pressing need for strategies specifically tailored to enhance digital literacy and comfort among older individuals. Simultaneously, the "geographical divide" also emerges as a dominant theme, indicating disparities between urban and rural regions or between areas with varying infrastructural development. This divide is particularly noted in studies from Canada (st_07), South Africa (st_09), Ghana (st_01), Indonesia (st_11), the UK (st_13), China (st_05), Taiwan (st_04), and the Philippines (st_02). The attention to geographical disparities underlines the challenges in ensuring uniform digital access and skills across vast and diverse territories, from remote rural areas to densely populated urban centers. Gender-based digital disparity, primarily represented as the "gender divide", is highlighted in the study from Indonesia (st_11). This study accentuates the unique challenges faced by women, especially in rural areas, reinforcing the notion that the intersection of gender and geography can further compound the digital divide. Another nuanced variety is the "ethnical divide", highlighted in the study from India (st_06). Such a divide acknowledges the differential access or digital literacy levels based on ethnic or cultural backgrounds, emphasizing the need for more culturally-sensitive interventions. Lastly, a more specific category emerging from China's study (st_14) is the "patient divide". This emphasizes the need to ensure digital inclusion for specific health-related demographics, further highlighting the diverse array of factors that can contribute to digital disparities. In summary, these studies, identified through their unique IDs, shed light on the multi-dimensional nature of digital divides. From age to geography, from gender to ethnicity, various factors intersect and overlap, necessitating a multifaceted approach to bridge these gaps effectively.

A dominant intervention approach observed is the "micro" level interventions. These interventions typically focus on specific communities or demographics and are tailored to address localized challenges. Studies from China (st_14), both Canada and Australia (st_10), India (st_06), the UK (st_03 and st_13), China again (st_05), Taiwan (st_04), Malaysia (st_12), Canada (st_08), and the Philippines (st_02) have embraced such micro interventions. These studies reveal the significance of targeted and localized strategies, emphasizing the importance of understanding and addressing the unique challenges faced by specific groups or regions. Simultaneously, the "policy" level interventions provide a top-down approach, creating frameworks or guidelines to address the digital divide. Notably, Canada (st_07), both Canada and Australia (st_10), and Indonesia (st_11) have looked into policy interventions. This emphasis indicates that beyond localized efforts, there is a need for broader structural and systemic changes, often facilitated by governmental or organizational policies, to ensure digital inclusivity. The "macro" level interventions, as highlighted by studies from South Africa (st_09), Ghana (st_01), Indonesia (st_11), and the Philippines (st_02), delve into large-scale

efforts that impact broader communities or regions. These interventions might involve infrastructural developments, large-scale digital literacy programs, or initiatives aimed at enhancing digital access at a wider level. Their mention underscores the understanding that while micro interventions address specific challenges, there's a simultaneous need for expansive efforts to create a broad impact. In conclusion, these studies, denoted by their unique IDs, illuminate the multi-tiered nature of interventions required to combat the digital divide. From grassroots, localized efforts to expansive policy-driven initiatives, a multi-pronged approach is evident in the attempts to bridge digital disparities across the globe.

A primary tool that emerges prominently is the utilization of "libraries" as hubs for digital access and literacy. Studies from South Africa (st_09), the UK (st_03), and Ghana (st_01) have leveraged libraries to facilitate digital inclusion. This emphasis on libraries highlights their role not just as repositories of traditional knowledge but as centers for digital literacy and access. Given their widespread presence and community-centric nature, libraries prove to be vital assets in the quest to bridge the digital divide, especially in regions, where direct access to digital resources might be limited. "Mobile applications" and related technologies form the crux of the study from Canada and Australia (st_10). This highlights the growing ubiquity and importance of mobile platforms in the digital landscape. By customizing applications to cater to specific demographics, such as the elderly, the study underscores the potential of mobile technologies as a means to foster digital inclusion, especially given the widespread proliferation of mobile devices. "Training" emerges as another pivotal tool, emphasized by studies from India (st_06), Indonesia (st_11), Malaysia (st_12), and Canada (st_08). Training sessions, whether they focus on basic digital literacy or more advanced skills, play a critical role in ensuring that individuals are not just provided with digital access, but are also equipped with the necessary competencies to navigate the digital realm effectively. The study from the UK (st_13) brings to light "projects" as tools–specific initiatives, perhaps short-term or pilot in nature, that aim to address digital disparities. Such projects might involve providing hardware, ensuring internet connectivity, or fostering skill development, signifying a multi-faceted approach to bridging the divide. Lastly, the study from the Philippines (st_02) introduces "telecenters" as a tool. These centers, often situated in regions with limited digital access, function as hubs for connectivity and digital resources, furthering the cause of digital inclusion, especially in remote or underserved areas. In summary, as denoted by their respective study IDs, these tools represent a diverse range of strategies and resources employed across the globe to combat the digital divide. From community-centered libraries to technologically advanced mobile applications, the spectrum of tools underscores the multifaceted nature of efforts required to achieve digital inclusivity.

Starting in China, studies st_14 and st_05 highlight the nation's approach towards enhancing digital skills among elderly rural residents and leveraging family intergenerational learning. This underlines China's multifaceted strategy, emphasizing both community-based approaches and familial support structures, indicating a blend of traditional values and modern solutions. Canada emerges prominently with studies st_07, st_10, and st_08. These studies emphasize Canada's focus on addressing geographical disparities, enhancing digital skills among the elderly, and leveraging arts-based community facilitators. Such a diversified approach indicates Canada's comprehensive strategy in acknowledging and addressing various dimensions of the digital divide, from regional to demographic disparities. The collaboration between Canada and Australia in study st_10 showcases a transcontinental effort, shedding light on the universal nature of challenges faced by the elderly, reinforcing the need for shared knowledge and collaborative solutions in the face of global challenges. India's study st_06 delves into technology-mediated learning for older adults and the importance of customized training. This approach highlights India's emphasis on education and training as primary tools for digital inclusion, especially for demographics that may traditionally be left behind. In South Africa, the study st_09 showcases libraries as pivotal tools for digital access in regions with limited resources, emphasizing the importance of community-centered resources in African contexts. The UK is represented in studies st_03 and st_13, focusing on digital proficiency among seniors and providing technological access to the digitally disadvantaged. This reflects the UK's comprehensive approach, spanning from skill enhancement to infrastructure development. Ghana's study st_01 emphasizes mobile libraries, highlighting innovative solutions tailored for regions with limited digital resources, underlining the blend of mobility and traditional library services. In Indonesia, study st_11 underscores the role of NGOs in bridging gender and geographical divides, spotlighting the crucial role of non-governmental organizations in amplifying digital inclusion efforts, especially in diverse and populous nations. Taiwan's study st_04 highlights

community support for remote schools, pointing to localized, community-driven solutions as pivotal in bridging educational digital disparities. Malaysia, through study st_12, focuses on ICT training programs for rural youth, emphasizing skill development as a primary tool for empowerment and digital inclusivity. The Philippines, as highlighted in study st_02, leverages telecenters to enhance connectivity, indicating the nation's strategy of centralized hubs as a solution for regional disparities. To sum up, as illustrated by their respective study IDs, the countries present a tapestry of global efforts against digital divide. From traditional community-driven approaches to technologically advanced solutions, diverse strategies underscore the adaptability and multifaceted nature of efforts to ensure digital inclusivity across different geographies and cultures.

A cornerstone of the digital divide is not just access to technology but also the ability to effectively communicate using these platforms. The studies presented highlight the importance of both these elements in addressing the divide. **Table 3** shows the digital divide analyses.

Table 3. Digital divide analyses

ID	Country	Digital divide perspective	Divide level	Divide varieties	Intervention types	Tools
st_14	Chine	A study was conducted to increase capacity of elderly patients to use mobile health devices through social activities.	Skills & capacities level	Age & patient	Micro	Social activities
st_07	Canada	It is based on examining expert opinions on projects to be developed for people living in regions that are disadvantaged due to digital transformations in Canada.	All levels	Geographical divide	Policy	
st_10	Canada & Australia	It focuses on customizing applications to enable older people's technological adaptations, especially in mobile technologies. In other words, it aims to create a conceptual structure to increase digital skills. To test feasibility of idea, elderly people were allowed to experience customized applications.	Skills level	Age divide	Policy & micro	Mobile applications
st_06	Indian	Technology-mediated learning approaches can provide learning opportunities for older adults interested in using ICTs, helping them identify potential benefits & acquire necessary skills. Customized training approaches for older adults can be implemented by organizations to bridge digital divide. It is important for academics to be mindful of individuals' time & availability when designing & implementing such approaches.	Skills & capacities level	Age & ethnical divide	Micro	Training
st_09	South Africa	It focuses on providing access to digital tools through libraries for those living in regions with difficulty accessing digital resources in South Africa.	Access level	Geographical divide	Macro	Library
st_03	UK	It examines digital proficiency of senior population in the UK, which has been identified as having limited adeptness in utilizing digital mobile technologies. Within scope of this investigation, libraries facilitated training sessions to enhance digital competencies of this demographic.	Skills level	Age divide	Micro	Library
st_01	Ghana	It examines mobile libraries developed to provide access to digital resources to people living in upper eastern region of Ghana who cannot access digital resources & cannot use mobile devices.	Access level	Geographical divide	Macro	Library
st_11	Indonesia	It focuses on examining views of NGOs that organize training on digital media literacy & increasing educational opportunities for women in Indonesia, especially in rural areas where the digital divide is more pronounced.	Access & skills level	Gender & geographical divide	Policy & macro	Training

Table 3 (Continued). Digital divide analyses

ID	Country	Digital divide perspective	Divide level	Divide varieties	Intervention types	Tools
st_13	UK	Providing access to technology & the Internet connectivity to digitally disadvantaged individuals, such as through initiatives that offer laptops & stable internet connections at school. It is offering support & training to enhance digital skills, particularly for those who lack sufficient knowledge and confidence to engage online effectively.	Access & skills level	Geographical divide	Micro	Project
st_05	China	It focused on family intergenerational learning projects that can be implemented to bridge digital divide for rural older adults, providing a practical & individualized strategy for digital literacy.	Skills level	Age & geographical divide	Micro	Project
st_04	Taiwan	The study is related to community support to provide the needed resources in remote schools is essential for bridging the digital divide for children in remote areas.	Access & skills level	Geographical divide	Micro	Project
st_12	Malaysia	The study is focused on providing ICT training programs like the RIGHT program, which equips rural youth with new knowledge and skills necessary to engage in occupation and work activities, generate income, and contribute to their communities.	Skills level	Geographical divide	Micro	Training
st_08	Canada	It is related to arts-based practitioners and community members as in-person facilitators to enhance participation in digital delivery of programs, with access to appropriate training, technology, and technical skills.	Skills level	Age divide	Micro	Training
st_02	Philippine	The study is related to the effectiveness of telecentres that aim to improve connectivity, bridge the digital divide, and promote social and economic development.	Access & skills level	Geographical divide	Macro	Telecenter

Outcome of Studies

Older adults & digital inclusion

A significant portion of the studies underscore the digital inclusion challenges and opportunities for older adults. Zhao et al. (2023) identified accentuates the imperative role of social activities in fostering digital capability among the elderly. This is further elaborated by Neves et al. (2018), which challenges prevalent assumptions concerning technology use among this age bracket, emphasizing the myriad factors underpinning their digital inclusion or exclusion. Tailored technology development for older adults, especially those from ethnic minorities, is explored (Choudrie et al., 2022). Casselden (2023) reports the tangible outcomes of a pilot initiative that equipped sheltered housing residents with digital skills. Adding a familial dimension, Cheng et al. (2022) spotlight the promise of family intergenerational learning as a method to enhance digital literacy among rural elderly residents in China. Lastly, Kosurko et al. (2022) casts light on a dance program's potential, delivered via diverse technological mediums, in bolstering the social inclusion of older adults in rural locales.

Equity, inclusivity, & infrastructure

A series of studies place a pronounced emphasis on equity, inclusivity, and the foundational infrastructure pivotal for digital access. Jetha et al. (2023) elucidate the paramount of equitable and inclusive design principles in the domain of digital technology. Advocacy for policy evolution is central (Lediga & Fombad, 2018), which posits that equipping public libraries to bridge the digital chasm is vital. An on-ground examination of the library connectivity project in Ghana (Ayoung et al., 2020), underscores its contributions

and the impediments it faces in democratizing ICT access for school students in secluded regions. The youth's digital proficiency and the cardinal role schools can play in bolstering it is the crux of study (Wilkin et al., 2017).

Role of community & organizations in digital literacy & inclusion

The role of community organizations and institutional bodies is another discernible theme. Suwana and Lily (2017) bring to the fore the instrumental role of specific organizations in assuaging the digital media literacy vacuum and in the empowerment of Indonesian women. Community engagement, as showcased by ChanLin et al. (2015), which elucidates the synthesis of volunteer services with tablet-based reading promotion for children in far-flung areas, is deemed invaluable. The potency of knowledge management practices in elevating the digital capacities of rural youth is the core message (Vong et al., 2017).

Reconceptualizing digital divide & its factors

Certain studies beckon a more nuanced understanding of the digital divide. Neves et al. (2018) exhorts the academic and practitioner community to reconceive the age-delineated digital divide, advocating for an appreciation of the heterogeneity of older adults' tech interactions. Jetha et al. (2023), meanwhile, introduces the notion of the 'resource divide', underlined by socio-economic variables.

Programs, projects, & training

Several studies are anchored in examining specific programs and training endeavors. Choudrie et al. (2022) vouched for technology-mediated learning as a viable avenue for older adult training. The transformative potential of the housing plus pilot for sheltered housing inhabitants is documented (Brown, 2023). The family intergenerational learning initiative (Cheng et al., 2022), presents a fresh perspective on leveraging familial bonds for digital literacy upliftment in rural China. The multifaceted delivery modalities of the sharing dance older adults program and their ramifications for social inclusivity form the essence (Kosurko et al., 2022).

DISCUSSION

This systematic review aimed to provide insights into the role of communication-mobile technologies in promoting digital inclusion over the past decade. The 14 studies reviewed reveal several notable findings that further the discourse on leveraging technology to empower diverse populations.

Aligning with the introduction and literature review, the studies underscore the multifaceted nature of the digital divide. The analysis reveals how it manifests across geographical, socioeconomic, and demographic dimensions (Abu-Shanab & Al-Jamal, 2015; Aruleba & Jere, 2022). The studies also reinforce the classification of the divide across infrastructure, skills, and utilization capacities (Dalgic-Tetikol et al., 2022; van Dijk, 2020). These insights mirror the discussions in the literature review concerning the layers and varieties comprising the digital divide.

Communication and access are two pivotal elements emerging from the reviewed studies. Enhancing digital access through community hubs like libraries and telecenters is a recurrent theme (Feurich et al., 2023; Furuholt & Kristiansen, 2007). Simultaneously, customized communication approaches, like leveraging libraries as training centers, also come to the fore (Mendoza-Lozano et al., 2021). This aligns with the introduction's emphasis on communication-mobile technologies as enablers of digital participation.

The importance of multi-tiered policy, macro, and micro-level interventions is pronounced in the findings (Ginossar & Nelson, 2010). This corresponds with existing discourse on bridging digital divides through cross-sectoral efforts (Neves & Mead, 2021; Vassilakopoulou & Hustad, 2023). The potential of arts, libraries, training, and mobile platforms also mirrors the introduction's discussion of communication technologies facilitating digital inclusion.

Some nuances do emerge. The role of community organizations, knowledge management practices, and importance of localized solutions are notable findings (Ginossar & Nelson, 2010; Zhao et al., 2023). The studies also highlight the need to reconceptualize digital divides, aligning with recent literature emphasizing critically examining such divides before interventions (Vassilakopoulou & Hustad, 2023).

However, certain aspects remain underrepresented. Gender and ethnicity-related findings are limited (Abu-Shanab & Al-Jamal, 2015; van Dijk, 2020). Disability and health divide dimensions highlighted in the literature review receive scarce mention (Croicu & Kreutz, 2017; Duplaga, 2017). The global south finds inadequate representation, with prominent studies skewed towards developed contexts (Aruleba & Jere, 2022; Ragnedda & Muschert, 2013). These gaps indicate potential areas warranting further investigation.

In summary, while substantial convergence exists between the systematic review findings and the topics highlighted in the preliminary sections of the paper, scope remains for enrichment. Expanding the discourse to address inadequately explored divides, demographic groups, and geographic regions can further enhance the conceptualization of communication technologies' role in promoting digital inclusivity. This systematic review offers a timely snapshot of the research landscape, providing a launch pad for continued interrogation of the digital access and participation challenges confronting diverse populations across the globe.

CONCLUSIONS

This systematic review synthesized evidence from 14 studies published between 2015-2023 that examined the role of communication technologies in bridging the digital divide. A rigorous search and screening process was employed to identify relevant articles from Scopus and Web of Science databases. A structured analytical framework was developed to assess the studies, providing insights into the multidimensional nature of digital disparities globally.

Key findings that emerged included the prominence of age and geographical divides and the importance of customized, communication-centric interventions like mobile applications, libraries, training programs and telecenters to address these gaps. The review highlighted the value of multilayered strategies spanning top-down policies, large-scale projects and grassroots initiatives tailored to local needs.

The studies underscored the centrality of communication-oriented solutions that not just provide access but build digital literacy, skills, and meaningful usage. While physical infrastructure is indispensable, developing content, training approaches and technologies designed around human communication and interaction are equally vital for digital inclusion.

However, the review has some limitations including its exclusive focus on English articles and two databases. Future systematic reviews could incorporate literature in other languages and use additional databases to mitigate language and database biases. The conceptual framework could also be expanded to encompass more divide typologies.

Nonetheless, this review makes notable contributions to research on communication technologies and digital inclusion. It provides a rigorous synthesis of evidence that policymakers, technology designers and practitioners could draw on to develop comprehensive, communication-centric and context-specific digital inclusion initiatives. It charts directions for future research on evidence-based solutions tailored to marginalized groups. Overall, the review highlights the pivotal role communication technologies could play in democratizing digital participation and bridging entrenched divides if deployed thoughtfully.

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