Unmasking Inequalities: Examining the Digital Divide's Impact on Vulnerable Populations and Pathways towards Digital Inclusion

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Abstract

The COVID-19 pandemic accelerated digital transformation while deepening social inequalities, especially for financially precarious groups. This qualitative study examines how the digital divide shaped access to education, healthcare, employment, and social support among low-income households, children, and people with disabilities in Tyrol, Austria. Based on 179 interviews, it shows how limited access, low digital literacy, and inaccessible design intensified exclusion and burdened both citizens and street-level bureaucrats. The findings highlight digital inclusion as a structural necessity for equitable public services and social resilience.

Keywords: Digital Divide, Social Inequality, Digital Inclusion, Social Determinant of Health, Digital Literacy

Introduction

The COVID-19 pandemic not only precipitated an unprecedented global health emergency but also acted as a powerful accelerant for digital transformation across different life domains, including education, work, healthcare, social services, and governance. While the immediate morbidity and mortality of COVID-19 dominated early analyses, its longer-term effects on the social determinants of health have been equally profound. In particular, the rapid shift to online modalities exposed and magnified a pre-existing digital divide. It increased the gap between those with ready access, skills, and meaningful engagement in digital environments and those without (van Dijk 2017; Sieck et al. 2021). E-government platforms have become increasingly important as a critical service delivery tool during lockdowns. By 2024, 39 percent of countries had achieved "very high" e-government development scores, partly due to new e-participation and digital literacy metrics targeting vulnerable groups (United Nations Department of Economic and Social Affairs 2024). However, these shifts also intensified disparities for households

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lacking sufficient infrastructure or skills (World Health Organization 2021; Ramsetty/ Adams 2020). When these digital platforms are implemented with an equity lens, they can not only close gaps in access and skills but also empower individuals and communities to move from passive users to active co-creators of health and social services. Building on this shift in agency, a deeper understanding of these dynamics emerges when digital factors are viewed not merely as adjuncts to social determinants but as "super determinants of health" that impact every layer of the socio-ecological system. In adapting the Dahlgren-Whitehead "rainbow" model to the digital age, Jahnel et al. (2022) propose a "digital rainbow" framework in which digital determinants, ranging from device affordability and connectivity to algorithmic design and user interface, interact with traditional social determinants to shape health equity (Jahnel et al. 2022). Chidambaram et al. (2024) further argue that digital determinants of health (DDOH) should be formally defined as the technological factors intrinsic to the design, implementation, and use of digital health services that influence access, quality, and equity. This perspective helps explain seemingly contradictory findings, disadvantaged groups may engage with certain low-barrier digital tools (e.g., wearables) yet struggle with more complex applications such as telemedicine, which require greater digital literacy and cognitive input (Fernandez et al. 2021; Kickbusch et al. 2021).

Despite growing recognition of digital inequalities, empirical evidence from the DACH region remains scarce. Badr et al. (2024) found 41 studies on digital health technologies and inequities, primarily from the U.S., U.K., Australia, and parts of Europe and Asia, but none from Germany, Austria or Switzerland. In Tyrol, Larasati et al. (2023) report that many low-income households lacked reliable broadband for remote schooling and telework, heightening social exclusion and health risks. Austria's fixed-line infrastructure still lags the EU with only 41 % of households having Fibre-to-the-Premises (FTTP), well below the EU average of 64 %, and 67.6 % access to Very High-Capacity Networks (VHCN) versus 78.8 % EU-wide (European Commission 2024). At the same time, digital literacy remains uneven. About 63 % of Austrian adults aged 16–74 have at least basic digital skills, slightly above the EU-27 average of 54 %, yet those with university-entrance qualifications are over six times more likely to possess these skills than those with compulsory schooling, and older cohorts face 70–80 % lower odds of basic competencies (Statistics Austria 2023). While policy measures seek to bridge these gaps, empirical research guiding these equity-centered interventions is essential.

This study investigates how the COVID-19 pandemic's digital divide shaped health outcomes, access to social support, social participation, and educational opportunities among vulnerable households in Tyrol, Austria. It addresses three interrelated gaps. First, it provides a feedback-oriented evaluation of local and national policies enacted during the COVID-19 crisis to mitigate the digital divide, highlighting both their strengths and limitations. Second, it underscores the importance of e-participation and citizen engagement in policymaking, drawing on principles from the 2024 UN E-Government Survey to argue for more proactive integration of public input in digital governance (United Nations Department of Economic and Social Affairs 2024). Third, it offers empirical insights of low-income households in Tyrol, examining the impacts of digital exclusion on health, education, social support, and civic participation. The paper proceeds as follows: first, key concepts of the digital divide and digital determinants of

health will be reviewed; then, empirical findings from Tyrol will be presented; next policy interventions will be evaluated and finally, implications for future interventions aimed at embedding digital inclusion as a core component of social equity and public health resilience will be discussed.

The Digital Divide: Implications for Society and vulnerable populations

The digital divide refers to disparities not only in physical access to digital technologies but also in the skills necessary to use these technologies effectively and in the capacity to derive meaningful benefits from them. These disparities shape multiple dimensions of social life, including education, employment, healthcare, and civic participation (National Digital Inclusion Alliance [NDiA] 2024; van Deursen/ van Dijk 2019; van Dijk 2017). Although roughly two-thirds of the global population is connected to the internet, significant regional, socioeconomic, and demographic inequalities continue to impede universal inclusion. In Europe, approximately 90 % of households have internet access, with countries such as Denmark and the Netherlands achieving near-universal connectivity. By contrast, eastern and southern European countries, including Greece, Croatia, and Bulgaria, trail with penetration rates around 85 % . Even in Austria, certain population segments remain excluded from digital participation (Eurostat 2025) (This disparity underscores that physical access alone is insufficient to ensure full participation in an increasingly digitalized society. Beyond physical access, the digital divide encompasses inequalities in digital literacy: the ability to use technologies effectively, confidently, and critically. Hargittai (2003) identifies four key influences on digital engagement: (1) the quality of available equipment and internet connections; (2) autonomy in technology use; (3) social support for guidance and problem-solving; and (4) familiarity gained through regular practice. These factors often interact with broader structural inequalities, compounding disadvantages for vulnerable populations. For instance, individuals with access to the internet may still lack the confidence or skills to benefit from online services such as e-government platforms or telemedicine. In Austria, the Digital Society Index highlights persistent gaps in digital competencies, especially among older adults and low-education groups (Statistics Austria 2023). This second-level divide, which focuses on differences in digital competencies, has become increasingly recognized as the primary driver of digital exclusion in many contexts (van Deursen/ van Dijk 2019). As digital services become essential for everyday life, failing to address digital literacy risks reinforcing social inequalities.

Income decisively shapes digital access and competence, directly influencing an individual's capacity to participate in contemporary society. Low-income households often face the dual challenge of affordable device shortages, internet service limitations, and reduced opportunities to develop digital skills. This lack of access and competence translates into cumulative disadvantage across key life domains, including education, employment, and social participation (Van Lancker/ Parolin 2020). Without targeted intervention, these disparities risk creating self-reinforcing cycles of exclusion that extend across generations. For example, children from low-income households without digital tools for remote learning are more likely to experience educational setbacks that impact their future opportunities. Thus, the digital divide is not merely a technological issue but a pressing social and economic concern with the potential to reshape societal structures unless addressed.

Intersectionality further amplifies these challenges. Vulnerable groups, such as low-income children, migrants, people with disabilities, and older adults, often face overlapping barriers that restrict their digital engagement (Cuevas Barron et al. 2022). Importantly, however, the barriers faced by these groups are not identical. Low-income households primarily experience economic exclusion, which limits both device ownership and access to digital opportunities, whereas people with disabilities often encounter design-based exclusion stemming from inaccessible technologies, insufficient assistive tools, and inadequate support systems (Pacheco/ Burgess 2023; WHO 2022). Similarly, migrants may confront language barriers or unfamiliarity with local digital infrastructures, while older adults face age-related obstacles to technology adoption. By examining these populations in parallel, this paper provides a multi-layered understanding of how digital inequalities manifest across social, economic, and health domains, identifying both shared vulnerabilities and specific barriers that require tailored solutions.

The consequences of digital exclusion extend across multiple sectors, affecting not only individual life chances but also broader societal resilience. In education, unequal access to digital tools and online learning platforms has widened achievement gaps, particularly during the COVID-19 pandemic when remote learning became essential (Van Lancker/ Parolin 2020). In employment, digital exclusion limits access to job opportunities, remote work, and lifelong learning, exacerbating labour market inequalities (Canton et al. 2021; Fernandes 2020). In healthcare, digital literacy barriers prevent marginalized populations from benefiting from telemedicine, patient portals, and remote monitoring services (Cuevas Barron et al. 2022; Lee et al. 2022). Similarly, in the realm of social participation, exclusion from digital spaces compounds social isolation, particularly for individuals in rural areas, older adults, and people with disabilities (Pithawalla/ Chhabra 2023). These sectoral impacts demonstrate that digital exclusion is not confined to any single domain but permeates multiple aspects of daily life.

Civic technology, defined as the co-creation and use of digital tools to enhance transparency and public participation in democratic processes, adds a further dimension to this debate (Kickbusch et al. 2021). Without inclusive civic technologies, vulnerable groups risk exclusion not only from essential services but also from decision-making processes that shape their digital futures. By integrating participatory digital platforms into governance and health systems, civic technology can help shift power dynamics, enabling citizens to become co-creators rather than passive recipients of services.

Efforts to bridge the digital divide must therefore involve sustained, multi-level strategies that simultaneously target access, literacy, and meaningful participation. At the policy level, governments should ensure universal, affordable internet access, invest in infrastructure, and integrate digital literacy into education systems (Richardson et al. 2022; WHO 2024a, 2024b). At the design level, inclusive technologies must be prioritized to meet the diverse needs of users, particularly people with disabilities, older adults, and individuals with limited literacy (Pacheco/ Burgess 2023). At the community level, localized initiatives, such as telemedicine programs coupled with digital literacy support, can help to overcome exclusion while fostering trust (Laschkolnig 2021; Lyles et al. 2022). These pathways towards sustainable digital inclusion will be further explored in the results and following discussion section, with a focus on transforming digital inequality into opportunities for social inclusion and resilience.

Methods

This study employed a qualitative research design to explore the lived experiences of vulnerable individuals during the COVID-19 pandemic, with a particular focus on the challenges of poverty, instability, and digital exclusion. Data were collected through biographical-narrative and problem-centered interviews (Scheibelhofer 2008), which allowed for in-depth examination of participants' life histories, including their educational pathways, employment trajectories, family circumstances, health status, and access to social support. This approach provided rich, context-sensitive insights into the social determinants shaping their experiences (Orton 2019). Between March 2020 and February 2022, a total of 179 interviews were conducted in Tyrol, Austria.

Participants were recruited through multiple channels, including flyers and posters placed in key community locations, as well as through trusted intermediaries such as counselling agencies and local gatekeepers. To build rapport and ensure diverse representation, a combination of snowball sampling and gatekeeper-mediated recruitment was used, supplemented by direct outreach at food banks. This multifaceted strategy aimed to avoid selection bias and over-representation of specific subgroups (Groger et al. 1999; Kawulich 2011).

The sample was composed to reflect the most vulnerable groups (Min 2021), specifically including individuals and households who self-identified as experiencing financial distress, such as difficulties in paying rent, utility bills, or covering essential living expenses. This subjective allocation was a prerequisite for participation, ensuring that those interviewed personally experienced economic hardship and instability. The sample encompassed diverse populations disproportionately affected by the pandemic's digital divide, including children from low-income families, working poor adults, persons living below the poverty threshold, and individuals with legally acknowledged disabilities who simultaneously faced economic insecurity. This approach enabled the study to capture intersectional vulnerabilities and the compounding effects of poverty and digital exclusion on daily life, while also preserving the authenticity of participants lived experiences (Orton 2019). In total, 143 individuals experiencing financial precariousness were interviewed, including children (9–16 years), working poor, people living below the poverty threshold, and people with legally acknowledged disabilities (and their relatives) experiencing poverty. To complement these perspectives, street-level bureaucrats from social and health services were also interviewed, providing insights into the challenges of service delivery and support provision under pandemic conditions (see Table 1 for sample details).

SAMPLE	SIZE (N)
CHILDREN (9-16 YEARS)	21
WORKING POOR	40
PEOPLE EXPERIENCING POVERTY (LIVING BELOW THE POVERTY THRESHOLD)	54
PEOPLE WITH DISABILITEIS (LEGALLY ACKNOWLEDGED DISABILITIES) & RELATIVES EXPERIENCING POVERTY	28
TOTAL NUMBER OF PEOPLE EXPERIENCING FINANCIAL PRECARIOUSNESS	143
STREET-LEVEL BUREAUCRATS	36
TOTAL SAMPLE	179

Table 1: Sample description

To deepen the understanding of individual trajectories, the study employed biographical reconstructions (Rosenthal et al. 2004) to explore key life events such as job loss, poverty onset, and health challenges. An inductive qualitative content analysis (Mayring 2014) was conducted to systematically organize the data and identify recurring themes and processes related to poverty, digital exclusion, and health risks. The 36 interviews with frontline service providers were also analyzed and integrated to offer complementary insights into service delivery challenges during the pandemic. Maintaining focus on rich data, nuanced, context-specific insights, and avoiding overgeneralization from a purposively selected sample, quantitative analysis was not employed, since numerical summaries cannot capture the complexity of individual trajectories unveiled through biographical reconstruction and inductive content analysis (Ahmad/ Wilkins 2024; Goodrick/ Rogers 2015).

The study adhered to established ethical research standards throughout. All participants were fully informed about the research aims, procedures, and their rights, and provided written informed consent; for minors, consent was obtained from legal guardians (Wiles et al. 2006; Sanjari et al. 2014). Anonymity and confidentiality were strictly maintained. Participants received compensation of €50 for individual interviews and participating children received €80. The study received ethical approval from the university's ethics committee.

Results

This study draws on 179 interviews conducted with diverse vulnerable populations in Tyrol, Austria, during the COVID-19 pandemic to examine how the digital divide shaped experiences of education, employment, social participation, and access to essential services. The analysis is organized into four thematic areas: (1) education and youth, (2) poverty, exposure, and social benefit uptake, (3) people with disabilities, and (4) service provision and the role of street-level bureaucrats. While these groups share exposure to digital exclusion, it is essential to recognize that the underlying mechanisms and impacts differ substantially. For low-income households, material deprivation and limited digital literacy create barriers to participation. For people with disabilities, exclusion often stems from inaccessible technologies and insufficient institutional support. This differentiated analysis highlights both commonalities and group-specific challenges.

Education and youth: Digital Disparities in Learning Access

The shift to digital learning during the COVID-19 pandemic exposed deep-rooted inequalities affecting children from low-income households, particularly in their ability to access education through digital means. The findings reveal that these children were disproportionately impacted by the digital divide, which hindered their capacity to participate effectively in online schooling. A primary challenge concerned limited access to personal digital devices. Many children were forced to share a single device with multiple family members, resulting in scheduling conflicts that disrupted their learning. As one participant explained: "Mostly I used my mobile phone at

home, so I don't have a computer or tablet at home" (KJSA-005&006)3. This situation was often compounded by unreliable internet connectivity. As another interviewee remarked, "But what good is a rented laptop if you have no internet connection?" (AD-016)4.

Even when families managed to borrow devices from schools, these solutions frequently failed to meet the practical demands of remote learning. Participants reported that borrowed equipment was sometimes incompatible with necessary software or came without basic programs such as Word. As one parent noted: "I didn't have a laptop either, but we were able to apply for one at school (...) but the internet didn't work on the laptop, there was no Word or anything like that" (KJ-001)5. These combined material barriers created significant obstacles for children attempting to complete assignments, attend online lessons, or maintain communication with teachers.

The physical environment further constrained children's learning. Many participants described how overcrowded living spaces left children without private, quiet areas to engage in schoolwork. One parent pointed out: "Not every child had a room of their own, and therefore a quiet place to study" (WP-023)6. For families with several children, the lack of sufficient devices and space meant that some children were excluded from online classes entirely. As another participant shared: "We only have one laptop. The 23-year-old bought one for themselves, then the 15-year-old got one, but the 13-year-old still doesn't have one (...) it was difficult" (WP-023). These conditions intensified existing educational inequalities by systematically limiting the learning opportunities available to children from disadvantaged households.

Beyond material deprivation, digital literacy emerged as a major barrier for both children and parents. Many families lacked the knowledge or confidence to support online learning effectively, which one participant described as a form of "new illiteracy": "What used to mean not being able to read and write is now called not being able to use a computer" (WP-006)7. Inconsistent communication from schools, delivered across multiple channels such as email, SMS, and WhatsApp, further complicated matters. This fragmented approach led to confusion and heightened stress, particularly for parents with limited digital skills or language proficiency. For children with migrant backgrounds, the absence of in-person interaction with teachers and peers intensified emotional distress and hindered learning progress.

Participants consistently reported that the quality of online education varied significantly depending on the resources of individual schools and the commitment of teachers. Many families, especially those for whom German was not the first language, expressed frustration over the lack of structured, coherent guidance during remote schooling. One participant summed

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[3] KJSA-005&006: Female, age: 15 (005) & 14 (006), native, secondary school, living situation: 005 (no single room), 006 (single room), learning mode: distance learning & on-site.

[4] AD-016: Male, age: 15, native, education: middle school, communication: Zoom call, learning mode: distance learning & on-site.

[5] KJ-001: Female, age: 15, native, education: middle school, digital access: shared laptop, internet: unstable connection, learning mode: emergency support (lessons).

[6] WP-023: Male, age: 45, sufficient language skills, married, 5 children, overcoming depression & long COVID, employment: part-time & marginal, communication: phone.

[7] WP-006: Female, age: unknown, native, single parent (1 child), education: university degree, employment: part-time, residence: property, communication: Zoom.

up the experience: "It was a nightmare in terms of quality (...) it was just to cry" (KJ-002)[8]. The cumulative effects of these barriers were profound. Many children experienced not only academic setbacks but also growing feelings of isolation, helplessness, and psychological strain. As one child described: "During the first lockdown, I developed a severe depression. Everything seemed so impossible" (KJ-002).

Overall, these findings demonstrate that the educational challenges experienced during the pandemic were not solely the result of material deprivation but were exacerbated by systemic failures in digital literacy support, educational communication, and mental health provision. Without targeted interventions that address both access and skills, digital schooling risks perpetuating and deepening existing inequalities in education and well-being. Importantly, however, the effects of digital exclusion extended beyond the field of education, shaping the daily lives of low-income families as they struggled to access essential social benefits and services during the pandemic.

Poverty Exposure and take-up of social benefit

The intersection of financial insecurity, educational disruption, and the increasing reliance on digital systems during the COVID-19 pandemic placed significant strain on low-income families. Many participants described the overwhelming pressures of managing multiple responsibilities, such as childcare, home-schooling, household duties, and, for some, remote work, without adequate resources or support. One participant, a single parent, shared: "If I fall, my children fall. And this pressure to keep going and not to fall takes a lot of energy. I have also had to juggle a home office, home schooling, care work and housework with two children. The multiple stresses of being a working single parent increased" (ONL_ADWP_006)[9]. This accumulation of stress contributed to severe mental health impacts, including heightened anxiety, emotional exhaustion, and burnout.

Digital exclusion further compounded these challenges by limiting families' access to essential services. The move to digital-only systems for financial aid, housing support, and healthcare created high entry barriers for individuals with limited digital literacy or language proficiency, particularly in navigating complex bureaucratic German. Some parents reported having to rely on their children's digital abilities to complete online applications. "The children filled out the applications," one participant recalled (AD-012)[10]. An experience that not only reversed traditional family roles but also exposed parents' vulnerability in front of their children. As one participant described, the combination of digital illiteracy, language difficulties, and lack of official guidance left many feeling frustrated and helpless. Several participants shared that they eventually abandoned efforts to access benefits altogether, unable to cope with the stress of navigating inaccessible formal processes, effectively excluding themselves from the social safety net.

These barriers exposed and amplified long-standing inequalities in access to digital technologies that are now essential for full social participation. To address the urgent need for digital

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[8] KJ-002: Female, age: 15, native, secondary school, learning mode: distance learning & on-site, digital access: own laptop, communication: Zoom.

[9] ONL_ADWP_006: Female, age: 45, divorced, university degree, 2 children, employment: full-time, income: < 2,900€ (net).

[10] AD-012: Female, age: 51, divorced, seeking employment, poor language skills, face-to-face interview.

devices during the pandemic, the regional government of Tyrol, in cooperation with the Chamber of Labour, introduced the "Digi-Scheck" program. This initiative offered subsidies aimed at helping low-income households purchase laptops or tablets for educational use: "[...] to financially support low-income families in the purchase of digital devices to enable e-learning" (Land Tirol, 2021). While well-intentioned, the program's strict eligibility criteria and limited financial support meant that many families were unable to benefit.

Participants highlighted several shortcomings of the program. Some were excluded due to rigid purchasing timelines or found the partial subsidy, covering up to 50% of the cost, capped at €250, insufficient given that school-required devices typically cost between €700 and €800. One parent reflected this frustration: "The funding initiative was very unsupportive (...) if a family has several children" (WP-023). For many families, even with support, the remaining financial burden was too high. Some resorted to leasing devices from private foundations, incurring monthly rental costs that ultimately exceeded the price of outright purchase. As one participant noted: "We've rented one now, with monthly rent, the second laptop" (KJ-007-008)11. These coping strategies, while temporarily effective, often deepened financial stress and failed to offer sustainable solutions.

Taken together, these findings highlight that digital exclusion among low-income households is not merely a question of access to devices but reflects deeper structural inequalities related to income, digital literacy, and institutional design. Without coordinated efforts to address both material needs and digital competencies, policies risk leaving the most vulnerable groups further behind in increasingly digitalized societies. At the same time, beyond the challenges linked to poverty and digital literacy, the pandemic also exposed distinct barriers faced by people with disabilities, for whom accessibility and usability of digital systems created unique forms of exclusion.

People with Disabilities: The Double-Edged Impact of Digitalization

The COVID-19 pandemic highlighted significant digital exclusion among people with disabilities (PWD), revealing how digital platforms and services often failed to meet accessibility needs. Participants described numerous barriers that prevented PWD from fully engaging with online services, including inadequate design and limited availability of accessible information. For instance, while some public platforms, such as the Austrian employment service eAMS, facilitated remote communication, these were not accessible to blind users: "Unfortunately, it's not accessible for blind people" (VP-22)12. Even where efforts were made to provide information in simplified formats, coverage was inconsistent: "Brochures in easy-to-read standards are being produced but not across the board" (VP-22). These deficits limited access to vital services precisely at a time when in-person interactions were restricted.

Service provision challenges were further exacerbated by the shift to remote formats during the pandemic. Participants shared that digital meetings were often inaccessible for visually impaired individuals, particularly when presentation materials could not be read through screen

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11 KJ-007-008: Male, age: 13 & 15, native, middle school, learning mode: distance learning & on-site, digital access: own laptop, communication: Zoom.

12 VP-22: Gender and age not specified, employment: vocational and social services, communication: face-to-face interview.

readers or other assistive tools: "I can hear this quite well, but with a PPT, I have no chance because I can't read it" (VP-5)[13]. While some respondents acknowledged that digital tools, such as video conferencing, offered advantages for people with mobility restrictions by reducing the need for travel, these benefits were consistently seen as conditional on system accessibility and user-friendliness. As one participant summarized: "Disabled customers often can't cope with online offers. They are overwhelmed" (VP-17)[14]. This highlights that usability, not simply access, was the core barrier for many.

Digital literacy emerged as a second major challenge, affecting both PWD and the support staff who assist them. Some individuals with disabilities reported being daunted by the technical skills required to navigate increasingly digital systems. Similarly, older support workers struggled to adapt to new technologies, limiting their ability to help clients effectively. This dual gap, both on the side of users and providers, intensified exclusion and underscored the urgent need for targeted digital skills training for both groups.

In the context of employment, participants highlighted persistent challenges in integrating PWD into increasingly digital workplaces. Employers expressed hesitation about hiring or accommodating employees with disabilities, often citing limited resources and uncertainty about the use of assistive technologies. Despite the existence of funding for workplace adaptations, many employers failed to provide essential equipment such as laptops or ergonomic devices. One employer remarked: "We don't get money or anything else, not even for an office or a workplace adjustment, like laptops, monitors, etc." (VP-10)[15]. These barriers extended beyond physical tools to affect wage structures, with some employers justifying reduced pay during extended learning phases: "First learning processes, then seeing if he can be given small tasks. He is not yet in the productivity, so I think it's fair not to pay him" (VP-10).

The shift to digitalization also increased social isolation for PWD, particularly those classified as high-risk during the pandemic. The elimination of physical workplaces and the automation of simple tasks marginalized individuals who previously relied on in-person interactions for both employment and social inclusion. "In the severely disabled sector, it is very important to build a relationship and a basis of trust. That's why personal advice is necessary," one respondent explained (VP-17). Participants underscored the importance of personal relationships and trust in disability services, which digital platforms could not replace.

Taken together, these findings highlight that digital exclusion for people with disabilities is not solely a matter of device access or connectivity but is deeply rooted in inaccessible design, insufficient digital skills, and the erosion of interpersonal support structures. Without inclusive digital systems and ongoing personal engagement, the rapid shift to digital service provision risks further marginalizing people with disabilities both socially and economically. Importantly, however, the challenges posed by digitalization were not limited to service users alone. The shift to digital systems also placed considerable new demands on those responsible for delivering support, particularly street-level bureaucrats managing the frontlines of social assistance during the pandemic.

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[13] VP-5: Male, age: 71, married, hearing-impaired, employment: retired but volunteer leadership & advisor, communication: face-to-face interview.

[14] VP-17: Female, employment: team leader, communication: telephone interview.

[15] VP-10: Male, age: 35–40, employment: leadership role, communication: face-to-face interview.

Service Provision and Street-Level Bureaucrats

The COVID-19 pandemic placed pressure on street-level bureaucrats, who serve as the frontline of social service delivery. The surge in demand for assistance, combined with an accelerated shift to digital platforms, significantly reshaped their roles and workloads. Many bureaucrats expressed frustration with the exclusive reliance on digital systems, which created new barriers for both service providers and clients. As one participant explained: "Digital illiteracy, dealing with technical equipment for the digital world - these are massive challenges. You often hear comments like, 'Everyone has a smartphone.' But that's one thing; Email is another challenge. Governmental systems are often difficult to navigate" (FD-010)[16]. For many clients, especially those affected by poverty or with a migration background, operating online systems without adequate digital skills, internet access, or devices proved nearly impossible. As one bureaucrat noted, "Online services are often very difficult for people. Many clients consent to transfer the application process to their social workers, especially if there is a migration background, but paper forms are often easier. Filling in application forms online is challenging for many" (FD-017)[17].

The digital transformation of services also had indirect effects on mental health, which became a growing concern for both families and service providers. Participants observed a marked deterioration in the emotional well-being of children and adolescents, exacerbated by social isolation, fear of infection, and the psychological toll of recurring lockdowns. These factors led to increased stress, anxiety, and uncertainty, particularly when combined with long waiting times for mental health support. As one bureaucrat lamented, "What is totally missing are positions for mental health problems. (…) Financially and time-wise, psychotherapy is simply not feasible (…). People wait months for a spot to become available" (FD-009)[18]. Vulnerable families, already facing digital exclusion, were often unable to access online mental health services due to a lack of devices or internet connectivity. The high cost of private therapy presented yet another barrier, leaving many without adequate psychological support during a period of heightened vulnerability.

In response to these challenges, street-level bureaucrats frequently found themselves compensating for systemic shortcomings by assuming additional responsibilities beyond their core roles. Many were required to assist clients with online form submissions, mediate between clients and complex digital platforms, and deliver services that could no longer be provided in group settings. For example, bureaucrats observed that completing digital applications was often so difficult for clients that consent was routinely given for staff to handle these tasks: "People often give their consent for ZeMIT to do this. But paper would often be better. Filling out the application form is difficult for many" (FD-017). The shift to individualized and digital services created new demands for time and resources, particularly in areas such as outreach social work, disability services, and family support, where in-person contact remained essential.

Despite these increased demands, bureaucrats faced severe limitations in scaling up service provision. Recruiting additional personnel was often impossible within existing budget and

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[16] FD-010: Gender and age not specified, employment: management position, communication: face-to-face.

[17] FD-017: Gender and age not specified, employment: consultant, communication: face-to-face.

[18] FD-009: Gender and age not specified, employment: consultant, communication: Zoom.

time constraints. Furthermore, not all specialists were able to transition to digital service delivery effectively, as there was insufficient time and capacity to provide comprehensive training. These findings highlight that while digitalization offers potential efficiencies, it cannot fully replace the need for in-person, relational services in the social sector. Without adequate staffing, training, and hybrid service models, vulnerable populations risk further exclusion from essential care and support.

Collectively, these findings underscore how the rapid shift to digitalization during the pandemic created complex and uneven impacts across vulnerable populations, deepening existing inequalities in education, social support, and service delivery. Addressing these multifaceted challenges requires targeted interventions, which are discussed in the following section.

Discussion

The COVID-19 pandemic has exposed and deepened longstanding vulnerabilities within social systems, bringing pre-existing inequalities into sharp focus. The findings of this study underscore the multifaceted nature of the digital divide and its profound implications for health, education, social participation, and economic stability, particularly among vulnerable populations. By examining the experiences of low-income households, children, adolescents, and people with disabilities in Tyrol, Austria, this study highlights how systemic barriers and social determinants intersect with digitalization to perpetuate exclusion in an increasingly digital world. Importantly, this study reinforces the view that digital inclusion and exclusion exist along a continuum rather than as a simple binary, shaped by intersecting social, economic, and cultural factors (Badr et al. 2024). This perspective emphasizes that reducing exclusion is not only about overcoming access barriers but also about actively enabling participation through multi-level and tailored strategies.

The transition to digital platforms during the pandemic underscored the critical role of both technology access and digital literacy as fundamental determinants of social equity. For children and adolescents, the abrupt shift to remote learning revealed striking disparities in access to devices and stable internet connections, particularly for low-income households. Participants described how limited digital resources forced children to share devices or rely on outdated equipment, severely disrupting their ability to engage in distance learning. Beyond the issue of access, limited digital literacy among parents and caregivers compounded these challenges, creating a cascade of educational difficulties and emotional distress. These findings align with Van Lancker and Parolin's (2020) assertion that the digital divide risks entrenching intergenerational inequalities with lasting consequences for children's academic and social development. Critically, the impact of educational disruption extended beyond academic performance. Participants frequently reported heightened mental health challenges, including anxiety, stress, and depression, which were exacerbated by social isolation and the absence of school-based psychosocial support systems. This reinforces existing research that highlights the dual role of schools as not only educational institutions but also key sources of emotional stability and social inclusion, especially for disadvantaged families (Haider et al. 2023; UNICEF 2020; Województwo Lubelskie 2024).

While these educational inequalities were pronounced, the pandemic also exposed distinct barriers to digital participation among people with disabilities. The findings revealed how inaccessible platforms, inadequate assistive technologies, and the absence of inclusive design standards significantly limited the ability of people with disabilities to benefit from telemedicine, remote working opportunities, and online education (Pacheco/ Burgess 2024; WHO 2022). Employment emerged as a particularly acute challenge. The reliance on digital work often shifted responsibility for workplace adjustments onto individuals and their private spaces, undermining inclusion and reinforcing inequity. Research indicates that people with disabilities faced higher unemployment rates and were often excluded from short-time work programs, increasing economic hardship and psychological stress (Biewer et al. 2020). Addressing these disparities requires structural labour market reforms, including accessible workplace adaptations, employer training on inclusive practices, and targeted employment programs that meet the diverse needs of people with disabilities (BMSGPK 2020). The Austrian Disability Council's critique of the exclusion of disability organizations from early pandemic response planning demonstrates how systemic neglect can exacerbate exclusion (Behindertenrat 2020). These findings stress the importance of embedding disability-inclusive approaches into both crisis preparedness and long-term digital strategies.

Economic precarity intersected with digital exclusion to further disadvantage low-income households during the pandemic. Government initiatives such as the "Digi-Scheck" program were intended to reduce barriers to digital access by providing subsidies for device purchases. However, participants reported that bureaucratic complexities, strict eligibility requirements, and inadequate financial support limited the program's effectiveness. These findings echo global patterns in which digital exclusion compounds socioeconomic inequalities, leaving vulnerable households without the tools necessary to participate fully in digital education, employment, and public services (Aissaoui 2021; Sieck et al. 2021). Participants expressed frustration with the rigidity and limited scope of governmental aid, underscoring the need for more flexible, comprehensive, and context-sensitive interventions. The reliance on digital public services during the pandemic revealed structural inefficiencies and a lack of user-centred design, which disproportionately affected marginalized populations, including non-native speakers, older adults, and those with limited digital literacy. These findings reflect Van Dijk's (2017) broader theoretical perspective that digital exclusion encompasses not only physical access but also the capacity to use digital technologies meaningfully. Street-level bureaucrats, positioned as intermediaries, often bore the brunt of these challenges. They faced increased workloads as they supported clients in navigating complex digital systems, frequently taking on additional administrative tasks at the expense of their primary responsibilities. This highlights the urgent need for simplified, multilingual digital platforms and comprehensive staff training to better meet the needs of both users and service providers.

Moreover, the rapid shift to digital service provision placed considerable pressure on social and healthcare staff, many of whom struggled to remain current with evolving digital solutions amidst heavy workloads. Participants noted that time constraints, insufficient training, and the lack of organizational support prevented many employees from acquiring the digital competencies necessary to assist clients effectively. This not only limited the reach and efficacy of digital services but also contributed to staff burnout and reduced service quality. These findings point

to the need for hybrid models of service delivery that combine digital innovation with sustained in-person support, while ensuring that frontline workers receive adequate time, training, and resources to adapt to digital transitions.

The findings of this study reveal that the digital divide significantly shapes broader social determinants of health, including access to care, economic stability, and social participation (Sieck et al. 2021). Limited access to telemedicine and digital health tools during the pandemic delayed timely care for marginalized groups, further widening existing physical and mental health disparities. For people with disabilities, the lack of accessible digital health services not only compounded exclusion but also heightened vulnerability (WHO 2024b; Holm et al. 2022). While telemedicine and digital platforms hold great promise for reducing geographical and infrastructural barriers, they often remain inaccessible to those without reliable internet connectivity or adequate digital literacy, creating a dual burden for disadvantaged populations.

Building digital health literacy is therefore essential, both for healthcare professionals, who must confidently recommend and prescribe digital services, and for communities, who need the skills to navigate digital healthcare systems effectively. As van Kessel et al. (2022) emphasizes, social and cultural determinants must be addressed when conceptualizing digital health literacy, as these factors shape both uptake and outcomes. Without strategies to address structural and cultural barriers, digital health initiatives risk perpetuating inequities rather than alleviating them. Global models, such as Estonia's integrated digital health system, demonstrate that long-term investment in infrastructure, accessibility, and public trust can create resilient and equitable digital ecosystems (van Kessel et al. 2022).

Emerging technologies, such as wearables, AI-driven diagnostics, big data, and precision public health, offer opportunities to make healthcare more preventive, personalized, and mobile (Kickbusch et al. 2021). Yet these benefits will not be distributed evenly unless trust, accessibility, and human rights remain central to digital transformation. Concerns over data extraction, surveillance, and unequal governance threaten to erode public trust and disproportionately impact vulnerable groups. Inclusive design frameworks, such as Singapore's GovTech diversity initiatives and the "eCanvas" platform for artists with disabilities, highlight the potential of human-centred, participatory approaches (Government Technology Agency [GovTech] 2019). These strategies can transform digitalization into a tool for empowerment rather than exclusion, supporting a broader shift toward civic technology.

The societal consequences of digital exclusion extend well beyond the pandemic, shaping the future of social cohesion, economic participation, and well-being. Without sustained policy efforts, digital inequalities risk entrenching cycles of exclusion that limit employability, hinder mobility, and deepen generational divides, particularly for young people lacking foundational digital and health competencies. Existing tools to assess digital health readiness often fail to consider equity outcomes, democratic participation, and youth perspectives, despite their futures being closely tied to digitalization. This underscores the need for holistic frameworks that integrate diversity, accessibility, and rights-based principles into digital transformation (Heizmann et al. 2025; Kickbusch et al. 2021). As societies advance further into the digital age, building digital resilience and health literacy must be recognized as essential social infrastructure, on par with education and healthcare, to prevent widening inequalities and ensure that digital innovation fosters solidarity, inclusion, and human rights.

This study's strengths lie in its comprehensive qualitative design, which captured diverse perspectives from vulnerable populations and frontline service providers. By employing biographical-narrative and problem-centred interviews, the study gathered rich, context-sensitive accounts of how the digital divide affected participants' everyday lives. The inclusion of street-level bureaucrats added valuable insights into the systemic challenges of implementing policy on the ground. However, several limitations should be acknowledged. The study's focus on Tyrol, Austria, limits the generalizability of findings to other contexts with differing social, economic, and infrastructural conditions. Additionally, the exclusive reliance on qualitative methods introduces the potential for subjectivity, although rigorous content analysis was employed to enhance credibility. The temporal focus on the COVID-19 pandemic may also limit the applicability of findings to post-pandemic settings. Future research should not only examine barriers to access but also investigate mechanisms that promote inclusion, adopting longitudinal and mixed-methods designs to track how digital equity can be sustained over time and across sectors.

Conclusion

This study reveals that digital exclusion during the COVID-19 pandemic did not merely reflect existing inequalities but actively intensified them - disrupting access to education, healthcare, employment, and social support. Vulnerable populations in Tyrol, Austria, especially low-income households, children, and people with disabilities, faced intersecting material, cognitive, and systemic barriers that curtailed their ability to participate in an increasingly digital society. These findings underscore that digital exclusion is not a singular technical issue but a multi-layered social problem embedded in broader patterns of structural inequality.

Importantly, these dynamics must be situated within the larger societal transformation processes accompanying digitalization. The pandemic accelerated digital shifts across all life domains, reshaping how states govern, how services are accessed, and how individuals relate to one another. Yet this transformation has occurred unevenly and often uncritically, with insufficient attention to equity, inclusion, and participation. Digital access, literacy, and usability have emerged as super-determinants of health and social inclusion, influencing outcomes across all sectors (Chidambaram et al. 2024).

Notably, this digital turn is unfolding against the backdrop of financial austerity and public sector retrenchment common in many contemporary welfare states. Under pressure to reduce costs and streamline operations, governments increasingly adopt online-only models for delivering essential services. These "digital by default" strategies mirror broader New Public Management logics, prioritizing efficiency and workflow optimization, often resulting in reduced accessibility for some users. Ethnographic research in Scandinavia demonstrates how such digitalized welfare agencies reinforce existing social stratification and produce new forms of exclusion (Schou/ Pors 2019). In the post-pandemic period, local authorities in Tyrol, Austria have pledged to uphold analog service options, yet ongoing austerity measures in the social sector have intensified reliance on digitalization as a cost-saving strategy. This mismatch leaves frontline providers in continued uncertainty, raising concerns that the structural digital inequalities revealed during COVID-19 remain unresolved, and may, in fact, be deepening. For street-level

bureaucrats and frontline staff, the burden of inclusion shifts onto them without additional support or training, further straining the social safety net. This technocratic orientation, if left unchecked, may undermine the universalistic aspirations of the welfare state by introducing new forms of digital gatekeeping. Vulnerable groups are disproportionately affected, not just by the absence of devices or skills, but by systems that are neither inclusive by design nor supported by adequate outreach. Without deliberate safeguards, the digitalization of public services risks evolving into a tool of administrative streamlining rather than social justice, reinforcing rather than reducing disparities (Eubanks 2018).

To counter this trajectory, digital inclusion must be reimagined as a core component of democratic governance and social resilience. This requires long-term investment in infrastructure, digital literacy, and accessible technologies, especially for those historically marginalized. It also demands a renewed commitment to participatory governance, where affected communities help shape the digital tools that increasingly mediate their access to rights, services, and voice. Hybrid service models that blend digital efficiency with in-person relational support are essential for meeting the diverse needs of citizens in complex life situations.

In short, the digital transition is not just a technological evolution; it is a political and ethical crossroads. Societies must choose whether to treat digitalization as an opportunity for deeper inclusion, or as a mechanism for quiet withdrawal from the responsibilities of equitable welfare provision. The findings of this study act as a call to action, urging us to resist the allure of technocratic minimalism and build instead human-centered digital systems that expand agency, trust, and solidarity for all members of society.

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Declaration of conflicts of interest

It is hereby confirmed that there are no conflicts of interest to declare. The professional judgment of the primary interest, be it the welfare of patients or the validity of research, is not influenced by any secondary interest, such as financial gain or personal rivalry. The impartiality and objectivity of our work and the interpretation of results are not affected by financial interests, employment relationships, consultancies, stock ownerships, honoraria, paid expert testimonies, patent applications/registrations, or grants/funding.

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