Coastal and Rural Digital Exclusion: The Case for Voice AI

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Abstract: The adoption of digital platforms for health and social resources disadvantages vulnerable populations, including older adults and those living in remote or deprived areas. This could be remediated using voice-based conversational AI (Voice AI) systems delivered via landline phone, bypassing the requirement for digital device access or digital skills. British rural and coastal regions often have poorer digital infrastructure and pockets of deprivation, and consequently higher levels of digital exclusion. This study explores digital exclusion in Southwest England and the suitability of Voice AI systems for supporting digital inclusion. Seventeen participants aged 50 years or over were interviewed by telephone and took part in one of two face to face focus groups to identify how digital exclusion impacts access to health and wellbeing resources. The results indicated that digital access was severely impacted by unreliable infrastructure and exacerbated by limited digital skills. Phone-based Voice AI systems could then provide viable solutions to support access to digital health and social resources for digitally marginalised coastal and rural communities.

1 INTRODUCTION

Digital exclusion comprises individuals being unable to participate in society due to barriers to their digital access, such as limited digital skills, poor device access, or negative attitudes toward technology (Helsper, 2021; van Dijk, 2020). It is often associated with a negative impact on health and wellbeing through limiting access and adoption of digital health and wellbeing resources (Mee et al., 2024). Older adults are particularly vulnerable to digital exclusion (Lythreatis et al., 2022) due to infrequent use of digital resources, old devices, and poor digital skills (Gallistl et al., 2021; Ueno et al., 2023). Despite these barriers to digital access for older adults, health technologies can support wellbeing through, for example, facilitating social connections (Quan-Haase et al., 2017) and reducing social isolation and loneliness (Hajek and König, 2021). This means digitally excluded older adults face health inequalities by not having consistent access to these resources. Community services and groups are increasingly transitioning to online platforms (Spanakis et al., 2021), leading to increased social isolation for digitally excluded older adults and consequently leading to poorer long-term health outcomes (Goldman et al., 2023).

In the UK and Europe, a large factor in digital exclusion is rurality (Salemink et al., 2017), exacerbating the difficulties faced by older adults who form a higher proportion of the population in these regions (Department for Environment Food and Rural Affairs, 2024). Within the UK, this typically results from poorer infrastructure compared to urban areas (Philip et al., 2017). Indeed, rural areas in the UK are more likely to suffer difficulties in accessing a reliable internet connection compared to urban areas (Rural Services Network, 2022). An additional complication is that 3% of the UK rural landmass has no 4G signal available and 9% of rural homes lack access to 4G signal (Ge et al., 2022), limiting the utility of mobile devices (Mascheroni and Ólafsson, 2016).

In the UK, coastal regions are associated with higher levels of deprivation compared to other areas (Mee et al., 2024). Furthermore, coastal areas may be considered the 'last mile' of infrastructure (Henderson and Roche, 2020), meaning that there may be

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logistical issues that affect the development of model infrastructure. The intersectionality of coastal and rural regions often compounds these issues; for example, Cornwall, in the Southwest of the UK, has the highest average age and higher levels of deprivation compared to other areas of the country (Ministry of Housing Communities and Local Government, 2019).

1.1 Models of Digital Exclusion

Contemporary models of digital exclusion (Helsper, 2021; van Dijk, 2020) present a hierarchical approach to understanding the factors that lead to digital exclusion. Van Dijk's (2020) model in particular presents a comprehensive overview of how the levels of the digital divide impact an individual's wider participation in society. Core components of the model are the four factors that comprise digital access, which in turn influence the outcomes of digital engagement.

The first level is **Motivation and attitude** which is driven by needs, motives, and attitudes. These influence decisions to purchase digital hardware and engage with digital resources. The absence of motivation to engage with technology can consequently lead to unsatisfactory outcomes from digital media.

The second level is **Physical access**, which distinguishes between three types of access: physical, material, and conditional. Physical access refers to an individual's opportunities to use digital media privately or in community settings such as libraries or community centres. Material access comprises the resources required to support continuous access to digital media, including subscriptions, software, and utilities such as electricity. Finally, conditional access refers to provisional access to applications or resources that might be associated with digital media.

Th third level comprises **Digital skills**, i.e. competencies, and literacy required to use digital media. This encompasses both direct interaction with applications as well as with other people through digital communications. The fourth level of access is **Usage inequality** which comprises the difference in usage between users. Some individuals may use digital media extensively, whereas others may restrict their usage due to their access to digital devices or skills. This is typically explored across frequency and amount of use, use diversity, and activity of use.

In Van Dijk's (2020) model these four levels influence an individual's **Outcomes of digital media use**. Engagement with digital media can provide benefits across several domains, including social, cultural, and personal domains (Helsper et al., 2015). The four levels of digital access influence the extent to which digital engagement is positive or negative.

Van Dijk's (2020) model also includes factors that represent an individual's resources, and categorical inequalities that have been shown to influence digital exclusion, which include personal (e.g. age) and positional (e.g. region) factors. Personal categorical inequality factors have a greater influence on digital usage than positional factors, in part due to positional factors also being influenced by the outcomes of participation in a digital society (van Dijk, 2020).

1.2 Voice AI System as a Digital Inclusion Tool

To tackle digital exclusion in coastal and rural regions, solutions are needed that can overcome barriers to digital inclusion. The ICONIC research project (**I**ntergenerational **C**odesign **O**f **N**ovel technologies **I**n **C**oastal communities; see Jones et al., 2024) is co-designing a **voice-based conversational AI system - Voice AI** - delivered via a phone line. Co-design embeds users within the design process, centering the design of new technologies around their life experiences to ensure that their needs are understood and not assumed (Thabrew et al., 2018). Co-designed technologies are often perceived as more accessible, are more likely to be adopted (Mitchell et al., 2023) and can support digital inclusion by lowering the digital skill barrier. The Voice AI would provide access to online information or services in response to voice commands via a phone line, bypassing the need for devices, an internet connection, and advanced digital skills.

Using voice interfaces to improve digital access is not new, as it provides an alternative to traditional visual interfaces (Pradhan et al., 2018). Recent work shows that conversational systems could be powerful tools for social inclusion (Song, 2023), and tackling digital exclusion (Sin et al., 2022). These systems provide utility for older adults when searching for information online (Pradhan et al., 2020), however, when delivered via traditional platforms such as smart speakers, smartphones, or computer, digital skills and device access remain as barriers (Park and Humphry, 2019). As the ICONIC project's device agnostic system bypasses these equipment barriers, it might then be an accessible solution to people living in coastal and rural settings. A co-design approach will be sensitive to the perceptions and attitudes of the users, ensuring that user voices are centred within the design process, supporting user acceptability and long-term engagement (Thabrew et al., 2018).

1.3 Research Questions

To understand the potential utility of phone-based Voice AI systems in coastal and rural communities, it is important to identify the factors that cause digital exclusion. This study had two research questions. In coastal and rural communities in Southwest England:

- What factors lead to digital exclusion in a rural, coastal community?
- Could Voice AI systems support digital inclusion?

2 METHODOLOGY

2.1 Design

This study is part of the ICONIC research project (Jones et al., 2024) which is taking an intergenerational approach to address digital exclusion faced by older people and the digital economic/employment exclusion of younger people. The project recruited participants in coastal and rural communities in Southwest England, to join workshops focusing on the co-design of a Voice AI system delivered via a phone line. Participants took part in a telephone semi-structured interview and a focus group discussion held during a co-design workshop. The interview was focused on understanding the participant's digital exclusion, and the focus group explored barriers to accessing online information and services, and opinions on Voice AI technology. Phenomenological inquiry was selected as the research methodology, as it provides an understanding of digital exclusion from the perspective of participants, based on their lived experience (Money et al., 2024). Ethics approval was obtained from the University of Plymouth Arts and Humanities Research Ethics and Integrity Committee (project ID 3941).

2.2 Participants

The study took place with residents of a rural village, Pendeen, and a coastal town, St Austell. Pendeen was selected due to its isolation, situated in the far Southwest of England. It has 920 residents and is classified as a "Rural hamlet and isolated dwellings in a sparse setting" and it is one of the most deprived places in the UK (Ministry of Housing Communities and Local Government, 2019). St Austell is also located in the Southwest of England. It has 20,900 residents and is one of the 10% most deprived locations in the UK (Ministry of Housing Communities and Local Government, 2019). Eleven participants (10 female, 1 male) with a mean age of 71.5 (SD = 5.6) were recruited via the Pendeen community centre. A further six participants (all female) with a mean age of 61.2 (SD = 8.2) were recruited in St Austell, via social media, ICONIC recruitment partners (including [Rural Town] Healthcare), and word of mouth. All seventeen participants were interviewed by telephone and took part in one of two focus groups.

2.3 Data Collection

Interviews and focus groups were facilitated by members of the research team. Semi-structured interviews were held over the phone, as participants preferred this platform to other options such as Zoom. For one participant, the telephone interview had to be rescheduled twice due to poor connectivity. Participants were asked questions about their access to digital technologies and resources, aligned with Van Dijk's model of digital exclusion:

- What technologies do you use in your day to day life and how often do you use them?
- What skills do you need to use technology?
- What other barriers stop you using technology on a daily basis?
- How does digital technology impact your daily life?
- How would you describe your digital inclusion in society?

To capture a full portrait of each participant's digital exclusion, follow-up questions were asked to identify specific barriers that related to digital exclusion.

Between one and four weeks after the interviews, all seventeen participants took part in one of two face-to-face focus groups. Both the interviews and focus group were transcribed verbatim and 'cleaned' manually to remove personally identifiable content. The qualitative data recorded were collated and then imported into NVivo 14 software (QSR International, 2023). Data were analysed using deductive thematic analysis, with overarching themes defined by Van Dijk's model of digital exclusion (van Dijk, 2020), and additional themes relating to perceptions of Voice AI technologies. Participants from Pendeen are indicated by the label 'Pend_', and St Austell participants are indicated by the label 'StA_', followed by an anonymous ID number.

3 RESULTS

Themes extracted from the interviews and focus groups have been grouped based on the components

of Van Dijk's model of digital exclusion, focusing specifically on the four hierarchies of access and the associated outcomes. An additional theme relating to the use of Voice AI systems was included, showing participant's awareness and previous engagement with the technology. Subthemes are described in headers within each theme.

3.1 Attitudes and Motivation

3.1.1 Negative Attitudes to Technology

Some participants perceived technology negatively due to local services closing, *"I think we're going too far. ... For instance, they are cutting down on facilities like post office, banks"* (Pend_6). There were also concerns over the reliability of technology-based services, *"I don't think we should rely on technology because, yeah, yeah, if it just one switch. It could all go off"* (StA_2). There was also some reluctance from participants to rely on the internet as a source of information, and that it was considered less trustworthy than the local community, *"I'd rather go to someone who's actually got the expertise and ask them how they use it and how they found it. I would trust people's opinion of it rather than the internet's opinion"* (Pend_8).

In contrast to the negative perceptions of technology, some participants positively appraised their devices, *"The mobile phone is a wonderful device"* (Pend_10).

3.1.2 Motivations to Use Technology

Participants expressed a motivation to get more out of technology to allow them to take part in more digital activities, *"The more I learn on the digital side, then hopefully I will get better at doing things and therefore be able to do more"* (Pend_2). The pervasiveness of technology was also a motivating factor, to avoid digital exclusion *"So much is now becoming digital and I need to get that knowledge up. So I thought, well, if anything that helps me. The fear is good"* (Pend_2).

3.1.3 Perceived Generational Differences in Attitudes to Technology

Participants acknowledged not growing up with technology influences their perspectives, *"We grew up with black and white TV, so it's all ... quite strange to us"* (Pend_2). Participants also suggested that the skill gap between younger and older adults is insurmountable, *"Obviously we're never going to get to the stage where kids grown up with it"* (Pend_2). Additionally older adults were characterised as more likely to be digitally excluded due to poorer digital skills and device access, *"Older people who aren't savvy with even technology or haven't even got access to it [the internet]"* (StA_2).

3.2 Access to Technology

3.2.1 Physical Access to Technology

Participants reported good access to digital devices, *"You know, we use the emails and computers, anything I need"* (Pend_4). Some participants expressed concerns over the costs associated with acquiring technologies, *"I would hope it would become more inclusive. That again depends on whether they can afford the technology ... Whether the families can afford the technology"* (Pend_1). Participants also expressed concern about the age of their devices, and whether they would need replacing over time, *"I'm concerned that the equipment that I've got, which was pretty good two years ago when my husband died will, in fact eventually need to be replaced. Haven't got a clue when that should happen ... I would feel very uncertain on that and ... I'm not alone in that"* (Pend_2). Participants that worked with vulnerable groups with limited access to devices stated there was a need to share hard copies of information to support social inclusion, *"I'll try and print off all the information as well for ones that haven't got access to mobile phones and things"* (StA_2).

3.2.2 Material Access to Technology

The largest barrier to digital access for these participants is the local infrastructure. Participants reported consistently poor connectivity that was related to the remote locale, *"A lot of us live right away from the hub of everything ... So I'm outside all the systems, as are the other three in in our lane"* (Pend_8). Connectivity issues may be partly related to the physical properties of where participants lived, and this issue may be widespread in Cornwall, *"I mean, even ours is parlous, our internet. Because we've got a granite house. I think the stone interferes with it. So I think that's a problem across Cornwall isn't it?"* (StA_3).

The poor infrastructure was perceived to result from a lack of concern from internet providers in rural areas, which resulted in outdated equipment, *"It's just crazy that in this day and age, everything is coming over land and even electricity cables and everything. And really by now it should be in the ground. If you go to London or, or any metropolis, they haven't got a load of wires, you know, going across. It's all*

you know beautifully underground and they have they have unlimited access to huge bandwidth on their Internet" (Pend_7). Ultimately, participants articulated the need for the infrastructure to undergo development to meet the standards of other areas of the country, *"Cornwall needs to catch up with the Internet"* (StA_1). The poor connectivity means that people in the local region faced with poor connectivity are more likely to rely on landline phones to stay connected, *"You're talking about areas, coastal areas and areas where there isn't necessarily brilliant Internet coverage and brilliant mobile signals. We forget there are people that totally rely on their landlines because they can't have the technology"* (StA_5).

3.3 Digital Skills

Participants described attempts to learn digital skills and identified a clear need for support to learn these skills, *"I'd just like to be with somebody ... who uses them [digital technologies], and would be able to show me what the problems are"* (Pend_7). Technology novelty was reported as being a source of uncertainty, *"It's new and I'm not familiar with. It. And I'm not so sure what I'm doing"* (Pend_10). Participants reported the need to support vulnerable members of the community in the use of technology for important everyday tasks, and that resources to upskill vulnerable individuals are limited, *"We've got a lady, haven't we in our group and she really struggled. She, you know, even to pay a bill, you know, something as simple as that ... we help her obviously. But if she didn't have us, you know, what would she do? The help isn't out there"* (StA_2).

3.4 Usage Inequality

Most participants reported using digital technologies with some regularity, *"I use them, a smartphone and a laptop. Well, every day"* (Pend_3). There were some participants that used their devices less frequently, *"Mobile phones we, you know, we don't carry them around like people do an extension to their arm sort of thing, but we take them out when we go. But it's usually just in case an emergency"* (Pend_5).

Participants described a limited number of uses for different technologies that were largely passive, including watching media and reading the news, *"Get up the various sites that tells me what's happening. Usually the war in Ukraine"* (Pend_5). Digital technologies were also used by some participants to find information, *"If we're stuck with a problem, the internet's the go to place. And often when you're talking about phoning places, I've almost got to the point now where you don't bother with the phone because usually it's online"* (StA_5).

3.5 Outcomes of Digital Access

The closing down of services in local towns led participants caused significant difficulties for participants, *"Yes, you can go online. Well, number one, as it happened when my husband died and I had to go in with quite a lot of paperwork. How do you do that when they're not there?"* (Pend_6).

The lack of reliable access to community information due to the transition to digital platforms was highlighted as a concern, *"It's so easy to be out of the loop, isn't it? And when you said about relying on family and friends, that's what happens now, isn't it? ... if you haven't got somebody advocating for you to do that, it must be the most isolating place"* (StA_5).

3.6 Voice AI Use

Participants reported that they were aware of smart speaker and voice assistant technologies, with some participants saying that they already used a smart speaker voice-based interface, *"We use Alexa. Sometimes we use an Alexa like what's the temperature going to be today? Things like that"* (Pend_8). Participants also highlighted how Voice AI technologies can benefit those with mobility impairments, *"It was so I can just turn the TV on and off and not have to keep struggling to get up to get to it. You know I couldn't get to it. It was really difficult. So in that way, yeah, it was brilliant* (StA_2). The use of smart speakers was undermined by the poor infrastructure rendering them unreliable, *"Like you know, having Alexa in your house and all of that, I find really important. But the whole thing falls down. Because of our appalling internet access, and it is appalling"* (Pend_8).

Participants also highlighted that there may be some individuals that may be reluctant to speak with a Voice AI system due to its artificiality, *"And I know some people would just, you know, just wouldn't want to engage with it at all because it's not a real person"* (StA_3). The use of Voice AI systems should also be clearly articulated to the user, as the realistic nature of Voice AI systems may deceive users, *"A lot of older people, when I think about my mother, like, would think it's [the AI] a real person"* (StA_3).

4 DISCUSSION

This study describes the characteristics of coastal and rural digital exclusion faced by two groups of partici-

pants co-designing a Voice AI system delivered via a phone line. The findings show the complexity of digital exclusion with varying levels of digital, access, skills, and usage across participants, with the most significant challenge being the the poor local infrastructure. The demographics of the participants also influences their digital exclusion, as they reported unfamiliarity with technology due to not growing up with it, outdated devices and uncertainty as to how and when to upgrade them (Ueno et al., 2023).

These data highlight how digital exclusion is a multifaceted spectrum and how factors (Helsper, 2021; van Dijk, 2020) interact to create digital disparities. For example, the largest reported difficulty faced by participants was the unreliable infrastructure in these coastal and rural locales (Henderson and Roche, 2020) and how this contrasts to the more reliable infrastructure in urban areas of the country (Philip et al., 2017). This limits the utility of digital devices and reduces access to digital information and resources (Salemink et al., 2017). These poorer outcomes in turn negatively impact attitudes towards technology and the motivation to use digital devices on a daily basis (Vaportzis et al., 2017), reinforcing digital exclusion. Consequently, approaches to tackling digital exclusion need to be holistic, and tackle underlying issues that restrict digital inclusion.

Due to the increasing transition of community services and resources to online platforms (Spanakis et al., 2021), digital exclusion can have a negative impact on health and wellbeing, exacerbating existing health inequalities. Participants described how vulnerable people that they know face isolation due to this as they may have reduced access to technology and lower digital skills. This social marginalisation can be exacerbated by the geographic marginalisation resulting from the poorer infrastructure in coastal and rural areas of the country compared to the urban areas (Philip et al., 2017). This isolation can also negatively impact digital skills for older adults, as previous research has shown that older adult internet users tend to have greater social support (Friemel, 2016) and that single-person older-generation households have more limited technology support and consequently access to digital resources (Ueno et al., 2023). This means that digitally excluded older adults may be unable to access important health and social resources (Hajek and König, 2021), increasing social isolation and highlighting the importance of identifying approaches to facilitate access to online information for digitally excluded members of society (Goldman et al., 2023).

4.1 Study Limitations

The main limitation of this study is that it employed small, self-selected samples from two locations. While this does provide valuable, in-depth insight into these specific contexts, these findings may not necessarily be applicable to other rural or coastal areas or populations within these regions. Furthermore, the sample featured a heavy gender imbalance, as sixteen of the seventeen participants across both groups were female. Previous studies of digital exclusion highlight a gender imbalance, as females report greater levels of digital exclusion than males (Hargittai et al., 2019). This has been reported to be due to lower levels of digital literacy as well as older females being perceived as less competent in the use of technologies (Gallistl et al., 2021). The imbalance observed here may then be due to self selection bias, as ICONIC is designed to support digital inclusion through the co-design of new technologies, and may then attract individuals that want to improve their own digital skills and access. Despite this bias, participants still reported varying levels of digital inclusion.

4.2 How Could Voice AI Promote Digital Inclusion for Coastal and Rural Communities?

The data reported here suggest that Voice AI systems could be used to support digital inclusion in coastal and rural contexts. However, typical access platforms for Voice AI systems (e.g. smart speakers) are unsuitable due to infrastructure issues, despite some acceptance of the technology. The ICONIC project's solution, to deliver a Voice AI system via a phone line (Jones et al., 2024) may be an acceptable alternative platform. Using a landline phone is familiar and accessible for these participants, evidenced by it being the primary platform for interviews, reducing the need for digital devices or digital skills. The system would still be dependent on a basic level of phone infrastructure, i.e. through a landline or mobile signal, however, it would be more robust to the internet outages reported by participants. As voice interaction is designed to replicate natural conversation, it represents a low-tech form of digital interaction, and presents an alternative to traditional visual interfaces, benefiting individuals with sight impairments (Gu et al., 2020). Voice commands are more intuitive for older adults than the potentially complex or unfamiliar UI of digital devices (Pradhan et al., 2020), and would therefore be easier for people with few digital skills to use.

Whilst Voice AI has the potential to support access to digital resources in coastal and rural communities,

participants did articulate the potential resistance to using a Voice AI system due to its artificial nature. Part of this resistance may be due to users being unaware that they are speaking to an AI. More formative work needs to be undertaken to negative attitudes to Voice AI systems. Part of this work should explore how best to obtain informed consent from users of the Voice AI system to ensure that they are aware that they are interacting with an AI, and would be an important consideration in the system's design.

5 FUTURE WORK

This ICONIC project (Jones et al., 2024) will run a series of intergenerational co-design workshops to create a Voice AI system that can be accessed via a phone line, exploiting the off-the-shelf availability of large-language models (Brown et al., 2020) combined with highly accurate end-to-end speech-to-text systems (Hannun et al., 2014). As participants reported age-related differences in technology use and skills, similar to previous literature (Vaportzis et al., 2017), ICONIC's intergenerational approach to co-design might support a more equitable design of the Voice AI technology. Contributions from these different perspectives and life experiences may then lead to a Voice AI technology that is more attuned to the specific needs of potential users bases and consequently be more acceptable when deployed (Thabrew et al., 2018).

6 CONCLUSIONS

This study highlights the barriers to digital inclusion in rural, coastal communities, particularly among older adults. Similar to other studies exploring the digital exclusion of older adults in rural communities, participants described issues with the coastal and rural digital infrastructure, as well as with digital skills and access to devices (Ge et al., 2022; Ueno et al., 2023). Addressing these infrastructure issues is key to supporting digital inclusion in coastal and rural communities. However, due to the economic barriers associated with infrastructure development, it is important to explore tools such as Voice AI systems, particularly if deployed via a device agnostic platform such as a phone line. This technology has the potential to mitigate some of the digital exclusion faced by older populations in coastal, rural UK communities by bypassing the limitations of unreliable infrastructure and the requirement for internet-ready devices and digital skills. This technology could consequently promote digital health equity through supporting digitally excluded populations to access important digital health and social resources and reduce health inequalities and loneliness.

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REFERENCES

Brown, T., Mann, B., Ryder, N., Subbiah, M., Kaplan, J. D., Dhariwal, P., Neelakantan, A., Shyam, P., Sastry, G., Askell, A., et al. (2020). Language models are few-shot learners. *Advances in neural information processing systems*, 33:1877–1901.

Department for Environment Food and Rural Affairs (2024). Statistical digest of rural england: 1 - population.

Friemel, T. N. (2016). The digital divide has grown old: Determinants of a digital divide among seniors. *New media & society*, 18(2):313–331.

Gallistl, V., Rohner, R., Hengl, L., and Kolland, F. (2021). Doing digital exclusion–technology practices of older internet non-users. *Journal of Aging Studies*, 59.

Ge, B., Harrison, B., Hayes, N., Mason, K., Perez, D., Wagg, S., Walker, T., and Wilkes, M. (2022). Digital poverty transformation: Accessing digital services in rural northwest communities. In *The British Academy, London*.

Goldman, S., Delore, E., Flesh, S., Langer, D., and Mazor-Karsenty, T. (2023). Digital exclusion and covid-19: Does communication technology correlate with well-being? *Physical & Occupational Therapy In Geriatrics*, 41(1):143–158.

Gu, J., Wang, X., Yao, X., and Hu, A. (2020). Understanding the influence of ai voice technology on visually impaired elders' psychological well-being: An affordance perspective. In *Human Aspects of IT for the Aged Population. Technology and Society: 6th International Conference, ITAP 2020, Held as Part of the 22nd HCI International Conference, HCII 2020,*

Copenhagen, Denmark, July 19–24, 2020, Proceedings, Part III 22, pages 226–240. Springer.

Hajek, A. and König, H.-H. (2021). Social isolation and loneliness of older adults in times of the covid-19 pandemic: can use of online social media sites and video chats assist in mitigating social isolation and loneliness? *Gerontology*, 67(1):121–124.

Hannun, A., Case, C., Casper, J., Catanzaro, B., Diamos, G., Elsen, E., Prenger, R., Satheesh, S., Sengupta, S., Coates, A., et al. (2014). Deep speech: Scaling up end-to-end speech recognition. *arXiv preprint arXiv:1412.5567*.

Hargittai, E., Piper, A. M., and Morris, M. R. (2019). From internet access to internet skills: digital inequality among older adults. *Universal Access in the Information Society*, 18:881–890.

Helsper, E. J. (2021). *The digital disconnect : the causes and consequences of digital inequalities / Ellen J. Helsper.* Sage Publications, London.

Helsper, E. J., van Deursen, A. J. A. M., and Eynon, R. (2015). Tangible outcomes of internet use: from digital skills to tangible outcomes project report.

Henderson, D. and Roche, N. (2020). Examining the policy mix for broadband deployment in wales: The role of informal coordination in the last mile. *Local Economy*, 35(1):48–67.

Jones, R. B., Baxter, R., Varga, M., Hagen, O., Aly, A., Bazazian, D., Veliz Reyes, A., and Gaudl, S. (2024). Intergenerational technology codesign in deprived coastal regions. In *ICDS 2024: The Eighteenth International Conference on Digital Society ICDS 2024*, page 7.

Lythreatis, S., Singh, S. K., and El-Kassar, A.-N. (2022). The digital divide: A review and future research agenda. *Technological Forecasting and Social Change*, 175:121359.

Mascheroni, G. and Ólafsson, K. (2016). The mobile internet: Access, use, opportunities and divides among european children. *New Media & Society*, 18(8):1657–1679.

Mee, P., Gussy, M., Huntley, P., Kenny, A., Jarratt, T., Kenward, N., Ward, D., and Vaughan, A. (2024). Digital exclusion as a barrier to accessing healthcare: a summary composite indicator and online tool to explore and quantify local differences in levels of exclusion. *Universal Access in the Information Society*, pages 1–13.

Ministry of Housing Communities and Local Government (2019). The english indices of deprivation 2019 statistical release.

Mitchell, J., Shirota, C., and Clanchy, K. (2023). Factors that influence the adoption of rehabilitation technologies: a multi-disciplinary qualitative exploration. *Journal of NeuroEngineering and Rehabilitation*, 20(1):80.

Money, A., Hall, A., Harris, D., Eost-Telling, C., McDermott, J., and Todd, C. (2024). Barriers to and facilitators of older people's engagement with web-based services: Qualitative study of adults aged¿ 75 years. *JMIR aging*, 7:e46522.

Park, S. and Humphry, J. (2019). Exclusion by design: intersections of social, digital and data exclusion. *Information, Communication & Society*, 22(7):934–953.

Philip, L., Cottrill, C., Farrington, J., Williams, F., and Ashmore, F. (2017). The digital divide: Patterns, policy and scenarios for connecting the 'final few'in rural communities across great britain. *Journal of rural studies*, 54:386–398.

Pradhan, A., Lazar, A., and Findlater, L. (2020). Use of intelligent voice assistants by older adults with low technology use. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 27(4):1–27.

Pradhan, A., Mehta, K., and Findlater, L. (2018). " accessibility came by accident" use of voice-controlled intelligent personal assistants by people with disabilities. In *Proceedings of the 2018 CHI Conference on human factors in computing systems*, pages 1–13.

Quan-Haase, A., Mo, G. Y., and Wellman, B. (2017). Connected seniors: How older adults in east york exchange social support online and offline. *Information, Communication & Society*, 20(7):967–983.

Rural Services Network (2022). House of lords communications and digital select committee inquiry 'digital exclusion and the cost of living'.

Salemink, K., Strijker, D., and Bosworth, G. (2017). Rural development in the digital age: A systematic literature review on unequal ict availability, adoption, and use in rural areas. *Journal of Rural Studies*, 54:360–371.

Sin, J., Munteanu, C., Waycott, J., N. Brewer, R., Sayago, S., Lazar, A., and Weber, A. (2022). Alexa, tell me a joke!:" voice interfaces are truly inclusive". In *CHI Conference on Human Factors in Computing Systems Extended Abstracts*, pages 1–3.

Song, J. (2023). *Advanced Virtual Assistants - A Window to the Virtual Future*, chapter The implications of providing voice-based chatbots in public service for digital inclusion and public communication. IntechOpen.

Spanakis, P., Peckham, E., Mathers, A., Shiers, D., and Gilbody, S. (2021). The digital divide: amplifying health inequalities for people with severe mental illness in the time of covid-19. *The British Journal of Psychiatry*, 219(4):529–531.

Thabrew, H., Fleming, T., Hetrick, S., and Merry, S. (2018). Co-design of ehealth interventions with children and young people. *Frontiers in psychiatry*, 9:481.

Ueno, A., Dennis, C., and Dafoulas, G. A. (2023). Digital exclusion and relative digital deprivation: Exploring factors and moderators of internet non-use in the uk. *Technological Forecasting and Social Change*, 197:122935.

van Dijk, J. (2020). *The Digital Divide*. Polity Press.

Vaportzis, E., Giatsi Clausen, M., and Gow, A. J. (2017). Older adults perceptions of technology and barriers to interacting with tablet computers: a focus group study. *Frontiers in psychology*, 8:294305.