Hidden Opportunities for Elder Living: Understanding Shared Technology Troubles and Benefits for Older Adults in the UK Cost of Living Crisis

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Abstract

The uptake of digital technology by older adults and service-providers has been partly driven by the pandemic but more recently by the erosion of in-person services because of increasing austerity and a harsher global economic climate. Against the backdrop of the UK's cost of living crisis, we examine technology used frequently within five older adults' households. Through two rounds of interviews and participant diaries, we show benefits and struggles of participants' costly technology use, reflecting on what 'cost of living' means when technology designed to simplify older peoples lives, encounters problems. For HCI practitioners, we provide evidence of how personal smart devices can be better tailored to help older adults support themselves both economically and practically, during the cost of living crisis. We propose avenues for future research and design that better support indirect costs and reflect on how personal devices can be made self-sustaining, integrated and repairable.

CCS Concepts

• **Human-centered computing** → **Empirical studies in HCI**.

CHI '25, Yokohama, Japan

ACM ISBN 979-8-4007-1394-1/25/04
https://doi.org/10.1145/3706598.3714012

Keywords

Older adults, cost of living, smart homes, workarounds, finance, energy, wellbeing

ACM Reference Format:
Ewan Soubutts, Aneesha Singh, Alice Ashcroft, Bran Knowles, Julia McDowell, Judith Tsouvalis, Jasmine Fledderjohann, Caroline Swarbrick, Richard Harper, and Yvonne Rogers. 2025. Hidden Opportunities for Elder Living: Understanding Shared Technology Troubles and Benefits for Older Adults in the UK Cost of Living Crisis. In *CHI Conference on Human Factors in Computing Systems (CHI '25), April 26–May 01, 2025, Yokohama, Japan.* ACM, New York, NY, USA, 17 pages. https://doi.org/10.1145/3706598.3714012

1 Introduction

In the space of a few years, the digital world has entered almost all aspects of our lives, from making a doctor's appointment, buying a train ticket and parking on the street. While many of us have benefited from this move to digitalisation a significant number of older people, especially those over 65, have found themselves digitally excluded to the point they feel overwhelmed, and face many barriers when trying to access the information and services they need.

In the UK, an economic downturn has manifested in the so-called 'cost of living crisis,'; a 'fall in the real, disposable incomes [...] (after taxes and benefits) that UK households own' [109], which has brought economic uncertainty and a lack of personal financial security, affecting people's wellbeing, including leading to depression, anxiety and risky behaviours [60, 110]. Individuals with low incomes and without full-time employment are the most affected, of which a significant proportion are over 65 years of age [1]. While

technology exists that tackles some of these issues in isolation (e.g. financial planning apps to manage individuals' financial security, or mindfulness tools to ease symptoms of psychological distress), no technology is designed to tackle complex societal problems like the cost of living crisis, directly.

Human-computer interaction (HCI) studies have often dealt with technologies that are designed to simplify people's lives. Many of these studies tackling financial and wellbeing issues are also situated in the home environment [34, 40]. For financial management, sharing banking app credentials with close others can provide older adults reassurance that their money is being looked after [46], while chatbots have also been leveraged to help older adults independently manage their financial security [21]. Both of these approaches are relatively inexpensive and ubiquitous in the UK context. Wellbeing technologies have also benefitted older adults physically through activity trackers enabling greater mobility in the elderly [115] and tailored voice assistants that can support mental agility into older age [91]. However, more bespoke solutions such as tailored VAs and chatbots often require greater upfront costs (either to purchase, or in terms of time spent learning), that hinders their designed simplicity, and ultimately adds to the cost burdens of older adults and their close others, resulting in additional costs of time, effort or money.

As such, there is a need to understand the role of technology in supporting the process of cost saving. In this study we provide exploratory evidence [77] situated within the UK cost of living crisis, that investigates technologies that both help and hinder households' cost saving processes. In turn, we propose avenues for better designing technologies that support individual and shared cost saving strategies. We namely examine the use of smart and non-smart technology in older adults' homes and its effect on their financial, personal and physical wellbeing against the backdrop of the cost-of-living crisis. To do this, we use a combination of contextual interviews and diary entries that provide both individual and comparative accounts of how people live with specific technologies in specific household settings. Conducted at two discrete time points in summer 2023 and summer 2024 respectively to establish a comparison, this study builds on Gaver et al.'s [33] work on the intimate lives of older people, showing how older adults seek to utilize their devices efficiently and practically for cost-saving purposes, with each household employing changing strategies over this time period.

This study explored five households' daily routines with their own devices through 7-day diaries. This allowed for documenting, probing and following up on specific experiences at important contextual moments in each diary, with interviews exploring key interactions between people and their devices. We cross-compare these personal and social dimensions of technology use and how the 'costs' associated with living extend beyond financial aspects; encompassing additional commitments of time, effort, laborious manual to digital transitions, conflicts of confidence and trust, and the ability to physically repair technology to make savings.

This paper contributes: ***1) An in-depth understanding of five households' struggles and successes using technology to make savings around i) time, ii) online finances and, iii) long-term health*** **financial (direct monetary costs), time-based (effort and time) and personal wellbeing (including physical and mental health) costs**, particularly focusing on support for one another through the shared use of devices (e.g. [36, 95]), ***2) Evidence of households collaborating as a means of overcoming the technical shortcomings of their devices and services***, and ***3) Design recommendations for digital systems that do not push older adults back into using non-digital alternatives when interactions go wrong*** [18].

2 Related Work

2.1 Older Adults Adopting Technology in the Home

A large majority of literature in HCI regarding ageing and technology focuses on the smart home. This work has been inspired by past HCI contributions such as Gruning and Lindley's [36] work around physical possessions in the home and their digital equivalents holding the same personal meaning as physical ones, and we build on this, identifying ways possessions in the home can be used as a conduit to provide benefits to their users. Themes that have been researched so far are the improtance of developing tehcnology that supports negotiation and sharing. Labour is often discussed in the relation to bridging the gap between digital possessions in the home and their online portal counterparts [90, 95], or in care [25, 49] with many online services being increasingly laborious. However, other accessing online services, such as using smart speakers for e-commerce activities can be time savers too[31].

Therefore, engaging with in-home technologies (though not exclusively 'smart home' technologies) could i) better foster digital transitions from formerly in-person services and ii) to better coordinate the sharing and equitable distribution of responsibility amongst older adults and their close others in their homes. The delegation and negotiation of tasks in the home has also been well documented in HCI from Harper [38] to Crabtree et al. [23] who identify the importance of delegating roles in the home space, showing how delegation and coordination provides mutual benefit through support for e.g. home maintenance and repair. More recently too, Lee et al. [52] suggest that negotiation is becoming increasingly important to engage in relations with and source crucial information from external providers, companies and specialists [6], which can often cost older adults significant effort individually.

2.2 Older Adults' Use of Financial and Energy Technology

Financial stability and technological support for older adults' finances has been discussed across a range of topics. Previous literature has largely focussed on issues of relational financial fraud and online scams that many older adults have been susceptible to [65, 68, 72]. Beyond the privacy and security concerns associated with this financial activity, other literature has focused on the impact that online banking and banking technologies (apps, card readers) has on older adults, particularly in the wake of in-person bank branch closures [46]. The change from non-digital to digital transactions is bluevery stressful for older adults to successfully perform digital payments [27]. Further, error recovery on digital banking platforms is another challenge for older adults who are used to cashiers or close others stepping in when problems occur

banking in person [42]. Others have also documented the benefits of 'coordinated support' using online tools and mobile apps, for example, to send payments to close family friends and relatives[108]. However, many older adults are discussed as being 'strategic' about when and how they spend their money, moreso when spending online [25].

The use of technology for personal financial self-management and wellbeing management is increasingly centered on the home too [83]. One issue common of online banking is unfamiliar and 'ambiguous' affordances across digital banking platforms that complicate interactions and make these platforms harder to transition to quickly [42, 46]. It has been well-reported, too, that inviting in new technologies without adequate means of supporting digital transitions for older adults risks greater digital exclusion [5, 75, 117], yet many services still fail to cater for these transitions, especially when the home has become the new site for no longer available in-person services [20, 81]. Knowles et al. [45] also suggest that older adults' ability to financially manage themselves is linked to doing actions like banking with others, to prevent distrust in online systems. Maqbool et al. [59] state the inextricable link between older adults' long-term financial planning and their social environments (pension allowance, state welfare and any financial support from close family and friends) whilst Latulipe et al. [47] argue for much needed nuance in allowing caregivers to manage or support older adults' financial activities with online systems if they struggle, to address power imbalances.

Many older adults also struggle with managing energy expenditure. Some studies show that older adults who frequently monitor their in-home energy supply and appliances experience greater anxiety than those who don't [15]. Further, smart meters can often be indecipherable and result in misunderstandings and failed bills for many people who are forced to interpret displays that hold little meaningful information that can direct their own actions [35]. The cost of living crisis has also exacerbated the use of these meters with many making compromises and workarounds to reduce costs, including counting how quickly expenditure goes up: "counting pennies" [39], and finding peak times to operate heating to save most money ("game the system") [61].

2.3 Wellbeing Technologies for Older Adults

Wellbeing covers a diversity of factors for a person, from safety, to trust to emotional state and physical health [100]. Specifically, for older adults, Wilson et al. [114] describe three pillars that constitute a person's sense of wellbeing at any given time; namely their physical, cognitive and social health. For physical and cognitive wellbeing, many seemingly less demanding daily tasks, such as washing or cleaning, can become more challenging as people age [44].

Prior work has also dealt extensively with technologies that could be deemed 'unremarkable' [102] (technologies that intentionally do not elicit strong emotions or reactions from their users). This includes technology ranging from alarm clocks to coffee makers or calendar apps, that encourage routine and planning [98]; and much of which, as research has shown, is designed to aid people's longer-term routines [96].

Less explored within HCI is also how technology (both digital and non-digital) can be designed to support activities with close others involved (e.g. informal caregivers, family, friends), who provide care for an older person [37, 54]. Also underexplored is how older adults' fears around misuse of technology are commonly associated with their personal data stored on devices (typically health or financial), including dealing with misinformation [116], embarrassment around mishandling of sensitive sensor data (e.g. from smartwatches) [63]. This misuse of technology [53], often results in a later unwillingness to engage with devices again, after things go wrong, which informs our perspectives for exploring device ownership in this work.

There is also a strong duality within HCI research on older adults around technology that is intended to be used by one person, that ends up becoming social [76]. Many studies focusing on the individual have explored the efficacy of personal smart devices in the home on [2, 9, 24, 67, 79] (e.g. the ability for those who are visually impaired or with cognitive impairments such as dementia to use voice assistants independently). Mennicken et al. [64] for example, discuss the benefits of calendar-like interfaces that can help older adults coordinate all their home appliances to promote wellbeing through independence.

However, others such as Lee et al. [51] have leveraged chatbots to foster introspection and self-compassion for older adults and their close others. Whilst these devices support personal wellbeing, they often also involve others to do so. Strengers et al. [97] discuss how approaching wellbeing devices with others can elicit experimentation between older adults and their close others resulting in feeling "content, healthy and comfortable" in one's own home.

Many studies also focus on eliciting a source of social connection for positive wellbeing too. These include dualities in care, stemming from negotiations of independence, when relying on others [87], to social struggles between older adults in navigating shared desires and aspirations in their homes [88], to how they learn about new devices together [16, 84, 106]. This literature review has revealed a number of areas where the cost of living crisis has impacted peoples' technological and economic habits. It has also shown a tension that we seek to address in our research: i) on the one hand, understanding better how the relentless rise in digital technology is hindering older adults in the way they manage and conduct their lives and ii) on the other, how new digital technologies might be better designed to help overcome new challenges that older adults are confronted with in later life, such as managing budgets in the face of the crisis.

3 Methodology

We used a combination of semi-structured qualitative interviews and personal photo diaries [26] to understand how technology is used in older adults' lives to support their wellbeing. We chose to combine diaries with interviews to help understand the regular cycles of a household and what they might enact with their devices (either to cost-save or not), over a seven-day period. During interviews, the diaries also became 'tickets to talk' about specific events or technology used [112]. This helped us probe in-depth on specific topics. The initial diaries took place in June 2023, with

interviews shortly after. The 1 year-post, follow-up interviews took place between June and July 2024.

3.1 Data Collection

Seven individuals from five different households from across London, UK took part in the study. Participants had to be over 65, resident in the UK for the seven consecutive days for the diary study and available either in-person or online for follow-up interviews. They also had to be willing to use a smartphone with a camera to take photos for the diary. For those who did not own a smart phone, the researchers provided one with instructions on use included.

The study received ethical approval from University College London's Institutional Research Ethics Committee. Recruitment took place online and via email. A recruitment brochure was emailed to local age-related charities for distribution to their members along with the study information sheet and consent form. Prospective participants were encouraged to email or telephone us and complete an online consent form to participate. Five people were recruited for the study and received a £35 shopping voucher for completing the whole (7 day) diary and attending a follow-up interview. They received an additional £20 voucher for follow-up interviews one year later. All participants were white British nationals, apart from P3 who was a white US national (see Table 1). All participants participated in the follow-up interviews in 2024, apart from P5 'Esther'.

3.1.1 Pre-Screening Interview. Participants were screened over the telephone before the diary study, where they were asked contextual information about their daily lives to ensure their eligibility. We checked their consent form and invited them to ask any questions they had about the study. These interviews lasted between 10-20 minutes.

3.1.2 Diaries. Diaries are a well-documented method within HCI research, from Brown et al.'s work using 7 day photo diaries in the workplace to act as "memory joggers" for participants [14] [p.3] to being used for daily personal reflections on paper in detailed auto-ethnographies [103] to logging and collating the technology use outside of the home [93]. For diaries, we focused specifically on older adults' daily use of technology. Older people often lead routine-driven lifestyles that involve others and often center around simple sets of tasks such as washing, bathing, cooking, cleaning or managing themselves and others [44, 101].

We took the former approach for this study to simplify the process of collecting data for our participants, who had variable technology literacy and limited time. Participants were instructed to take 1-2 photos per day that could be considered a 'diary entry' and accompany this with a piece of text describing what they had chosen to photograph, to jog their memory later. This number of photos was chosen to help to reduce participant burden as taking more photos could prove too laborious. Only one participant borrowed a smartphone from us while the rest used their own. Some participants chose to record short voice notes instead of writing text pieces. It was left to the discretion of each participant whether they sent diary entries to us daily, or whether the completed diary was sent to the researchers at the end of the 7 day period. All participants completed the diaries for the full 7 days.

We chose 7 days for the duration of the diaries to avoid repeated entries, as after a week events within people's lives are likely to recur [66]. Photos used in this work have been anonymized to remove identifiable information. Participants were specifically instructed to not take photos of sensitive information e.g. bank details, credit card numbers or home addresses, and none did.

3.1.3 Diary Exit Interview - 2023. At the end of the 7-day diary period in June and July 2023, participants were invited to an exit interview with the researchers to discuss their experiences of completing the diary study and the content that they had captured. These interviews lasted up to 1 hour and researchers probed the participants about the photos they had chosen from their diaries and what each photos or event meant to them.

3.1.4 1 Year Follow-up Interview - 2024. The final round of interviews with households 1-4 were conducted in June 2024. These followed up on the diary entries from the year previous and interviews probed into changes from when the photos were taken, asking about e.g. *"Has anything changed about how you use X technology?"*, *"Can you describe what devices you are using day to day now?"*. These interviews lasted between 30 and 45 minutes.

Table 1 below details each participant's ID, individualized names, age, gender and self-described household role (derived from the diary data).

3.2 Household Roles

Below we provide a brief description of the household roles that each interviewee performed and those around them, who interacted with their devices throughout the course of the diary study. All participants contributed to these role descriptions and had sight of the final presentation of this data prior to submission.

Aoife lives by herself in a two-storey suburban dwelling. Her husband who lives abroad stays in contact with her over Zoom. Aoife performs a range of activities but finds her time stretched across multiple hobbies and activities.

Aoife's husband **Andrew**, who lives abroad often provides her with remote support for her technology use at home, whether this is navigating a new operating system or with staying in contact with him and other friends of theirs over email.

Second, **Barry** lives with his wife in a terraced house and likes to explore new innovations. He finds it helpful to keep the old alongside the new and keeps track of his finances offline, creating financial records, despite experimenting with new smart meters and tracking tools.

Celine lives in a single-storey home. She plays a strong social role managing her husband's finances and activities. She feels more comfortable using digital tools e.g. calendars on her iPad. She is not afraid of new tech and often uses it to help her e.g. plan social events with friends and family.

Celine's husband **Chris** lives with her in their home and is often supported by Celine to perform social tasks, manage his finances online or to provide support for physical alterations to the couple's home.

ID	Name	Age	Gender	Interview	SES
P1	Aoife	77	Female	In person	Higher income, own home
P2	Andrew	76	Male	Online	Higher income, own home
P3	Barry	75	Male	Online	Higher income, own home
P4	Celine	75	Female	Online	Higher income, own home
P5	Chris	75	Male	Online	Higher income, own home
P6	Daniel	74	Male	Online	Higher income, own home
P7	Esther	73	Female	In person	Lower income, council owned

Table 1: Participant demographic information. N.B. A 'council-owned' property is one that is part owned by the local authority for people who require more financial support than buying a home entirely by themselves, i.e. social housing.

Daniel is a natural tutor and teaches young people on a weekly basis at a local hardware 'share and repair' weekend group. He lives alone since his wife passed and expresses interest in technologies that help him remember e.g. his wife and help him to generate ideas for new devices.

Lastly, **Esther** lives alone in a two bedroom semi-detached house. She has regular visits from her daughter who often comes to use technology with her. Esther uses a range of devices including a laptop and iPad and self-manages all of her personal finances and daily activities.

3.3 Data Analysis

The data (photos, audio notes and text) from the diaries was analysed by the paper's first two authors. An inductive and iterative thematic analysis was conducted on the data with a first round in summer 2023 and a second analysis round in summer 2024 (following the 1 year follow-up interviews). A reflexive thematic analysis process [11] was chosen and applied across the whole data set (interviews and diary entries and images). Interview audio was auto-transcribed using Office 365 tools and then cleaned by the first author. Codes were initially generated on transcripts in Word, then moved to NVivo to compare and contrast individual codes and generate higher level themes. Following the additional interviews in 2024, the codes were updated in NVivo and moved to Miro (a mind-mapping tool) to visually present the complete data set and more easily identify links between codes e.g. *'division of shared labour'*, *'wider social support'*, and *'distributing information'* all fell under the broader descriptive theme of *'sociability'* and linked to people's costs to their wellbeing. The photo diaries augmented this process, and we reviewed written text and images from participants, and decided where best to position these when describing our participants' experiences of the 1 year period. Generating the final codes was an iterative process [10] between the first and second author where codes and themes were first interpreted, then described between authors to compare interpretations of the data, then decidedly distinguished until cross-cutting themes (that are discussed in the following section) were agreed upon.

4 Cost Saving Strategies with Technology

This section presents an overview of the key costs to participants at the summer 2023 and 2024 data points. Participants' diaries reflect direct workarounds they made individually and with others to overcome technical challenges and make personal savings e.g. to their time or finances. Here, we discuss the strategies participants first employed in 2023 (later reflecting on again in 2024), and then adapted, using their devices alone, or with others, to make savings on these costs as the crisis progressed. Advancements in their own strategies included money management workarounds for clunky online systems which we discuss first, generating mental models of personal appliance use, repair as a site for saving and managing manual to digital transitions with others.

4.1 Digital System Breakdowns and Failed System Digitisations

This section provides context for a range of individual problems with digital tools and devices that hinder our older participants' regular activities, rather than enhancing them. These resulted in a variety of costs, beyond the purely financial, that had affected them since the cost of living crisis began. We focus on three of these in this section, namely: *financial and energy costs*, *costs to time* and *wellbeing costs* arising from using digital systems beyond their homes. These accounts reveal shortcomings in the design of tools and technologies and demonstrate the workarounds our participants implemented to individually or collectively overcome some of these challenges.

4.1.1 Financial Challenges and Technology Breakdowns. Our participants often tried to manage their own money through digital banking platforms (DBPs [46]), which aim to allow individuals simpler access to their money and personal financial accounts, without the requirement to go to a physical bank. There were many instances where people struggled to take advantage of online services, systems or banking that worked against their financial interests. In many cases, they preferred using in-person banking services as opposed to online banking. However, in-person banking too is becoming increasing less common in the face of branch closures [3]. Esther and Aoife discussed the alternatives presented to her in the face of a local bank branch closure: *"they just decided that's where I was going to be based. [...] I didn't even get a say over the new branch." (Esther-I1)*, *"I'm over in [redacted] now, which I've calculated is 2.3 miles further for me. And [...] I can't always afford to get the bus." (Aoife-I1)*. This combined financial and time cost was common and

others found that when directed through digital services e.g. banking chatbots, a great deal more time was spent dealing with these than could be saved otherwise: *"If you speak to a person online, they seem to take a responsibility for the problem and actually help you to get it resolved [...] chatbots [don't] have that level of commitment" (Daniel-I1).* Banking therefore appeared to be made increasingly more challenging than going into a physical bank (which our participants were familiar with), as the digital services being provided were not aligning with the digital skills of older adult customers.

Barry experienced a similar issue when moving to an online app to collect digital loyalty rewards for using a local coffee chain. He explains how the promise of this app should have saved him considerable effort remembering the physical stamp card: *"Pre-COVID [I] used to go into to [local cafe] and you'd have a loyalty card which they'd stamp. And I mentioned tangentially in the diary nowadays [...] they don't expect people to carry around loyalty cards, they just expect you to have the app, so we no longer have this loyalty aspect to our cafe [chain] purchases. So I suppose, in some ways that that is a very minor example of how we're missing out." (Barry-I1).* Whilst completing tax returns are well-known for their difficulty, Celine explained the process of filling in a UK tax return form online for her husband (a non-digital user), generated unexpected complexity to such an extent that the pair reverted to the offline alternative: *"This one [referring to Fig 1] is the [HMRC UK Tax] website. [It] is totally incomprehensible and we spent hours together trying to get that [tax] form. [...] And he ended up, in fact, asking them if he could have paper copy. [...] But, I don't know what we're going to do next year." (Celine-I1).*

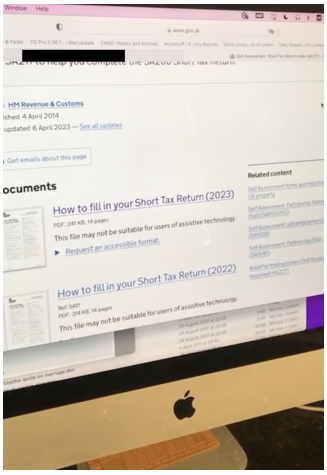

Figure 1: Celine assisting Chris with his HMRC tax return, from her photo diary.

4.1.2 Fraud-Related Experiences. Our participants also highlighted their expectations that web platforms and services that they use would keep them safe from digital harms, such as fraud. Further, fraud and scams were of paramount concern across our participants, with Daniel explaining: *"It's not just my generation that fall for these things. It's the ease with which people seem to be able to scam." (Daniel-I1).* Esther too held a great deal of concern over being hacked: *"I did have a Facebook thing that got hacked [...] maybe I'm unnecessarily cautious, but I'll never even say a password out loud any more, because I know smartphones can listen in." (Esther-I1).* Esther's account here shows how such negative online experiences can sometimes border on paranoia for future interactions. Barry also expressed dismay at common pitfalls when using technologies such as online banking and raised concerns about scamming for himself and other people his age, as it takes effort to resolve scamming and other technical issues with online accounts: *"'...and I do worry about, y'know, someone breaking into [my] solicitors' emails. And sending your house money off to the wrong account and so on." (Barry-I1).* Whilst Barry conflates technical errors here with fraudulent online scams, there is an overlooked design issue around responsibly informing, e.g. older users about the nature of technical messages they see on screen as a means of reassurance and improving trust in these services.

4.1.3 Energy-Related Challenges. Beyond pitfalls and scams around finances and billing, our participants expressed difficulty with the presentation of their energy bills, making finding useful financial information about e.g. their energy expenditure difficult: *"What I do find annoying is that they [energy companies] say [...] go to your online bill, click this to see one thing, click that to see another, whereas [...] the printed bill was a lot paper, but you could sort of ruffle through it all to find why I was spending more several months ago." (Esther-I1).* Daniel too, found that: *"Your bills don't really tell you what you're spending a day. What you do notice is that if you put the washing machine on, or if you put the oven on, that uses a lot of energy, whereas perhaps the coffee machine doesn't." (Daniel-I2).* Both Daniel and Barry also found that their in-home smart energy meters were unrepresentative of their appliance costs: *"I've got this machine there staring at me saying you just made yourself a cup of coffee and it cost £0.02's worth of electricity [...] people must be looking at it and thinking, 'this is controlling my life'". (Daniel-I1), "the meter that [energy company] left basically is left switched off because it's not telling me anything that I don't already know about what each device uses per day. Meaning would be saying to me something like [...] I lose X pence per hour because I'm not turning off the stove after 30 minutes." (Barry-I1).* Whilst Barry proposed a workaround here for the smart device to provide more useful information, Daniel's experience was more common across our participants. This underscores the ambiguous nature of energy meters, which are designed to simplify daily expenditure readings, but instead elicit anxiety as an unintended consequence of their design. What Barry talks about in the next excerpt, shows how easy it is for older adults to also feel unsupported over using and maintaining their own energy equipment and how, when problems occur they can feel reliant on energy companies to fix these: *"'You've got to be on your toes. I take everything for granted until something goes wrong and then you have to find a way around it. Like when our [outdoor] gas meter stopped communicating with [energy company]. [They] sent me an email saying, go outside, look at the meter. [...] But [...] I couldn't make [expletive] heads or tails of that." (Barry-I1).* Celine too, found it time consuming to still have to manually provide readings when the device supposedly tracks energy use with high granularity: *"you expect you get this new technology like a smart metre that's going to make life easier for you. And you're still having to send meter readings."*

(Celine-I2). Celine's account again illustrates how this digitisation does not remove the labour associated with energy monitoring, nor simplify the task, but instead changes the type of actions required to complete it (similarly to Celine's tax return dilemma). In many of these cases, older people are left to devise strategies of their own to maintain their energy or determine the meanings of energy-related devices in their homes, without additional support. In the following sections, we explore how some, though not all, of these challenges are limited by participants' physical abilities and later, how some of these challenges were overcome by our participants and the coping strategies they used when technology was not suitable to support them here.

4.1.4 Wellbeing Struggles. Beyond these challenges for energy, there was also challenges for our participants to maintain their own wellbeing at home, due to their own health and also breakdowns beyond individual devices, with systems failing or being only partly digitised. Aoife described the costs of getting much-needed replacement hearing aids: *"I thought about getting hearing aids privately [but it's] very expensive." (Aoife, I1).* She added that this was complicated by *"little buttons [that] don't make it easier. They're so fiddly." (Aoife-I1).* Here, a tradeoff is exemplified around hearing aids, which are designed to be discrete, but which can cause a problem for older users with reduced dexterity to reach smaller buttons on the devices. Celine and Daniel, who both had lower mobility, struggled to maintain adequate movement in their lives. Celine in particular, mentioned her desire to remain mobile into older age, saying: *"I know it's [walking] important [...] I set myself a target of 20 minutes a day. But getting up and actually... you know, getting going... that's setting me back. And I certainly can't afford a personal trainer!" (Celine-I1).* Celine, Chris and Daniel, who self-describe as having lower mobility, explained the inconvenience of using devices like iPads and Alexas in their home, to maintain their social lives, with this personal limitation: *"I missed a call from [friend in America] the other day, [because] if I'm not using the iPad at any one time I wouldn't be able to hear any notification, from the kitchen [or] wherever I was, in time." (Celine-I1).*

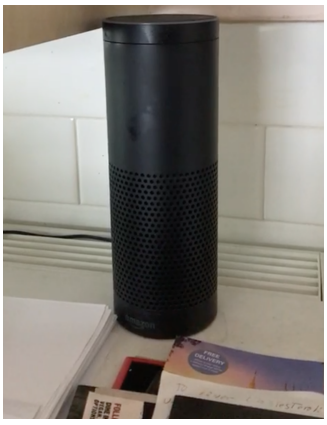

Figure 2: Celine making use of her Alexa device to have social drop-ins with friends and family.

Chris added to this, explaining: *"It's like in the old days and the landline rings, [...] and you have about 5 seconds to answer it. So it's not much different now." (Chris-I2).* Again, a technology that is designed to aid convenience by being hands-free is not reflective of Celine and Chris' habits as an older couple moving between rooms frequently; so quickly becomes an inconvenience to them both. Daniel added to this, contextualising his experience too: *"you can be sitting in the kitchen and Alexa will go off, what do you call it [drop-in], and by the time I've got to the other room, they've rung off." (Daniel-I1).* Further, the design and placement of built-in smart meters to our participants homes also presented a mobility challenge. For Barry, whose meter was fitted low down to the ground, he was required to bend down every time he needed to take a meter reading outside: *"...my arthritic knees of course. So when going outside, I'm not sure if I'm coming back up, every time I bend over and squint into the box for those little numbers." (Barry-I1).*

Figure 3: Barry's original energy meter, placed very low down to the ground.

Celine and Chris too, experienced this issue with their built-in smart meter, adding: *"it's a real nuisance because in our little Victorian terraced house the meter is in the downstairs toilet, really up high. And then you have to put a little step on in order to read it, and I can't do it. So my husband is sort of teetering on the brink [on the stepladder] there trying to read the meter with the flashlight." (Celine-I1).* The placement of smart meters, while decided by an energy company and not Chris and Celine, again evidence how little input households hold in the design and setup of these devices, with most needing to adjust their own lifestyles to reliably use this equipment. Despite these various problems with in-home technology, our participants demonstrated a strong enthusiasm for overcoming these problems with workarounds both individually and together, that we discuss in the following sections.

4.2 Individual Strategies Inside the Home

In this section we showcase how participants overcame some of the challenges they experienced with their devices and services individually, to make both direct and indirect savings, and overcome or circumvent specific costly challenges, some of which are outlined above.

Participants overcame the obstacles they encountered with external systems, services or costs in a number of different ways. Where systems failed them, e.g. in the case of Barry's energy meter, he

DAY FOUR 21 JUNE	This day every month I venture into my front garden, rain or shine, because my gas meter no longer communicates with [redacted] Energy so I have to send them a reading to ensure an accurate bill. Soon somebody will come to instal a new smart meter – something smart that I will truly appreciate as I shall no longer have to get down on my hands and knees and strain my eyes to detect those five illuminated numbers.	Smart meter	Down on hands and knees

Figure 4: Barry's diary entry (from June 2023) detailing his difficulty using the meter provided by his energy supplier.

decided: *"I had to call someone out [to fix the meter]. I'm a bit of a technophobe, but my feeling is there's not much you can't put right by throwing money at it unfortunately. And, and even then, it took them a while to agree to come out [...] it was a real back and forth for a few weeks." (Barry-I2).* In many ways Barry's experience is contrary to that of our other accounts, where participants do not want to 'throw money' at problems to fix them and instead prefer their own workarounds, although the negotiation required to have companies 'fix' their devices was more common.

4.2.1 Money Management Strategies. Bills and keeping track of finances was something our participants particularly struggled with. Esther showed her dismay at the difficulty of viewing her online bills with the interfaces provided: *"what I find annoying is that [...] if I want to look at something that's several months ago I just have to click previous, previous, until I get back there, which is a real pain." (Esther-I1).* Her concerns around online banking security after being hacked made her reluctant to view her bills on her smartphone and instead resorted to paper: *"I considered [smartphone banking] but with all the hacks I've seen in the Independent [newspaper] and after last time, I just wanted a printed bill on a bit of paper, that you could just sort of ruffle through and that you could see it all in one place, you know." (Esther-I1).* As a result, Esther decided to download all her bills en-masse to save her time later flicking through different pages: *"I found it a lot easier just to group them together and then make one big Excel file that I can add to every month. So it was a lot of time sort of flicking through up front, but it's something I can come back to every month and just pop the new bills into now." (Esther-I1).* Esther's improvised workaround here shows an unsupported approach to gathering the information wanted when the designed visual elements (e.g. of an online bank) are obfuscating and costly to older people's time, especially as someone who was recluctant to use digital platforms, due to her past online experiences.

The concern around what would happen if they did not engage with digital, permeated a lot of our participants' experiences, particularly around finances, resulting in an almost unwilling engagement to solve their problems using technology: *"I have to go into Internet banking to transfer money, so that once the Council gets their Council tax... in two days time now, [but] if I didn't have access to the Internet, the money wouldn't be there y'know [...] eventually, unless something happened, I would be evicted." (Daniel-I2).* Similarly, Celine felt a need to upskill herself as a result of the anxiety she experienced a year previously with her husband's tax form: *"Well, a year ago with that SA200 [tax] form, I think we both [her and husband] felt out of our depth, so since then I've gone out of my way to contact the HMRC and make sure they tell me how to navigate their website to get a hold of these documents. [...] It had us on edge. Especially at a time when you don't know when you're going to be robbed for your next penny." (Celine-I2).* These accounts showed an unwilling need for participants to up-skill themselves on digital services out of fear of an unknown outcome being imposed upon them. In both Daniel and Celine's cases, they were again unsupported by the services they were using and had to navigate these services out of necessity.

4.2.2 Energy Management Strategies. Daniel and others often described the intimidating nature of devices such as the in-home (energy) device (IHD, Fig 5.) that were designed to helpfully represent energy usage data, but inadvertently reinforce financial anxiety and energy usage worries, which can affect those on lower incomes the most: *"I find it really intimidating that when there's this energy crisis going on, I've got this machine there staring at me saying you just made yourself a cup of coffee and it cost £0.02p's worth of electricity. […] I wouldn't say we're well off, but… people must be looking at [theirs] and […] worrying about turning the central heating on or off […] and thinking 'this is just controlling my life.'" (Daniel-I1).* Here, Daniel explains how simply viewing the meter results in anxiety for him, and potentially other older adults on lower incomes. Esther too, empathised with people who may be on lower incomes than her, saying how smart meters have the potential to cause worry for people, adding: *"I have got a smart meter for my electricity [...] I try not to use more than I need to. I don't sort of think 'ohh I've got to keep to sort of a pound a day' [...] [but] some people are not so fortunate, so they would probably track it more diligently." (Esther-I1).*

Figure 5: Esther's IHD (In-Home Device) in use.

However, during their second year interviews, both Aoife and Daniel explained how they had developed an innate sense of how

much energy individual appliances were using, that was not informed by smart meter use. Aoife described this as: *"[There's] a pecking order. [...] if the washing machine's going round and round fast, or if I've just got the lights on for an hour or so, then it's going to be very low use. Because those are quick things. [But] for something like cooking, where the gas is on a while, or the tumble drier... those are going to put the little dial up [higher smart meter readings]." (Aoife-I2).* Daniel too, explained how he gave up on checking the smart meter for accurate readings and instead formed his own mental model of energy use instead: *"The smart meter [became] a bit of a curse. [...] Every morning we [Daniel and his wife] were looking at it, 'How much did we use yesterday?', 'How much did we us the day before?' [...] All these calculations go on in your head, and it's totally unnecessary [...] So we've stopped looking. We just know now, that obviously [we] spend less in the summer or more in the winter and it balances out." (Daniel-I2).* There is an opportunity here for energy system designers to engage with this type of mental model that can translate usage actions into insightful representations for older adults. In Daniel's case in particular, holding this strategy in mind became self-soothing and relieved his worry about the daily expenditure, which his smart meter was reinforcing. In contrast, Barry found the smart meter superfluous to his energy monitoring, adding: *"the meter that they left basically is left switched off because it's not telling me anything that I don't already know." (Barry-I2)* and for Celine, who previously struggled with submitting manual meter readings each month added: *"I'm not looking at the bills [...] Alexa has actually helped with that. I suggested to [husband] that we have a list on it now, that we add to for a month, every month and then I'll know, at the end of each month, how much I really used [appliances] and if they [energy company] want to raise anything with us, well, they know where to find me!" (Celine-I2).* Celine and her husband outsourced the cognitive load of their appliance-related usage, to their smart speaker and evaluated it against their meter reading each month. This strategy was more similar to Esther's personal approach of printing off her bills and adding to them manually every month, albeit augmented digitally by their Alexa, for Celine.

Whilst these accounts showcase the individual strategies some of our participants used to overcome costly problems, mostly around banking and energy technologies, they also discussed shared strategies around overcoming problems not directly related to cost, too.

4.3 Shared Strategies Inside and Outside of the Home

In this section, we identify how our participants also used shared strategies (either with people they lived with in their homes, or those they worked closely with outside of their homes), to make savings for themselves and others. These included running technology maintenance 'cafe's', taking on roles as social liaisons in the home, going beyond the home to seek out technology support and also transitions to digital systems that participants figured out together.

4.3.1 Cost-Saving Through Repair. During both his first and second interviews, Barry described his role co-running a 'repair café', designed for older adults and relatives as a place where they could bring technology they were struggling with, or which had broken down, to be repaired. Barry described how: *"most products are not designed to be repaired" (Barry-I2).* Instead, Barry and other volunteers would offer to search online for spare parts, or physically mend devices during a session at the local library. There is cause to consider repairability as a function of usability here too, so that components which are costly to replace are evaluated against a device's overall ease of use. He goes on to describe a range of maintenance duties he has performed over the year period including fixing 'Hi-Fi' music players, desktop computers, kettles and other household appliances, which he documents in his diary. In most cases, Barry described fixing the technology with the owner present, so that *"there's a learning component [...] they can see what we're doing there, and hopefully, they can then go away and fix it themselves at home if it should break again. So [...] we're also giving out a bit of ourselves [skills] to make them more confident, make them feel like they can mend their possessions too." (Barry-I1).* Barry goes on to point out that he often needs to provide the most cost-efficient recommendations, because *"...quite often the reason why we can't [repair the tech] is that the spare part that they might need is actually more expensive than a new item." (Barry-I2).* In these cases, he must outline the financial trade-off to an attendee, and explain that although it may be a beloved posession, the costs to repair may outweigh the costs of replacement for them.

Figure 6: Barry helping another attendee of the repair café to fix a broken device.

4.3.2 Negotiating and Sharing for Social Benefits. Beyond direct repairs to technology to save on costs, there were also less tangible benefits that our participants demonstrated together that saved them e.g. time when organising and going about their lives. Celine often managed Chris' (who did not own a smartphone) social calendar saying: *"We have a WhatsApp group here on our road. And I'm on WhatsApp because you can get [it] on your [smart]phone, which my husband doesn't have. So I'll pass on messages to him, that I get from our neighbourhood, that might be cutting the bushes, or whatever." (Celine-I1).* Chris then explained that he could field emails or web-based text messages on their shared iMac: *"...except when I get stuck. [Then] I just yell for [Celine]." (Chris-I2).* In this way, co-managing their social lives saves Chris time, and, as with the tax return form, Celine is able to lend her technical know-how to benefit Chris. This was similar in David's household, who discussed the division of technical labour by one another's experience and familiarity: *"I tend to do the financial stuff so it's spreadsheets, paying the credit card bills every month. And she's sort of more socially active than I am." (Daniel-I2)* Similarly, Aoife's husband, Andrew, who lives abroad,

is often able to video call with Aoife to support her online. He describes helping her save time navigating a new operating system on her laptop: *"[Aoife]'s struggled with Windows 10 because they've gone very much to a visual side and a lot of the text prompts have sort of disappeared." (Andrew-I2).* Aoife echoed this, adding: *"...if you're not careful, you can wipe out emails on your server." (Aoife-I2).* Andrew did not correct this misconception about the storage of emails (neither Aoife nor Andrew hosted their own email server), yet the visibility and logical retrieval of emails and personal data was important to Aoife, which Andrew supported where he could. Aoife referred to this on occasion too, pointing out her preference for an earlier operating system because: *"Windows 10 always wants to tell you what to do [whereas] Windows 7 doesn't." (Aoife-I2).* In this case, as operating systems have moved forward, the interface design no longer aligns with Aoife's expectations for visual metaphors on screen, likely causing this mismatch. This caused some further concern for Aoife, when worrying about whether she would be able to stay in contact with her husband using her newer PC: *"I hope nothing goes dramatically wrong. [...] because I rely very much on the computer for being in touch with my husband in Canada." (Aoife-I2).*

4.3.3 Shared Manual to Digital Transitions. Barry's previous experience struggling with his paper-based coffee chain card, later transpired that he had embraced the chain's digital smartphone app. He described how both he and his wife had transitioned to using the app, which presented new challenges too: *"I've got the app and I'm sitting in [coffee chain], looking at my smartphone, looking at the app and the app is saying 'password [Barry]?'. And [Barry], of course can't remember the password." (Barry-I2).* Barry goes on to explain how, on a separate occasion his wife intervened to assist with logging into the app: *"So skip forward a couple of weeks, and we're back in [coffee chain] and my wife turns to me, seeing that I'm not getting let in [to the app], and says 'well, I saw this coming and so after a few mis-attempts, I do gain entry, which I think I may have missed out on a hot drink, otherwise." (Barry-I2).* In this way, Barry's wife acted to jog his memory and make the saving possible. A similar situation occurred for Celine, who assisted her husband Chris to transition from paper-based bills to paperless billing: *"...so they give you a discount if you're [using] online [billing] of course, rather than it being sent in the mail. [...] At the moment, we just get them posted to us each month." (Celine-I1).* Later, Celine indicated that although they had transitioned to online payments, like Esther, the formatting of online billing was unintuitive for Chris: *"We are now using [energy company's] online system, but [...] last month, we found a spike in our electic use, that we didn't know where it was from and [Chris] spent hours scrolling back through tracking that down, whereas if he'd had them all in front of him, it might have taken far less time for us." (Celine-I2).* These strategies show that transitions to digital services from formerly non-digital methods, do not work seamlessly for older adults, due to the nuances of information not being available 'all in once place', due to difficulty not being able to easily recognise patterns in e.g. energy usage and take action on this. The manual option is still preferable in many cases, for people like Barry who simply wish to retain and easy to remember non-digital payment method.

4.3.4 Wellbeing Workarounds and Resolutions. Finally, our participants also navigated difficulties to their health and wellbeing with others. Aoife discussed how she befriended another hearing aid user at her local church to get advice on using her newer hearing aids: *"Somebody at church sort of said to me 'I've got hearing aids that I control with an app – and it's simple'. [...] It has certainly made me consider the investment of a [smart]phone, so that I don't have these little buttons [on side of hearing aid] that are too small for my fingers. [...] at the moment, I will just go in on a Sunday and if I have any problems, [friend] can help me out with them or show me on her phone at present. [...] But it's a decision I've not come to quite yet [to purchase a new smartphone]." (Aoife-I2).* Aoife's support from her friend at her local church may be a step towards her acquiring a smartphone so that she does not have to use the difficult to press physical buttons, yet this has also allowed her time to weigh the benefits of investing in the device before committing, to determine whether managing her hearing aids without the smartphone is still feasible longer-term.

In her diary, Aoife goes on to describe how the process of getting the new hearing aids also required repeated trips to her surgery for intrusive earwax removal that was affecting her hearing: *"The first [Fig 7] is my GP surgery. Well, I needed to get some earwax removed. It's one of these things where you go to the pharmacist and they look and say, yes, you've got some earwax, then you have to go to the GP surgery to ask them to give you a referral back to the pharmacist. And then you have to go to the pharmacist to make an appointment." (Aoife-I1).* Aoife later described how she was able to talk the GP round to providing her with a referral for new hearing aids: *"I'd had four removals, the last year and we weren't getting anywhere so eventually, I had to muster up my courage and I turned to [GP] and said, 'look, I just can't hear our of my right ear still properly'. [...] eventually [I] got the referral in-house which was an unexpected blessing." (Aoife-I2).* Here, Aoife describes how the difficulty in the process of negotiating and demonstrating how greatly her health had been impacted by repeat operations and back-and-forth'ing between the health provider and the independent pharmacist added unnecessary complexity from navigating both services' complex systems that were not designed to share information between one another. Eventually, Aoife was able to negotiate with her GP to acquire the new hearing aids, but at the expense of her time and hearing while navigating these services.

Figure 7: Aoife attending her GP surgery for earwax removal and new hearing aid fittings.

For Barry, Celine and Chris, who struggled with their mobility and safety as a result of precariously-placed built-in smart meters, both households later suggested workarounds to these access issues. For Barry, negotiating a replacement meter was the solution. Barry engaged with his energy company, seeking support: *"The electricity company actually came out and installed a new meter and IHD [In-Home monitoring device] a couple of months ago. When they first did it, I wasn't getting any readings, so they had to come back again a few months later and fix it and do a check of how much I'd used in between that time. [...] And they weren't happy at first. It did take some time to get them back over again.... [but] it is better, it is better, [and] somewhat more on the bright side, I now can get at it without worrying about getting back up again." (Barry-I2).* Whilst Barry ultimately succeeded in his negotiation with the energy company, Celine and Chris were required to be more creative in order to fix their meter at home. Whilst they had not mentioned reaching out to their energy company for a replacement, Celine explained: *"It's still a hazard, in our home. But I went round to [neighbour's] house the other week. And she's on a Victorian terrace too, which is of a very similar layout to our home. And she, very cleverly built some steps into the side of her downstairs toilet, [similar to] where ours is too. [...] [So] Chris and I thought why not? And so that was a little project, with one hell of a mess that came with it!" (Celine-I2).*Whether through negotiation or improvisation, Barry, Celine and Chris all managed to develop workarounds to their problems together, however, at the cost of substantive time and physical exertion to rectify access to the smart meters. Designers of smart energy tools must therefore work closely with energy companies to ensure implementation of these devices does not compromise their design and accessibility and if necessary, modify the design of meters to be less reliant on the diverse physical housing stock they are placed in.

These accounts demonstrate how our participants individually and mutually improvised technical workarounds that were likely unsupported by technology providers (e.g. Daniel's password sharing or Celine's step ladder). We also show how participants made use of their shared social contacts and networks to facilitate better use of their own devices. In many cases, these strategies presented both temporary and permanent solutions for our participants, where either direct cost or effort wasovercome to achieve a more satisfactory solution with their technology or service.

In the following section, we discuss how these findings hold implication for the design of home financial, energy and wellbeing technologies for HCI researchers and practitioners working with older adults.

5 Discussion

Through engaging with five separate households in 2023 and 2024, we observed changes to the way that older adults manage their technology use during the cost of living crisis and the ways in which they developed workarounds to effortful problems. Our findings highlighted the distinctions between the individual and shared practises that older adults employed during this period and how they overcame (and didn't overcome) burdens with systems and devices related predominantly to finances, energy costs, time and wellbeing. In this section, we discuss how the outcomes of technology helping or hindering cost saving is useful for HCI practitioners and service providers, as we strive to better tailor such devices to support older adults.

5.1 Supporting Unplanned and Hidden Costs

In this section, we propose that more time and support must be given to intangible costs for older adults during this crisis, with technology built around e.g. negotiation, time and maintenance that occur between older adults regardless. For HCI researchers there is a need to further investigate why e.g. smart energy technologies, designed to simplify engagement with people's money spent on their energy use, require such additional labour (especially from older adults) to maintain. Further, there is a need to explore how data is shared between e.g. wellbeing systems that do not engage with one another, to benefit older adults' efforts.

Our participants accounts frequently made reference to how they were required to negotiate, either with one another (in shared households), between themselves and service providers, or between themselves and energy specialists. Furthermore, when participants struggled with their technology, such as Barry with his original energy meter, or Aoife with her hearing aids, they were both required to reach out to service providers and worked hard to negotiate replacement devices that better suited their mobility and health needs. There is opportunity for companies to allow older adults to use online tools to (as a means of speculative futuring [8] or collaborative co-design [49]) identify opportune places to install cost-saving devices like smart meters within the physical infrastructure of the home to mitigate problems such as hard to reach devices, that are designed to simplify engagement with personal costs. HCI researchers could also explore, for example, how older adults would engage with such a form of 'mapping' for these devices in the home, that could in turn be adopted by service providers

when installations occur. As Celine mentioned regarding her hard to reach energy meter, layout and difficult positioning of in home-devices often has negative consequences on older adults' wellbeing in the home too [17]. Nor are these concerns unique to older adults; mobility restrictions can affect people of all ages, and greater consideration to layout and positioning of home devices has the potential to benefit many population groups.

It also seems prudent to consider how gender roles and expectations influence household tasks and technology-related decisions [28, 58, 62]. Research suggests that age intersects with gender norms [69, 85], which has potential to shape how responsibilities and support are distributed within the home, which can impact technology adoption and usage patterns [92]. Although gender was not an analysed factor in this study, it could be considered in future research.

An additional and common hidden cost to all of our participants was the significant investment of time taken to accomplish tasks. Most notably, was Celine and Chris' difficulties navigating a UK government online tax portal, which took a number of days for the pair to resolve. One of the main detractors for older adults and one of the reasons our participants actively avoided using online systems, is that many do not see the benefits of making a manual to digital transition (e.g. from paperless banking [7], to online energy monitoring [78]), when the processes that supposedly support these transitions are so convoluted to use. Reluctance to engage with digital therefore springs from this, such as the case of Barry's loyalty card and Esther's mass-printing of her online bank statements. This points to a strong need to reduce the time spent for older adults navigating and using digital systems, in particular, to provide or access information (similar to Light et al.'s recommendation to let new technology integrate in social (household) settings over time [55]). Practically, this could see, for example, energy companies conducting pre-screenings of households either over the phone or online, with structured visualisations (or questions), to let shared homes indicate their sociotechnical boundaries [45, 71] and personal abilities [70, 118], which could be applicable to people of all generations, beyond older adults too. For HCI researchers, there is a need to explore how manual to digital transitions are facilitated (whether by energy companies or device designers) for older adults, and identify where the mechanisms that enable these transitions require either social or technical engagement to effectively facilitate a transition and sustain engagement, without as in Chris and Esther's case, returning to paper-based alternatives. There is further cause for HCI to examine the means of engagement between e.g. energy companies and people like Esther who do not regularly engage with digital (if at all), to identify ways older adults can take advantage of online data and rewards, to instil greater cost equity in those older citizens who are regularly digitally disengaged. This in turn, has increased the labour burdens of security [34], care [95] and maintenance.

The role of maintenance and repair is an important and often overlooked cost and time saving mechanism, that HCI research on older adults in particular, overlooks. Some works such as Jung et al.'s [43] note how repair is a sustainable means of ensuring technology can last beyond a device's expected lifecycle. However, as Daniel noted in his discussion of the repair café; most artifacts are not designed to be repaired extensively. As such, there is a need to put in place processes to mitigate planned obsolescence in technology development [41]. Successive iterations of consumer devices often leave older, yet functional technology obsolete, when it is still workable, but just in need of repair. Advocating re-use and repair instead of built-in obsolescence is therefore a time save for older adults and also beneficial to the global environment and ongoing climate crises too, that the cost of living crisis stems from.

There is also an emotional cost to replacing artefacts, which is important to acknowledge when examining costs. HCI has often discussed how health and wellbeing-related technology such as hearing aids [73], stairlifts [94] and smart speakers [91], hold intrinsic emotional ties to their owners and replacing or altering these devices significantly, can be emotionally taxing. Providing older adults with a way to more robustly repair their possessions should be given far greater consideration, through providing e.g. familiar repair tools, or simply to follow instructions provided with technology, that will give older adults more independence to fix beloved possessions by themselves, or through enabling them to seek out support from e.g. repair cafes, who can source technical information about personal belongings before they arrive.

5.2 Integrating and Supporting Shared and Social Mechanisms to Facilitate Digital Engagement

One of the key strategies our older adults made use of to overcome technology and service challenges and costs was to collaborate to achieve technical aims. The role of the social intermediary, which has been documented elsewhere in HCI [19, 57, 76], as a means to substitute technical knowledge, was seen in our study, in particular by Celine and David, as a way of also saving time in their households. Aside from digital upskilling, there are also opportunities here to better design social technologies that do not require active engagement. For example, analogous to a driver and passenger, systems and e.g. social media apps could make better use of this dynamic for accounts that are shared, or for two or more people living together, where less engaged users can interact in a more passive way. The home is an ample site for extending social media's functionality, and building on a Weiserian vision [111], could see older adults engaging more passively with social media or messaging tools there. This could be through other appliances or spaces in the home, removing need to pick up a smartphone. However, there is an opportunity to reduce such time-costs, through asynchronous passive engagements in the home with social tools built into the infrastructure of the home space [40], that could better allow for older adults to acknowledge others without being fully present in social interactions to the same extent as the social 'drivers' there.

Our findings also revealed how participants were keen to attempt to resolve technical issues, until they became stuck. For Chris, this took the form of offering to field emails on behalf of Celine, and likewise she was able to assist with his tax return. For Aoife and Andrew, the change in visual layout on her operating system interface was off-putting for Aoife, which led to misconceptions about where her digital possessions (emails, photos) were stored and the process of retrieving them. Although Andrew did not express whether he felt similarly, this extends findings from Schoenebeck et al. [89] who suggest that there is added pressure on older adults to preserve their data as they transition into later life stages. This also builds

on work by Escarcha et al. [30] that suggests that technology increasingly can appear to eerily have a 'mind of its own', reflecting Aoife's comments about 'wiping out her emails' and also how older adults may also be susceptible to unforseeable problems, such as with Daniel, who relied on his spouse to recall his password for him. In this way, there is a need to better scaffold support for the unexpected and unforseen. One approach to this through research, could be to scope and map out older adults' foreseeable and unforeseen problems when using in-home devices using e.g. a 'johari window'-style exercise. This could in turn instil, as Lin et al. [56] describes 'shared agency' for older adults with different levels of digital experience, as a route to greater equity.

5.3 Mitigating Wellbeing Costs for Older Adults

Lastly, our accounts also demonstrated how our participants looked after themselves and others. Our accounts from Celine and Daniel regarding the placement of their energy meters showcased the awkwardness of many technology installations. Clunky, obtrusive and inaccessible technologies have been well documented in HCI literature [13, 50, 94, 99], however these have largely been focussed on technologies designed to support wellbeing that have been user unfriendly. The positioning, placement and overall design of smart meters, which are built into the home infrastructure, have also been widely overlooked from an accessibility perspective. To reduce the physical costs placed on older adults to regularly read, inspect or upgrade these meters (and the time liaising with energy companies to fix problems with them), there is a need for energy companies to provide more tangible tools to support in-home maintenance and monitoring of smart meters (akin to those provided to maintain other smart home systems [29, 80]). This could prevent older adults from compromising their wellbeing while taking meter readings, or relying entirely on energy companies to resolve their technical problems. Further, as Barry outlined, energy companies could work to standardise smart meter interfaces to be less inscrutable (through being unique for each company) and more universally accessible, through the implementation of a visual language that is suitable for the elderly [86, 107, 113].

To support wellbeing more directly, there is also a need to reduce circular interactions for older adults like Aoife, who are looking to repair or upgrade personal health devices (such as her hearing aids). Aoife's story regarding being sent back and forth between her GP and her pharmacist evidence a clear need for transparency in the exchange of personal health information across multi-party systems [70, 105]. Allowing Aoife to understand why the GP and her pharmacy could not agree on her treatment or involve her in it could have saved Aoife considerable time in seeking out this information from them.

Aoife's account also highlights the importance of sharing experiential knowledge between friends and close others regarding personal wellbeing. While technology can go some way to supplementing wellbeing knowledge as Astell et al. [4] describe: "enabling participation [beyond] individual [wellbeing] activities" [p. 10], current smart technology is less supportive of the sharing of experiences. Aoife's socialisation through Zoom with her friends was the most practical way of sharing knowledge and whilst other research has extensively documented the benefits of health communities sharing experiences using social media platforms such as Reddit [12, 32, 48], there is still a need to better facilitate local experiences (e.g. national, or even regional). Such experiences could allow older users to set their expectations of local healthcare systems, better understand how local processes work and ways to identify the most direct routes to acquire new wellbeing technology or routes to treatment [114].

6 Limitations

Whilst this study aimed to capture an accurate picture of the cost of living crisis for older adults, there were also constraints to our approach that meant we could not provide a fully representative picture of the crisis for all older adults.

Namely, we acknowledge that the 7-day period for the diaries was relatively short, limiting our ability to capture nuanced changes in older adults' daily lives and routines and more diverse circumstances and interactions. While the collected diaries provided rich data, extending the study period could reveal deeper insights into specific challenges faced by participants, like Aoife's possible adoption of a smartphone for her hearing aids in the future - and whether this would provide her any additional savings, or the longer-term savings and impact of Daniel co-running the repair café. As the 7-day period for the diaries is relatively short, we encourage HCI researchers adopting a combined interview and diary study approach, to consider running these over longer timeframes to capture changes in technology use as they happen e.g. at 1 month-intervals over a year (e.g. [104]).

We also acknowledge the limits of the small participant sample being predominantly white and middle class, albeit recruiting people of different nationalities and genders, as well as the small sample size for this in-depth study. Recruiting diverse samples of older adults within user studies [45, 82] is challenging, yet not uncommon [94]. Whilst this socioeconomic group is affected by the cost of living crisis in the UK, it would be worthwhile conducting diary studies with people of different income backgrounds and more discretely measuring income types (as opposed to letting participants self-define this e.g. Esther was the only participant who self-identified as 'lower-income') as those on lower incomes would be more affected by the current cost of living crisis. Future studies should actively recruit diverse participants, including those from different income backgrounds, to more comprehensively explore the financial effects of the cost of living crisis on technology use. Beyond this, most of our participants were digitally engaged to some degree and regularly used their devices to manage cost of living-related challenges. There is further scope for HCI researchers to work with local authorities and e.g. energy companies to seek out those who do not regularly engage with digital solutions (whether through online banking or energy dashboards), to identify barriers and means of engaging them either directly, or by proxy (close others, or through organisations). Despite the small sample size, we believe our focussed thematic analysis [22] allowed for in-depth engagement with participants, avoiding negative impacts of reported data.

We acknowledge our positionality within this work too. The first and second authors who conducted this work are aged under 65 so do not fit within the older adult category within the UK

and also hold a 'middle-income' socioeconomic status. As most of our participants experienced their lives at home with different lifestyles and health statuses to us, we acknowledge our role to best empathise with this group, though our accounts may not be truly reflective of older adults' experiences.

Finally, we acknowledge that the 'cost of living crisis' as it is understood is a predominantly socioeconomic issue. Our findings are largely contextualised within the HCI space and outcomes and implications for researchers and practitioners do not directly solve the core issues around the cost of living crisis, such as a energy inequality or wealth disparity, though we do hope that this work raises considerations amongst researchers as to how future research tackles problems in this space. We encourage researchers to be broad in their thinking regarding this issue and when devising research questions to tackle, particularly with older adults affected as a result of the global cost of living crisis. As poverty is also on the rise for older adults, and expected to worsen [74], this is an opportune time to identify new support sociotechnical support mechanisms to prevent older adults newly slipping into poverty.

7 Conclusion

This paper provided understandings of how the cost of living crisis has impacted on older people's technology use for their daily activities through nine qualitative interviews, and photo diaries from five different households. Our findings reveal a variety of hidden costs to older adults beyond financial ones, such as costs to time, frustrations with using digital services for personal reassurance, difficulties feeling unsupported with online services, and how more intangible solutions such as repair should be considered more often for older adults who make use of digital devices and services. Our data showed how through contact with others such as close family and friends, working together often reduces technological burdens. We also revealed how altruism and negotiation benefitted participants and close others in moments of crisis and how digital and hardware skills are transferrable from older adults to other generations. Overall, this shows that there are many ways to better engage older adults with digital services and support savings of all kinds. We therefore advocate effortful re-engagement with older adults of all ages and walks of life to provide equity through tailored and reliable systems.

Acknowledgments

Thank you to all of our participants for their time and engagement with this research and to AgeUK London for their support with this work. This work was funded by EPSRC DigiAge: Equity for Older Adults grant (EP/W025337/1).

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