Connected Homes

Co-creating connected homes with households to support wellbeing in a rural location

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Introduction

The needs and desires of households have changed in relation to wider changes in work, education, service provision and health care. Households are reliant on digital connectivity for many aspects of their daily lives including remote working, online learning, consumption, utilities, telehealth, entertainment and for communication with friends, family as well as services. These are accessed via platforms, social media, mobile apps, smart devices, and sensors. Given this reliance, it is important to understand how connected homes meet the needs and desires of households to assess how they can support household wellbeing.

To understand how they do this requires household-centric research. To address the development of connected homes from the point of view of households, the 'Co-creating connected homes with households to support wellbeing in a rural location' project explores the ways in which digital connectivity, data-driven services, and home life are interconnected in a rural area, namely, the Crichton Estate Quarter in Dumfries and Galloway.

This pilot project seeks to explore some of the characteristics of connected homes, develop working concepts, and methodologies for further research. The aims of the pilot project are to:

1. Gain an initial understanding about how to develop connected homes in rural areas that are sensitive, ethical, and appropriate because they understand and give voice to households and their members.
2. Explore how to co-create new knowledge, concepts, theories, and designs of connected homes through interdisciplinary research and multi-sector collaboration.
3. Identify what practices are appropriate, which stakeholders are relevant and what type of open and inclusive innovation process are required to ensure that the design of connected homes and data-driven services create the homes that households need.

The objectives are to:

1. Identify some initial insights about how household composition, housing type, digital access and skills, inequalities and wellbeing factors influence variations in connected homes in rural areas.
2. Understand how connected homes are created by household cultures, practices, relations, and imaginaries of home in rural areas.
3. Undertake participatory design with households, service providers and technology and home developers in the design homes and of technologies to support household wellbeing.

The pilot study started in December 2021 and finished in May 2022. The project is a partnership between the University of Glasgow (UofG) and The Crichton Trust (CT), which is part of a wider UofG and CT collaboration. The project team consists of: Prof. Bridgette Wessels as Principal Investigator (UofG); Jennifer Challinor (CT) as Co-Investigator; Dr. Sandy Whitelaw (UofG) as Co-Investigator; and Dr. Ryan Casey (CT/UofG) as Research Associate. This pilot project was funded by Research England's Connecting Capability Fund.

The report first provides some background information about connected homes, wellbeing and households. It then discusses the contact of rural living in Dumfries and Galloway, which is followed on by an overview of the methodology of the project. This is then followed on by outlining the key findings before discussing the key conclusions of the project.

Background

Increased interconnectivity and smart technologies represent a shift in homes and home lives. Households are reliant on connectivity and digital systems and services in the ways they manage their homes and undertake home-based activities (Argandona *et al.*, 2021). Connected homes have 3, 4 or 5G connectivity, are linked with smart devices and data-driven monitoring and learning systems.

The ways households understand, use, and assess connected homes is key in the shaping of connected homes. Household activities and knowledge, together with housing and home technology, shape what home is and what it means. The development of connected homes involves understanding households, what home means for people and their families, and how they perceive and use digital technologies for their wellbeing. To assess how connected homes can support household wellbeing means addressing several types of households in terms of composition, living arrangements, culture, and resources. It requires assessing home as an economic, social, and cultural entity. This includes dwelling spaces, interactions and relations amongst household members, artefacts, technologies, and networks. Home in ideal terms is a base for self-actualisation, autonomy, and dignity that gives feelings of being at home, comfortability, and feeling at ease (Mallett, 2004; Livingstone, 2021).

Homes, including connected homes, are important in supporting wellbeing in (a) subjective of ways of feeling secure and being happy, in (b) objective ways in terms of income, housing and living standards, and (c) for digital wellbeing in terms of people's relationships with technology and the ways it can impact their health (Veenhoven, 2014; Søraker *et al.*, 2015; OECD, 2019). The development of connected homes involves ensuring that households and their members retain dignity, which is the right of a person to be valued and respected for their own sake and to be treated ethically. It also involves supporting self-actualisation, which is the realisation of one's potential, and the full development of one's abilities and appreciation for life (Whittlestone *et al.*, 2019).

The context of connected homes in rural places is important, as rurality is not often well-represented in considerations of the domestication of ICT and the intersection of wellbeing and connectivity. The pervasiveness of digital technologies and their ubiquitous place in everyday life is often situated in urban contexts (smart cities, etc.) which highlights how people live with technologies in well-connected and densely populated areas but neglects the perspectives and experiences of people and communities in non-urban places. Rural places are impacted by geographic and social inequalities, which in turn, impact the availability, quality, accessibility, and use of digital technologies in rural communities (Graham *et al.*, 2012; Roberts *et al.*, 2017). Rural places can form 'distributed cities' (Boulos *et al.*, 2015) together which are an amalgamation of their smaller distinct identities, towns, neighborhoods, and villages in order to pool resources for ICT infrastructures and broadband provision. Such efforts are a way for rural communities to work together to bring attention to rural places in policy agendas and to offset high installation and maintenance costs of ICT infrastructure (Wagg *et al.*, 2020).

Rural places are also not often well-represented in national data about wellbeing. Either homogenously perceived as affluent (based on smaller affluent pockets), or in contrast, linked with poor socio-economic and health rates, measures of wellbeing are often not sensitive to the diversity of rural communities and place-contingent issues. Some scholars (Barca *et al.*, 2012; Winterton *et al.*, 2014) argue that initiatives and policies aimed at improving wellbeing and quality of life in rural places should be 'place-based' (see Cummins et al., 2007) in that they take into account the unique social, cultural, and institutional factors of a place (local culture), involve the participation of local people to foster local innovation (enhancing community capacity), and consider the geographical contexts (local-global processes, spatial ad/disadvantages, environment and climate, etc.). These understandings of the importance of local context have informed the design of this project.

Dumfries and The Crichton

The geographical and demographic characteristics of Dumfries and Galloway create an influential context for the work. The region can be characterised as broadly 'rural' in nature with a modest population (around 150,000) across a relatively large area (a population density of 60 per square mile compared to 168 across Scotland a whole). Additionally, the age demographic is skewed strongly towards older people. Dumfries and Galloway has the oldest age profile in Scotland – the lowest percentage of 0-15 year olds and the highest over 65 years. Significantly, projections to 2028 suggest that these circumstances will not significantly change – in comparison to the rest of Scotland, the region will experience relatively greater declines in both overall birth rate (from 10.2 to 10 per 1000), and the proportion of those in the 0-15 years age group (a 14.2% decrease). At the same time, the percentage of those in the 75 years + group will see the largest increase in the country (23.7%). These data clearly have an impact on the demand for health and social services and the way that they can effectively be delivered across the region.

Whilst the 2020 Scottish Index of Deprivation (SIMD) suggests that in comparison to the rest of Scotland, Dumfries and Galloway has relatively moderate levels of deprivation (ranked 20th out of the 32 local authorities), there is a recognition of highly concentrated areas of deprivation located in large towns such as Dumfries and Stranraer, as well as being associated with experiences of rurality.

In relation to the region's economy, actual and projected growth in Dumfries and Galloway is lower that Scotland and the UK and seen to be dependent on the public sector and a relatively narrow group of low profit industries (mainly agriculture, tourism and 'service' type activity). Employment levels are lower than the national average (68% in Dumfries and Galloway compared to 73.8% for Scotland) and for those in employment, median earnings in 2021 are £533 per month compared to £611 across the UK and the rate of growth in wages to 2019 has been lower in Dumfries and Galloway compared to Scotland (an increase of 4.9% compared to 9.6% nationally).

Various aspects relating to housing are significant to the project. Proportions of tenure types are broadly comparable with national levels: owner occupied, 64%/62%; social rented, 21%/23%; private rented, 13%/14%. Rates of regional housebuilding are the lowest in Scotland (22 homes annually per 10,000). The vast majority of dwellings in the region are based on a single person (34.3%) or two people (36.3%) with a project increase of 4.6% in single occupancy by 2028. There is a broad perception of relatively high levels of digital exclusion within the region: 8% of homes in Dumfries and Galloway are unable to receive a high-quality fixed broadband connection (compared with 2% across the UK) and 7% of households are unable to receive 4G mobile signal.

The Crichton

The Crichton estate, managed by the social enterprise The Crichton Trust, is on the site of a former psychiatric hospital founded in 1838. As a result of 'care in the community' developments, the 85 acres of parkland and gardens site that was owned by Dumfries and Galloway Council was de-commissioned as an in-patient facility across the 1990s up until 2013. Maintaining a fully integrated model, the Crichton Development Company was established in 1995 to regenerate the redundant hospital buildings and subsequently, the Crichton Trust has attracted a wide range of businesses and enterprises, including: 90 commercial businesses; three restaurants; four universities and one further education college (with a total of 6000 students); a nursery and primary school; a NHS healthcare center; an cultural events centre and conference suit and a host of associated facilities (spa, pool, golf, football club and gym). 2021 saw The Scotland 5G Centre officially launch its first live 5G private network across the Crichton estate. This programme will accelerate the adoption of 5G new opportunities and economic progress through various innovations and new ways of connecting people and places.

Our central research question is:

How can connected homes meet the needs and desires of rural households?

The research design of this project is based on a participatory approach in household and technology studies (Silverstone *et al.*, 1992). To assess how best to utilise the advantages of connected homes and how to manage the risks requires household-centered research, which focuses on the needs, desires, and knowledge of households (Fung and Gale, 2021). More attention is needed on how households adapt technologies into their household lives and what gaps and risks they perceive and experience as well as what works for them. To date, research on the developments of the connected home has been from a technology developer and service provider point of view (Harper, 2011). More research is needed to explore the complex variables of home life such as family and parental styles factors, community and societal factors, parent-child communication, family rituals, roles, rules, and decision making (Norgaard and Brunso, 2011; Ndiaye et al, 2013) in order to gain an understanding of connected homes that are comfortable, secure, and give householders a sense of being at home.

The subsidiary research questions are:

In what ways might housing inequality, social inequality, and digital inequality feature in the development of connected homes in rural areas?

How are rural households using digital technologies and data-driven services?

To what extent are households having to adapt digital technologies meet their needs, practices, and imaginaries of home life?

Why are household perspectives important in the design of connected homes, and how might they contribute to in the design and development process of connected homes?
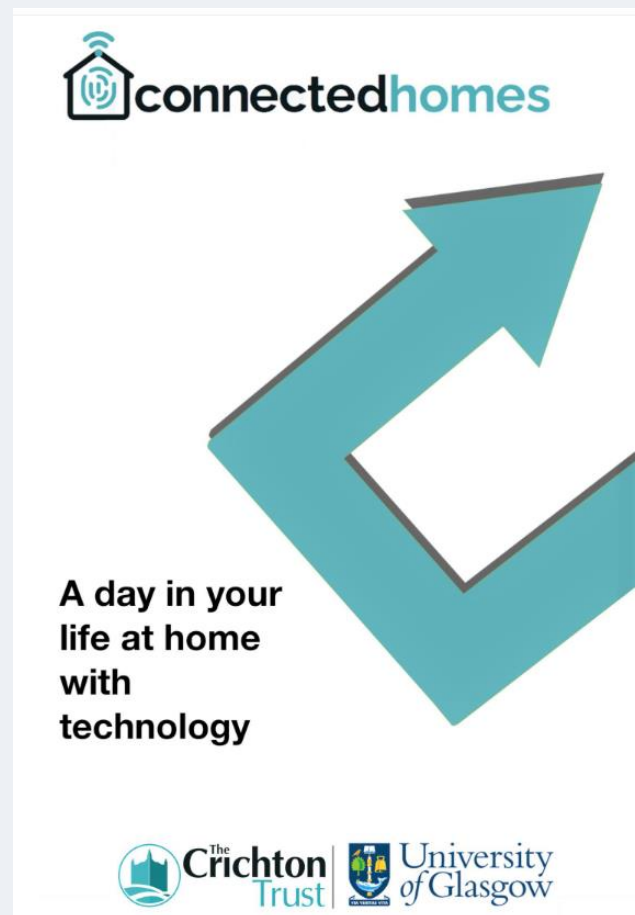
Methodology

The focus of this research is centered on the perspectives of households. We have taken a home-centric and household-centric approach, emphasising understandings and practices of automation in developing an understanding of household autonomy, dignity, and negotiation. The research problem requires an approach that can ask questions of the different dimensions, practices, and meanings of CIL Homes. We therefore use an integrative mixed methods approach that combines a range of qualitative methods to collect data about the dimensions of homes, automation, and household life.

Data collection methods

We undertook a thematic document analysis of publicly available local and central government reports and published research reports. This has helped us to build a preliminary understanding of inequalities in the areas of housing, social, and digital, and create an early model of the ways in which these may intersect in household lives and in how households may or may not be able to develop connected homes to support their wellbeing. Four qualitative data collection methods were then used to explore the different dimensions of connected homes. Household members were first invited to complete a **one-day diary** which encourages them to detail the digital technologies they use at home (when, where, whom with, and what they like or do not like about them) on any given day. Households were then invited to take part in a collective household **focus group** and individual **walking interviews** with a member of our research team which explores household negotiations around digital technologies, how households use digital technologies and data-driven services, what adaptations households make, and what it means to feel 'at home'. Lastly, households took part in a **co-creation design workshop** in which they spoke about and designed what they need (essentials for living) and want (what can improve their lives) from a connected home which involved designing and redesigning domestic spaces and integrated digital data-driven technologies using craft materials such as Legos and drawings. All this data has been analysed using thematic analysis.

Participating households

Four local households in Dumfries were recruited as part of this study by convenience and responses to local advertisements, for a total of seven participating individuals (4 men/boys and 3 women/girls). Participants ranged in age from 12 - 79 years old, some still in secondary school, some working full-time or self-employed, and some retired. All participants identified as White. *Household 1* consists of a recently retired woman (65) who uses digital technologies sparingly for social, cultural, and practical reasons. *Household 2* consist of a nuclear family including a mother (45), father (54), and teenage son (15) who all either work (both self-employed) or attend school full-time. This household has enthusiastically adopted the use of many digital and smart technologies into the home for many reasons. *Household 3* consists of a single parent family including a father (54) who works full-time and a daughter (12) who lives in this home part-time. This household uses digital technologies for various practical, cultural, and social reasons. Household 4 consists of a retired man (79) and his wife (who did not wish to participate) who take up digital technologies in the home for practical and social purposes.

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Key Findings

- *Connected homes are shaped by the temporal and spatial dimensions of household routines. This encompasses household activities, schedules, communication, layout/rooms, and technologies used throughout the day.*

- *Connectivity and digital technologies are experienced as something households actively engage with, but also as background practices and activities which provide essential services. This reinforces how connectivity is part of the infrastructure of the home.*

- *Autonomy, dignity, and negotiation are important in the experience of living in connected homes. Households want to feel in control and that they can make adaptations.*

- *Households want connected homes to be designed or adapted in more flexible ways to meet their needs and wants throughout the life course.*

Image taken from co-creation design workshop in May 2022 in Dumfries

Key finding #1

Routine, time and space

Routine, time and space

The dynamics of time and space in relation to household routine is an important finding from our participating households. Households interact with digital connectivity through various devices in the home throughout the day. Much of this is structured around household routines, such as activities, practices and communication both internally (between household members) and externally (beyond the home). However, we have found that not only is the use of technologies and data-driven services shaped by household routines, but that routines can be mutually shaped by connectivity, datafication, and technologies in the home.

In order to better understand connected homes, it is important to consider temporal aspects of connectivity. This includes features such as: the different times of day and night; the rhythms of the household and each individual household member; where people spend time using technologies, not using technologies; time spent together, and time spent apart. For example, lighting features as an important example of the temporal dimensions of connectivity in the home. One household diary entry describes the importance of both natural and artificial lighting solutions in relation to their craftwork:

> *'Weaving. Don't like lighting. Need strong 'daylight' (5500ish Kelvin) over work area. Central ceiling light was bought because it [can] be adjusted 3000-6500K but it's not bright enough and I am in my own shadow. Recently bought a daylight table lamp which is better. Selecting colours and working under artificial lighting is a common problem for craftworkers.'*

For this household member who repurposed what was a spare bedroom into a hobby room, she has had to rely on technological lighting solutions in order to be able to continue her daily craftwork at different times of day and during different times of the year. This demonstrates how seemingly technology-free home activities are underpinned by connectivity and digital technologies in the home.

Connected homes are also shaped by spatial dimensions of household routines. Household members use technologies or do certain activities in specific rooms of the home. Rooms and spaces in the home become defined by their purpose: beds, kitchens, hobby rooms, gardens, as well as gathering spaces versus rooms where they can (or wish to) retreat. We have found that household routines are shaped by the flow of domestic space, and more so, that interconnectivity has expanded the ways in which people relate to domestic space as it flows beyond the physical house. As one household member explains during a household focus group:

> *'Even if you're busy or if you're not at home and someone comes to the door with a delivery, you get the notification, then you can speak to them through the doorbell as well and say, just leave it wherever or whatever. That's quite handy. Or even just to see that someone's been or that someone's came home when they're meant to be home, you know, things like that [...]'*

Digital technologies such as smart doorbells and other home monitoring systems have enabled people to stay connected to home activities, communications, and practices even when they are not physically there. Data-driven digital technologies allow people to stay perpetually connected to home throughout the day.

Connectivity is important to peoples' everyday routines inside and outside the home, when households are together or apart, and through the temporal and spatial dimensions of household rhythms and flows. This is why a key finding from this study is that connected homes are shaped by the temporal and spatial dimensions of household routines.

Key finding #2

Active engagement versus background technologies

Active engagement versus background technologies

The second key finding from our project is that connectivity and digital technologies are experienced as something households actively engage with, but also as background practices and activities which provide essential services. Households therefore can be seen to frame their engagement with different technologies in ways that both foreground and background the role of connectivity in the home. Many essential technologies and data-driven services such as heating schedules, smoke and carbon monoxide detectors, motion-sensor lighting, and movement/location tracking systems were discussed in ways that featured in the background of everyday life as reliable, automated technologies that households did not have to consciously think about. As one household member begins their diary:

> *'5:00AM – Central heating is programmed to fire up at this time. We have a combi boiler which produces hot water on demand and circulates hot water to the radiators […]'*

Automated schedules for heating mean that the boiler 'awakes' before the rest of the household wakes up and removes the inconvenience of thinking about having to heat the home. The ways these technologies go largely unnoticed and are relied upon demonstrates how connectivity becomes embedded in the infrastructure of home. Alternatively, there were other technologies, activities, and household practices discussed by participating households in which digital technologies and data-driven services were actively engaged with throughout the day and foregrounded as part of their daily routines. In the example below, a household member reflects on an alcoholic drink tracking app they use:

> *'It's more just a tracking device but it does make you think when you're – you know, I don't drink during the week at all but if I did in the past, you'd quite often think, I'm not going to have a glass of wine tonight cos I'll need to put it on the app.'*

This household member manually tracks and inputs data on alcohol-based drinks they consume for self-accountability and not only has tracking become part of their everyday life, but the practice of tracking has impacted whether or not they will actually have a drink. Other examples of foregrounded technologies in the home include other forms of health and wellbeing data (such as pedometers, smart watches, heart rate monitors, etc.), smart meters, screen time statistics, and the streaming of boxsets and other online content (which are important for many households as together or alone-time). Many of these examples include the ways household and personal data are reflected and presented back to household members, demonstrating the 'liveliness' (Lupton, 2017) of digital data-driven technologies and the ways in which they become foregrounded in household practices, communication, and activities. For example, one household member was notified about a potential heart issue by her smart watch, and while she now receives care for it by healthcare professionals, she also self-monitors her health data as part of her daily routine. Between the background and foreground, digital technologies are increasingly part of the infrastructure of connected homes and how individual and collective wellbeing is managed. Our second key finding, therefore, is that households experience technologies in the home as part of their active and background practices, activities, and communication.

Key finding #3

Autonomy, dignity and household negotiation

Autonomy, dignity and household negotiation

The third key finding from this project centres on household autonomy, dignity, and the negotiations that take place at the household level over interconnectivity in the home. All participating households in this study agreed that it is important to them that digital technologies in the home should be easy to install, use, and fix when things go wrong or stop working. Many households use online resources such as DIY tutorials to repair technologies themselves, such as the household member in the focus group excerpt below:

'I would always have a go myself first and search every opportunity to try and resolve it before I ever went to somebody else to try and fix it for me. I would exhaust Google I think (laughs), before I'd ask anybody else for help.'

This household member uses many digital data-driven technologies and feels confident not just introducing new technologies into the home, but also confident (and determined) to repair broken devices or services on their own. However, some other participants were less confident in their abilities to use and repair certain domestic technologies and admitted to not knowing what they would do if essential automated smart devices in the home stopped working:

'The phone has got the Hive app on it, and I use that when - I'm actually, I was thinking, I don't actually know how to use controls on the wall for the central heating (laughs). I do it all through the app on the phone and if anything happened to the phone I'd have to read the manual for how to adjust the thermostat.'

It is important to households that they feel confident to use and repair household technologies in order to maintain a sense of autonomy and dignity in their own homes. While smart apps and automated systems make household life more convenient, they should not amplify or create new forms of dependency. This is particularly important in a rural context where electricity and other forms of connectivity can temporarily fail. Digital devices and systems need to have both automated and manual functions that households at all levels of digital adaptation can feel confident operating. This highlights the importance of the responsibilisation of home care. Household members need to feel they can trust the digital systems in their home, and that technologies do not erode their senses of self-trust and self-confidence.

Privacy and security are also important values for the households that have participated in this project. Various forms of home and personal security technologies have been discussed to protect households from physical and online insecurity such as CCTV, location tracking, online banking alerts, scam-conscious caller ID, and house alarms. Many household members expressed, however, that collective security should not come at the expense of dignity and privacy:

'I think that's an important point – no one's using it to sneak up or to spy on anyone, if you know what I mean. We all know that the cameras are there and we've all got access to see what's happening all the time for us, because I know that could be an issue in other homes. But that's something that we've been quite open about, to make sure that it's not spying (LAUGHS). [...] It could be very intimidating, you know, I think it could be if someone was trying to be watching you all the time.'
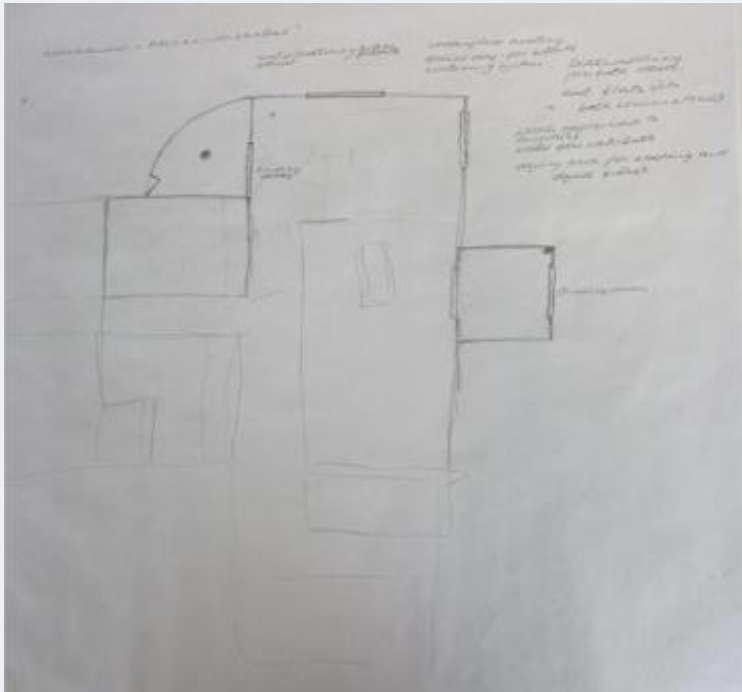
This household valued the peace of mind achieved through using monitoring technologies in the home and felt that they came to a shared understanding of how and when this technology should be used. This highlights the importance of household negotiation and decision-making in connected homes. This extends beyond the theme of privacy, as connected homes are often negotiations of power between household members; focusing on issues such as what digital technologies are introduced, who uses them and when, and who controls them. As households continue to domesticate digital data-driven technologies in the home, we have found that households also desire space and time for privacy and disconnection from monitoring technologies, as well as processes of automation.

Key finding #4

Flexible design and adaptations

Flexible design and adaptations in connected homes

The final key finding is about design, in that connected homes need to be designed or adapted in more flexible ways to meet the needs and wants of households throughout the life course. The role of home changes over time and under specific circumstances, which means its flow, layout, the technologies and how they are used,

need to be adaptable to different requirements. Several households discussed the dynamic identity of rooms in the house, as bedrooms and dining rooms also became work and hobby spaces during the Covid-19 pandemic. Flexible outdoor space has also become increasingly important and features prominently in the designs created by participating households.

In the design to the left, one household worked with their existing house layout but redesigned the connections between indoor and outdoor spaces both in term spatial flow and light. Two glass conservatories with a woodburning stove have been added to the home to house indoor plants and bring more natural light and heat into the home. Additionally, a door was added to the conservatory nearest the back garden and patio to create easier access which the household felt was missing. Heating, lighting, and spatial flow are important design aspects that households want to be able to change and control in their own homes. In the design below, a different household also incorporated important elements from their household practices and values into their connected home design.

In the design to the right, this household designed a new courtyard and extension on their existing home that blends indoor and outdoor space as well. This includes physical spaces and furniture that meet household needs such as a driveway and garage, patio, and office rooms. However, this design also includes the placement and integration of monitoring systems that reflect existing household practices and bring this household peace of mind. This demonstrates how social values and household practices can be incorporated in connected home designs.

To the left, a different household exemplifies the importance of both flexible and value-driven design.

This household design includes a new open floorplan and flow between spaces so those living there feels closer together in the home. However, a separate technologically disconnected room has been added as a space where household members can be alone and feel like they have privacy from both people and data-driven devices/services. These designs demonstrate how connected homes can incorporate meaningful aspects of home life.

The sense of feeling 'at home' is often personal, meaningful, and difficult for households to express. Autonomy and control over home adaptations and design is an important part of what makes people feel at home. Digital technologies in the home, particularly automated ones, ought to be relied upon to function as they should, yet households should also be able to control them manually if needed or preferred. For example, one household designed a new automated watering system for their garden, so the plants do not feel like a burdensome commitment, but they also wish to turn off the automated system if they feel like watering plants themselves. Having more control over reliable automated systems is a way that connected homes can help to design out burdensome dependencies and commitments. These findings demonstrate how household-centric design can empower households and support wellbeing.

Conclusion

The project sought to address how connected homes may or may not address the needs and desires of rural households. It took a household-centric perspective to explore how several types of rural households are using and adapting digital technologies in developing homes that are connected. It considered inequalities in terms of access to broadband, housing type and tenure, digital skills and literacy, socio-economic profiles, and health and life stage concerns.

In overall terms the project shows that digital technologies and services are part of household lives and that they are an established part of homes. However, the integration of digital technology into homes varies and the development of connected homes is *ad hoc*. Households buy digital technologies to meet their specific needs and desires and although these are embedded into household practices, they are not necessarily thought about in terms of connected homes. The need for excellent broadband provision underpins the development of connected homes.

The pilot project shows that the ways connectivity is embedded in homes is through the ways in which households domesticate them to fit into their daily routines and imaginaries of home. Households tend to work in two ways: (a) domesticating technologies from home-based activities and service needs or (b) technology-driven take-up, seeking to keep up with the latest technology trends. Both approaches, however, merge when members of households negotiate how best to use technologies in the home.

The evidence from the pilot shows that households can domesticate the technologies they feel comfortable with and ones that meet their needs and wants. They are good at learning to find a way to work with technology, however, that learning varies, and more support is needed to ensure that all households have the knowledge and support to adapt technology into the kind of homes they want.

In terms of domesticating connectivity through technology, our pilot shows that this is strongly shaped by household culture. This means that although technologies and connectivity are often seen in purely functional terms, when looking at connected homes, that functionality is related to, and shaped by, the meaningfulness of aspects of home lives. Connected homes therefore need to embrace hobbies, socialising, engagement with wider social issues such as current affairs, accessing information as well as managing utilities and accessing services.

Connectivity is understood and experienced both in the background and foregrounded in household practices, communications, and activities. In the background, connectivity is part of the infrastructure of homes for essential services as well as for an entire range of household practices. For utilities such as heating and light, digital connectivity and devices work in the background and need to be reliable and to work automatically. There are two key factors to consider. One is that there needs to be a back-up should electricity or other aspects of connectivity fail and two, that households have control in setting and monitoring these more background aspects of connected homes.

In terms of more foregrounded use of connectivity in relation to its use for hobbies, work, study, and healthcare there is a sensitive balance between household autonomy and freedom to select what they want to use for what and why. There is a need to ensure that connected homes are value-driven by household culture. These values include senses of privacy, security, and control and the autonomy to create the kinds of home lives households want. These values underpin changes that households may face over the life course. Therefore, households need to be able to adapt connected homes to meet their needs and wants over the life course.

The changing role of homes in relation to fluctuating needs and expectations of households has

implications for the design of homes, their domestic spaces, and technologies as well as furniture and so on. Households are usually presented with old housing that they need to retrofit or new housing that they have not had any input into. This creates a challenge for households in adapting housing to meet the new requirements of homes, both in terms of new household practices and how to fit recent technologies of connected homes into housing and domestic space. It also impacts on their ability to adapt homes to meet new requirements across the life course.

One of the key design findings is that homes need to be designed or retrofitted in more flexible ways. The overarching vision of the design of connected homes is that they should be open plan with flexible and adaptable interior walls. The design needs to provide good lighting, accessible spatial flow, and the ability to create personal work, study, and hobby spaces. It needs to provide spaces for shared activities as well as solitary activities. It needs to be well connected with technology seamlessly but accessibly, and include technology free spaces. Care is needed in how technologies are embedded in domestic space, both background and foreground applications need to be embedded into spaces but in ways that households retain control and autonomy.

Future research

The need to develop household centric homes means that attention should be focused on how household perspectives can be included in the design of housing and technology. The pilot project shows that household can articulate what they want from homes provided they are supported in that journey. To foster inclusive innovation and participatory design of connected homes involves asking households to reflect on their housing, activities, and practices as well as their technologies through diaries and focus groups. This prepares them for co-design workshops for connected homes. To scale up this approach, neighbourhood household design groups could support better design of connected homes.

The ways in which households feature in the ways homes are connected digitally and for what purpose means research and development must address three key features:

- o How to ensure that politics and power dynamics within households are equitable and fair for each household members as connectivity is embedded in homes
- o How to ensure that connected homes retain – or improve - senses of autonomy and dignity of households and their members
- o How to improve the design of homes and domestic spaces to facilitate connected homes that are driven by household values.

The development of connected homes is incremental because households buy digital technologies for specific purposes and adapt and domesticate them into their domestic routines and spaces. This highlights the role of households in the innovation of using digital technologies in homes. Households however need a supportive environment as homes transition to connected homes. Here a public health approach to supporting connected homes could be useful in adopting an inclusive and holistic approach to planning. Future research can also look at household and family politics and dynamics in relation to connected homes which remains underexplored.

Next steps

This small-scale pilot project has provided rich insight into what households want and need from connected homes in order to support their wellbeing and how we can support households to express and articulate those desires. This project has opened up avenues for potential future research into connected homes on a larger scale both nationally and internationally. As homes move into the future, we need to consider affordability, adaptability, sustainability, and the rising costs of living. More research is needed to better understand how these factors impact households from a holistic perspective in rural places and beyond.

Policy recommendations

- ## The inclusion of connectivity and digital wellbeing in community care needs assessments

Connectivity and digital wellbeing criteria should be included in needs assessments in community healthcare and occupational therapy, particularly in rural places impacted by social, housing, health, and digital inequalities. Increasingly, essential civic, care, and social services, as well as other basic needs, are digitally mediated and it is important that connectivity is recognized as a basic need and utility. Access to reliable broadband and other vital digital technologies and data-driven services should be embedded in community care.

- ## Strengthen community capacity to support households

In order to empower households to express what they need and want from digital technologies in the home, we need to improve the discourse around digital technologies in the home and give households the tools to articulate and express what they need and want from connected homes, as well as make decisions together. This would involve building community capacity into schools, community support organisations, and other places in the community for helping local households make fair decisions and adaptations together in a supportive environment.

- ## Consider connected homes as part of the public health approach to household wellbeing

A public health approach would be an impactful way of framing the ways in which connected homes can support wellbeing. Within the public health domain is the notion of a 'settings' approach and we argue the home as such a setting, particularly a connected home. The WHO define this as 'the place or social context in which people engage in daily activities in which environmental, organizational, and personal factors interact to affect health and wellbeing… where people actively use and shape the environment… thus it is also where people create or solve problems relating to health.' The home represents an important site of public health and there is potential for digital technologies and services embedded in the home to feature more in public health interventions that foster healthy homes.

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