Digital exclusion and relative digital deprivation: Exploring factors and moderators of internet non-use in the UK[☆]

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A B S T R A C T

This paper investigates internet non-use in the UK. We apply Resource and Appropriation Theory (RAT), identifying main factors associated with internet non-use in the UK: (1) older age, (2) lower socio-economic classification, (3) disability, (4) less education/qualifications, and (5) lower housing tenure. We extend RAT by exploring magnifying effects of disadvantages, particularly, moderating effects of gender, housing tenure, urban/rural, North/South divide, and ethnicity. Internet non-users tend to be in lower-paid jobs, which impacts productivity even more during than before Covid, closing the loop of the RAT vicious circle. A thread runs through the results on the importance of attitudes and motivation. Accordingly, we recommend interventions based on Relative Digital Deprivation Theory. Once an individual understands that they suffer digital inequality, they are more likely to change attitudes and behavior to reduce inequality. If encouraged by family and friends, they may then view internet non-use as fixable and worth fixing, potentially becoming internet users.

1. Introduction

Access to information and communication technologies is important both on a world scale, contributing to sustainable development goals, particularly Goal 10 "Reduced Inequalities" (Lythreatis et al., 2022) and on an individual level, as there is a strong association between lack of internet access/use and health and wellbeing (Kickbusch et al., 2021). Specifically, a study across five countries finds that older adults that do not use the Internet face more dependency and need more care than those who use the Internet (Lu et al., 2022). Lloyds Bank (2022) reports that the UK organisation that people who do not use the Internet find most difficult to interact with is the National Health Service (NHS). The NHS, in common with health services in other developed countries (Lu et al., 2022) is committed to delivering services digitally (NHS, 2019, 2022), exacerbating a digital divide between those who can and cannot access digital services (Yao et al., 2022), resulting in health inequities disadvantaging people who do not use the Internet (Watts, 2020). Consequently, continued progress in reducing the digital divide is essential for health in the UK and other developed countries. Moreover, it is not only health that is affected: there is ample evidence for adverse

effects of internet non-use on (e.g.) employment (Robinson et al., 2015), pay (Si and Li, 2023), money management (Holmes and Burgess, 2022), online learning, and shopping (Park, 2017). The requirement of health and (for example) local government for individuals to access services digitally presents double jeopardy for those digitally excluded. First, internet non-use tends to result from barriers that are invisible to digital systems, and second, those barriers (such as less education/qualification) make navigating digital systems more difficult (Allmann and Radu, 2023). Most people who do not use the Internet do not know about available support (Centre for Ageing Better, 2021). This issue is widespread, across Europe and middle-income countries (Allmann and Radu, 2023). Nevertheless, this current paper focuses the UK, which '… is characterised by a high Internet penetration but varying degrees of adoption and digital competencies' (Ragnedda et al., 2022a, p.5). Research dating back several years presents empirical evidence demonstrating the role of digital technologies in building consumer wellbeing and ameliorating social exclusion in the UK (e.g. Dennis et al., 2016, 2017; Papagiannidis et al., 2017, 2023). Yet little has changed: in the UK, 77 % of over-70s have little online engagement; socially excluded groups are least likely to be able to use online services;

virtually every service and government department ignored those suffering from internet non-use during lockdown (Good Things Foundation, 2021; Lloyds Bank, 2021a, 2021b). In short, internet non-use has adverse effects on consumer wellbeing and feeds social exclusion, with all the individual and social issues that entails.

During the Covid-19 pandemic ('Covid') many UK services, support, social contact, retail, leisure, entertainment, education and work activities had to move online (Good Things Foundation, 2021; Lloyds Bank, 2021a, 2021b; World Health Organisation (WHO), 2020; Zaagsma et al., 2020; Roscoe and Johns, 2021). Hence, Covid has widened the disadvantages of internet non-use even further (Allmann and Radu, 2023), adding to the importance of addressing internet non-use.

Accordingly, this paper addresses research questions (RQs):

RQ1 What potential factors explain non-use of the Internet?

RQ1a What are reasons stated for having no Internet at home?

RQ1b What are the main antecedents (in terms of person profile) of Internet non-use?

RQ2 How are the effects of the main antecedents of internet non-use moderated by (a) Covid, (b) gender, (c) housing tenure, (d) urban vs rural residence, (e) North vs South residence, and (f) ethnicity?

Most academic research into internet non-use investigates specific topics with specific groups using qualitative methods (e.g., 15 interviews with people aged 65+ (Gallistl et al., 2021); 30 interviews with disabled people (Egard and Hansson, 2021)). A UK quantitative study used a stratified sample of 868 via an online survey; hence, although respondents of 'varying degree of adoption and digital competencies' are included (Ragnedda et al., 2022a, p.5), internet non-users are not included in the study. In a rare example of a larger study, Lu et al. (2022) analysed nationally representative samples of five surveys covering 23 countries totalling over 100,000 respondents, but only age 60+. The UK Office for National Statistics (ONS) carries out substantial, representative surveys (on which we base this paper). The relevant reports from ONS (e.g. ONS, 2019a), however, are based only on tabulations and related graphs, so cannot identify co-linearity or moderation. Reports and articles that we draw upon must therefore be viewed with caution. Accordingly, this study fills a literature gap by analysing UK nationally representative samples from ONS[1] and the Office of Communications (Ofcom)[2] examining a variety of antecedents influencing internet non-use before and during the Covid-19 coronavirus pandemic (Covid). The paper contributes in a number of ways. To our knowledge, this is the only academic study to (1) draw upon a large and representative enough sample to study a phenomenon affecting a small minority of the population, those who do not use the Internet (two datasets $n > 60,000$ each from ONS and two $n > 3000$ each from Ofcom); (2) study the factors associated with internet non-use (antecedents) using path analysis (regression), thus minimizing co-linearity concerns; (3) compare the influences of antecedents before and during Covid; and (4) study factors moderating the association between antecedents and internet non-use, thus extending Resource and Appropriation Theory (RAT) (van Deursen and van Dijk, 2019).

This paper responds to Lythreatis et al.'s (2022) call for more research to understand the digital divide, especially aspects yet to be addressed in practice. Lythreatis et al. (2022) report a structured literature review that explores the "… factors that affect the digital divide … identified in recent literature" (p. 3). Of nine main categories, education is most prominent. Findings are broadly consistent with those from medium to large UK surveys that do not appear in the Lythreatis et al. (2022) review due to not being published in highly-ranked refereed journals. Hence, importantly, Lythreatis et al. (2022) omit data such as from ONS, that links internet non-use to older age and factors associated with lower material resources, such as socio-economic classification (SEC) and disability (e.g. Lloyds Bank, 2022; Ofcom, 2021; ONS, 2019a). In the literature review below, we first briefly examine the main theory frameworks, followed by the main factors identified by previous research to influence internet non-use. Hypotheses and conceptual framework are then developed, followed by the method and analytical techniques. Then we present our findings. Finally, we discuss theoretical and practical implications.

2. Literature review

2.1. Theory frameworks

This current paper focuses on internet non-use as a dimension of digital exclusion (ONS, 2019a; Gallistl et al., 2021; Lythreatis et al., 2022). Liao et al. (2022) use key-route main path analysis to synthesise theory frameworks relating to the multi-dimensional digital divide from 2855 papers into two clusters. One cluster, which includes the well-researched Technology Acceptance Model family, concerns individuals' psychological status. Our approach based on reported causes of internet non-use leads us to the other cluster, relating to the process of procuring resources for (e.g.) digital access, skills or engagement, including Domestication (Scheerder et al., 2020) and Social Capital (Helsper and van Deursen, 2017). More specifically to internet access, van Deursen and van Dijk (2019) apply Resources and Appropriation Theory (RAT). RAT holds that societal inequalities lead to unequal resource distribution, resulting in unequal internet access, skills, uses, and outcomes (van Deursen and van Dijk, 2019). Given that most prior research into the causes of the digital divide (Lythreatis et al., 2022) focuses on societal inequalities, we therefore adopt RAT as our overarching theory framework. A central tenet of RAT is the vicious circle of social inequalities such as lack of financial resources and education driving lack of internet access, which can restrict access to (for example) information, jobs and shopping bargains, thus worsening the lack of resources and reinforcing societal inequalities (Allmann and Radu, 2023; van Deursen and van Dijk, 2019). Inequalities such as older age, disability, less education/qualification, lower housing tenure (less likely to own home), lower SEC, gender, urban/rural, ethnic minority, North/South divide and household composition are frequently reported in internet non-use studies. Such studies often apply (parts of) RAT in practice even though RAT is not always acknowledged. In the following section, we briefly review prior research on these factors. Importantly, we build upon RAT by considering possible multiplicative effects of disadvantage on internet non-use (moderations), which we develop in the 'Hypotheses and conceptual framework' section below.

Two theories in Liao et al.'s (2022) "individual's psychological status" cluster have been extensively researched: Technology Acceptance Model (Pal and Vanijja, 2020) and Uses and Gratifications Theory (Büchi et al., 2016). We choose the third, Relative Digital Deprivation Theory (RDDT) (Helsper, 2017), because it has seen little research attention to date, yet may be important in motivating people who are internet non-users to use the Internet. According to RDDT, once people realise that they are digitally disadvantaged, they are likely to change attitudes and take steps to reduce their inequality (Liao et al., 2022). This expectation is supported by research in Switzerland by Friemel (2016), finding that internet use is strongly associated with encouragement from family and friends. Accordingly, we expect that (lack of) motivation plays an important role in internet non-use. We therefore examine motivations and the role that RDDT can play in strategies and

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[1] The UK Office for National Statistics (ONS) is the United Kingdom's largest independent producer of official statistics and the recognised national statistical institute of the UK. It is responsible for collecting and publishing statistics related to the economy, population and society at national, regional and local levels. It also conducts the census in England and Wales every ten years.

[2] The Office of Communications (Ofcom) is the UK's official regulator for broadcasting, telecommunications, and postal industries, oversees competition and maintains standards in these sectors. In addition to its regulatory role, Ofcom collects and publishes a variety of data related to its remit. Those public data are accessible on Ofcom's website, and are a valuable resource for consumers, industry professionals, researchers, and policy makers.

tactics for reducing internet non-use.

2.2. Digital exclusion

Digital exclusion can be understood and defined in multiple ways (Liao et al., 2022). For example, it is characterized as a shortage of necessary tools (Roscoe and Johns, 2021), and deficits in access and capability (Lu et al., 2022; Greer et al., 2019) to utilize technologies like the Internet. This concept encompasses three interconnected elements particularly noticeable among UK adults, according to Ofcom (2022): the absence of internet access, a deficiency in digital skills, and a lack of financial resources for internet accessibility. In this paper, we consider a specific dimension of digital exclusion: internet non-users who have never used the Internet, or have not used the Internet for more than three months (e.g. ONS, 2019a; Gallistl et al., 2021; Lythreatis et al., 2022). Notwithstanding, we discuss and comment on a range of measures including not having the skills and/or resources to access the Internet or carry out other digital tasks.

2.3. Factors that influence internet non-use

1. Age

Several studies find that older generations are more likely to be internet non-users (e.g. Faith et al., 2022; Lu et al., 2022; Matthews et al., 2019), which is an important concern for wellbeing as those who are internet users tend to enjoy more social support (Hunsaker and Hargittai, 2018). Seniors are often able to become internet users if they receive support from family and friends (Friemel, 2016). Older generations in low- and medium-income countries (e.g., China, Poland) suffer internet non-use more than those in high income countries (e.g., UK, USA) (Lu et al., 2022). However, although older generations in low- and medium-income countries may be internet non-users, they tend to be supported by their younger families (e.g. Slovenia: Dolničar et al., 2018) as they often live under the same roof (Mubarak and Suomi, 2022). Moreover, ageing is an issue mainly for developed countries (Mubarak and Suomi, 2022); one-person households of older generations are increasing in developed countries (Ruggles and Heggeness, 2008). Hence, older generations in those countries may lack support from younger people and face more internet non-use.

2. Socio-economic classification/income (SEC)

Most studies of the determinants of internet non-use draw attention to the role of factors related to financial resources and SEC (e.g. Hargittai, 2010; Kim and Hwang, 2019; Lythreatis et al., 2022). In the UK, those with lower income, SEC or economically inactive are much more likely to be internet non-users (Ofcom, 2021; Matthews et al., 2019).

3. Disability

People with disabilities face increasing difficulties in accessing the Internet (Terras et al., 2018), and in the US, are three times more likely to say they never go online as those without disability (Perrin and Atske, 2021). While disabled people's typical financial and education/qualification inequalities are barriers to internet access, they also tend to consider that the internet is not disability-friendly (Bureau of Internet Accessibility, 2022). Egard and Hansson (2021) interviewed 30 Swedish people with various disabilities including blindness, impaired finger mobility and other mobility disabilities, highlighting that changes in digital technologies have become a huge obstacle. People with intellectual disabilities tend to use the Internet less due to monitoring and restriction by gatekeepers (Chadwick, 2022). Chadwick et al. (2022) examine internet use by people with intellectual disabilities analysing data from eight countries. The size of each dataset is not revealed but findings indicate that internet use has become an even more serious

issue for people with intellectual disabilities since the outbreak of Covid, for example, in finding Covid-related information published online. In summary, we expect that people with a wide variety of disabilities tend to use the Internet less than those without disabilities.

4. Education/qualifications

Lower education/qualification is reported to be associated with the digital divide (Hidalgo et al., 2020) and non-use of the Internet (French et al., 2019; Pérez-Morote et al., 2020). During Covid lockdowns, this association caused double jeopardy in that children who were unable to access the Internet were unable to participate in education (Ragnedda and Ruiu, 2020) and presumably achieved lower attainment than they otherwise would have. Lack of (offline) literacy is likely to feed through into lack of digital literacy (Ranchordás, 2021; Salemink, 2016). Use of computers and the Internet necessitates basic literacy skills as opposed to phones that are "illiterate friendly" (Sorj and Guedes, 2005, p3). People who lack confidence in (offline) literacy are more likely to be internet non-users (Blank et al., 2020; French et al., 2019). Young adults' offline literacy is not improving in the UK unlike almost all other OECD countries and is now ranked 25th out of 32 (Farquharson et al., 2022).

5. Housing tenure

Residents of social housing are more likely to be internet non-users than those in other tenures (ONS, 2021a). Given that internet non-use is largely driven by socio-economic exclusion, this is understandable but there are many other factors directly linking poorer quality housing with reduced digital access, including building construction (e.g. WiFi/mobile-impervious concrete), lack of (or expensive) built-in broadband connection, overcrowding and lack of privacy (Holmes et al., 2022). There is a "Catch-22 relationship" between housing and internet non-use, in that bidding for social housing is mainly done online, making it extremely difficult for people without internet access to move to more suitable property (Holmes and Burgess, 2022 p.5).

6. Ethnic minority

Research on association of ethnicity with internet non-use is inconclusive (Lloyds Bank, 2022). An effect is reported in some countries: fewer ethnic minority used or had access to Internet compared to white majority (e.g., US: Choi et al., 2022; Davis et al., 2020; Hungary: Helsper and Galacz, 2009; New Zealand: Goodwin et al., 2009; Brazil: Wainer and Covic, 2010). In the UK gaps between ethnic groups were narrow prior to Covid (Helsper and Galacz, 2009). However, Covid has changed delivery of many services including health care (Wosik et al., 2020; Leung et al., 2020). Studies during Covid uncover an effect of ethnicity on the digital divide in health care. For example, Crellin et al. (2022) report that ethnic minority patients encounter more difficulties with the digital health service than white majority in England. Similarly, Chunara et al. (2021) find lower levels of accessing digital health care from black minority compared to white patients. In sum, Covid seems to aggravate internet non-use in health care service for ethnic minorities (Litchfield et al., 2021).

7. Urban vs rural

Rural areas in some countries suffer more internet non-use (e.g., in the USA, Choi et al., 2022) due to poor broadband connection whereas urban areas have more developed infrastructure (Ge et al., 2022). Similarly, in Spain rural and agricultural areas suffer internet access issues related to low economic resources (Kerras et al., 2022). UN (2020) reports large differences in internet access from home by children and young people under 26 between rural (25 %) and urban (41 %) global average. In the UK, over 93 % of rural households are connected to the

Internet (compared to 98 % of urban ones) (Statista, 2023); of those, 2.9 % of rural households cannot achieve speeds of even 10mps compared to only 0.2 % of urban ones (Ofcom, 2020). Nonetheless, prior UK research indicates that people in urban areas are more likely to be digitally disadvantaged than rural, possibly due to economic factors (Ragnedda et al., 2022b), as many UK rural dwellers are actually in affluent areas near to towns (Blank et al., 2020) and the most deprived areas of the UK tend to be in towns and cities (Agrawal and Phillips, 2020). Notwithstanding that prior research is lacking, given the relatively narrow connectivity gap favouring urban, we expect that the effects of deprivation in urban areas will result in (on average) lower internet use in urban rather than rural locations.

8. North vs South

Previous studies highlight a digital divide between the less affluent North and more prosperous South in the UK, indicating that people in the North of the UK are less likely to use the Internet than the South (Lloyds Bank, 2021a). ONS (2019a) reports that the North East of England is the region with the second highest proportion of non- users of the internet (Northern Ireland is highest).

9. Gender

Stereotypically, females are considered less techno-literate on average than males (Holmes and Burgess, 2022), although van Deursen and van Dijk (2019) find males and females to be similar in tech use, except only that men are more likely than women to use two or more screens. Findings vary among studies (Kuroda et al., 2019; Jones et al., 2022). Bleja et al. (2020) report no significant difference between male and female internet non-use in Germany. Analysis of secondary data from Eurostats 2016 indicates no statistical differences between males and females in adoption of e-service among 28 EU countries (Elena-Bucea et al., 2021). In contrast, Jones et al. (2022) report female adolescents experience more difficulties in accessing the Internet than males in Jordan. Gender disparities in internet use are more pronounced in certain countries (Kuroda et al., 2019). In sum, there seems to be little gender differences in internet non-use in developed countries such as the US, the Netherlands, and UK while in developing countries, for example, Bangladesh and Cambodia, due to socio-cultural factors, gender disparities in internet use (greater use by males) are more in evidence (Mariscal et al., 2019).

3. Hypotheses and conceptual framework

The links between the above variables and internet non-use have been well-researched so we do not seek to test these as hypotheses. Rather, we aim to identify variables strongly associated with internet non-use, and examine moderating effects on the association between factors and internet non-use.

3.1. Effect of Covid

The first UK Covid lockdown started in March 2020 when services, education, health care, leisure, entertainment and work activities moved to largely or even entirely digital (Good Things Foundation, 2021; Lloyds Bank, 2021a, 2021b; WHO, 2020; Zaagsma et al., 2020; Roscoe and Johns, 2021). The UK government refused to intervene with subsidised internet connections for those in need, partially on the grounds that they could use libraries for connections – which were soon closed (Holmes and Burgess, 2022).

Several studies report older age as a predominant factor in internet non-use, the older, the less internet use and more at risk during lockdown (e.g., Faith et al., 2022; Lu et al., 2022). Older generations' internet use is reported to have risen since the outbreak of Covid: for example, a tripled amount of online banking registration from age 70+

during lockdown (Lloyds Bank, 2020) and a large increase in video calls and emails during lockdown from 50 to 70 years olds in the UK (Ipsos MORI and The Centre for Ageing Better, 2020). Covid may have encouraged older people to go for digital, hence:

H1. Covid has influenced (moderated) the association between older age and internet non-use such that the association is weaker during Covid than before.

On the other hand, people in lower SEC (e.g., Davies et al., 2021), with disability (e.g., Chadwick et al., 2022), or lower education/qualification (a double jeopardy as most education moved online: e.g., Davies et al., 2021) are more likely to be digitally excluded during Covid as the effects of their disadvantages are multiplied by lockdown restrictions, due to the difficulty of obtaining support (Allmann et al., 2021; Allmann and Radu, 2023; Ragnedda et al., 2022b). Hence, we hypothesize that:

H2. Covid moderates the association between (a) lower SEC, (b) disability, and (c) lower education/qualification with internet non-use, such that the association is stronger during Covid than before.

3.2. Other possible moderating variables

In developed countries, there is little difference between males and females in internet non-use (Kuroda et al., 2019). However, in older age groups, we expect a gender divide. Older females are more likely not to use the Internet than males in, for example Nigeria (Adeleke et al., 2021) and China (Yang and Du, 2021). The finding in China is ascribed to lack of financial resources of older females. A gender pay gap persists in the UK for women 40+ resulting from often working in lower-paid occupations (ONS, 2019b), increasing with older age due to lack of pension provision (Price, 2006). We argue that lack of resources (for older females) leads to a strengthened association of both older age and SEC with internet non-use. We extend this line of argument to two other characteristics that are strongly associated with economic disadvantage: disability (ONS, 2021b), and lower education/qualification (Hodge et al., 2021). In the case of intellectual disability, for example, gatekeepers tend to restrict internet access partly on cost grounds (Chadwick, 2022), thus magnifying the effects of lack of financial resources. Hence, we expect that:

H3. Gender moderates the association between (a) age, (b) SEC, (c) disability and (d) education/qualification with internet non-use such that the association for females is stronger for older age, lower SEC, disability, and lower education/qualification.

In developing H3, we expect that lack of resources (for older females) leads to a strengthened association of (e.g.) older age and SEC with internet non-use. In effect, we suggest that multiple disadvantages tend to be magnified in their effects on internet non-use. Prior research to support details of the below hypotheses is sparse but by way of example, the combined effects of ethnic minority and disability on health and community care are documented (Shah and Priestley, 2001; Vernon, 2002). Disabled ethnic minorities suffer double discrimination: perceived racism from the white majority (Vernon, 2002) and disability prejudice even within their own ethnic communities (Shah and Priestley, 2001). Care outcomes are accordingly worse than for other groups, in particular on account of lack of access to support (Vernon, 2002). We expect that such doubly disadvantaged groups will similarly lack support for addressing internet non-use. Choi et al. (2022) report a similar magnified adverse effect of ethnicity and older age on internet non-use in the US. We therefore extrapolate to extend our expectations to similar moderators associated with economic disadvantage: rented accommodation (e.g., Hilber and Schöni, 2021; English Housing Survey, 2022), urban rather than rural (ONS, 2021c), North rather than South (ONS, 2021c), and ethnic minorities rather than white majority (Phan et al., 2022). Notwithstanding the limitation that further interactions other than ethnicity with disability and older age are speculative, we expect

that:

H4. Housing tenure moderates the association between (a) age, (b) SEC, (c) disability and (d) education/qualification, with internet non-use such that the association with rented accommodation is stronger for older age, lower SEC, disability, and lower education/qualification.

H5. Urban vs rural areas of the UK moderate the association between (a) age, (b) SEC, (c) disability and (d) education/qualification, with internet non-use such that the association with urban areas is stronger for older age, lower SEC, disability, and lower education/qualification.

H6. The North/South divide of the UK moderates the association between (a) age, (b) SEC, (c) disability and (d) education/qualification, with internet non-use such that the association with the North is stronger for older age, lower SEC, disability and lower education/qualification.

H7. Ethnicity moderates the association between (a) age, (b) SEC, (c) disability and (d) education/qualification, with internet non-use such that the association with ethnic minorities is stronger for older age, lower SEC, disability and lower education/qualification.

Finally, RAT suggests that access to digital technologies impact participation in society, which reinforces inequalities (van Dijk, 2005, 2017). Prior research suggests that internet low- or non-use tends to lead to reduced work opportunities and productivity (Ragnedda and Ruiu, 2020; Ragnedda et al., 2022a, 2022b), which in turn leads to lower income and SEC, closing the loop of the RAT vicious circle and reinforcing the antecedents of internet non-use. We lack direct productivity measurement in our datasets, but use hours worked in the previous week as a proxy. We therefore hypothesize that:

H8. Internet non-use is significantly negatively associated with hours worked in the previous week.

The conceptual framework is illustrated in Fig. 1.

Other direct paths examined are housing tenure, ethnic minority and urban/rural (Table 1), plus North/South divide and gender, which are not directly significantly associated with internet non-use.

4. Method

First, we use two datasets from Ofcom, Adults Knowledge and Understanding Survey 2021, and Media Literacy CATI Omnibus survey, 2021, both over 3000 respondents, collected from online surveys but with additional face-to-face for respondents who lack access to the Internet. As only a nominal proportion of respondents are internet non-

Table 1

Path analyses comparing predictors of low use of Internet and association of low use of Internet with hours worked in the previous week before vs during Covid.

Path to time from when last Internet used	Compared to before Covid, the effect is greater (or less) during Covid by (rescaled 0–100)[#]	Standardised path coefficients (t-values)		Difference between groups Δχ² (1df)
		Before Covid n = 68,719	During Covid n = 68,656	
Older age	(−8.3)	0.339 (85.0)	0.256 (62.6)	410.3 (99.0)
Lower SEC	7.1	0.163 (41.1)	0.234 (54.6)	60.7
Disability	10.7	0.078 (21.4)	0.185 (47.6)	297.6
Lower education/ qualification	(−6.9)	0.094 (24.0)	0.025 (6.04)	171.2
Lower housing tenure	2.7	0.066 (17.4)	0.093 (24.6)	21.8
Ethnic minority	(−4.3)	0.053 (15.1)	0.010** (2.9)	71.2
Urban rural	No significant change	0.016 (4.7)	0.021 (6.1)	0.1 ns
Last Internet Used → Hours worked	1.4	−0.023 (6.0)	−0.033 (7.1)	4.6*

Datasets used: LFS: before Covid, January – March 2019; during Covid, January – March 2021.

R^2 of last internet used = 0.20 before Covid, 0.173 during Covid. Fit statistics are not reported as each separate part (left and right hand) of the model is saturated. $\Delta\chi^2$ = difference in χ^2 values between models; 1df = one degree of freedom between models.

Path coefficients and differences significant at $p < 0.001$ except where stated: ** = $p < 0.01$; * = $p < 0.05$; ns = non-significant. df = degrees of freedom. The highest variance inflation factor (VIF) is 1.463, indicating that co-linearity is not an issue. Significance testing of path coefficients is by Bootstrapping/Monte Carlo as the variables are not normally distributed.

Housing tenure, ethnic minority, urban/rural, North/South divide and gender have been well-researched and are not part of our hypotheses but we include in the path analysis for completion. North/South divide and gender are non-significant, so not shown in the table for clarity.

[#] Difference between standardised path coefficients, multiplied by 100 for clarity.

users, we restrict quantitative analysis of these Ofcom datasets to their useful descriptives of, respectively, confidence in reading and writing and, answering RQ1a, reasons stated for having no internet at home.
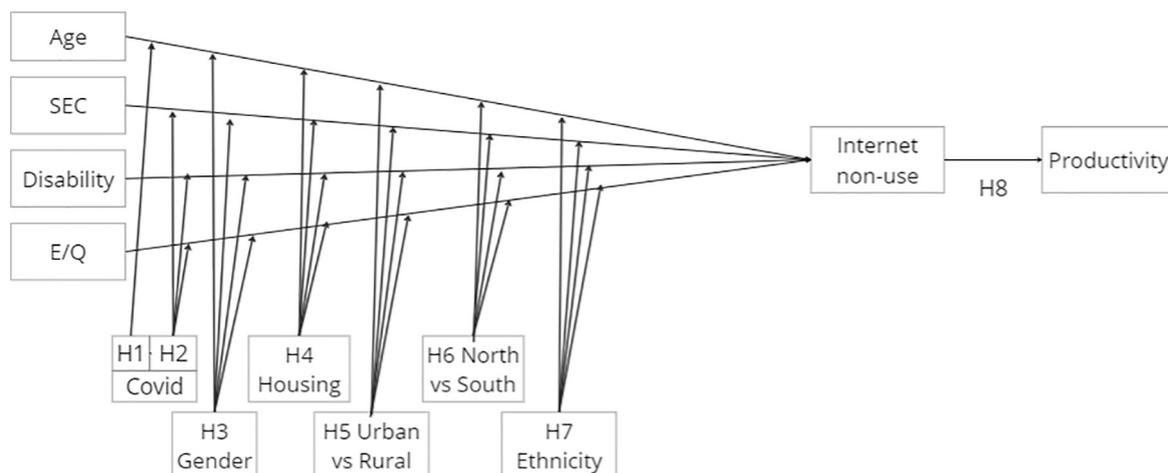
Fig. 1. Conceptual framework.
Note: Only the conceptual framework is illustrated. SEC = lower socio-economic classification. E/Q = lower education/qualification.

To answer RQ1b, we test antecedents of internet low- or non-use including age, lower SEC based on occupation type, disability, lower education/qualification, and lower housing tenure. Apart from disability (dichotomous) we treat these (including internet non-use) as ordinal variables, each having at least five scale points (appropriate for analysis by IBM SPSS AMOS (Byrne, 2001)) (see ONS LFS variables in Appendix 1). Internet use and non-use is entered into the model as a scale variable, as there are graduations of non-use in the data: (1) used in last three months, (2) Between three months and a year ago, (3) More than one year ago, (4) Someone else does it for me (proxy), (5) never used it or don't know. We use datasets from ONS: two editions of the Labour Force Survey (LFS), the largest UK household survey, each over 68,000 responses, one before Covid (January to March 2019) and one during (January to March 2021). The larger size means that smaller sub-sets such as those who do not use the Internet can be studied; 4474 (6.5 %) of the before-Covid sample have not used the Internet for three months or more. Of those, 3645 (5.3 %) have never used the Internet. During Covid, 3685 (5.4 %) have not used the Internet for three months or more; of those, 2924 (4.3 %) have never used the Internet. They are collected by telephone and face-to-face survey, which means that internet non-use is more accurately represented than in the Ofcom datasets.

To answer RQ2, we consider moderators that may affect relationships between the above constructs and internet non-use. These include the effects of (a) Covid, (b) gender, (c) housing tenure, (d) urban/rural, (e) geographic region (North/South) and/or (f) ethnicity. Moderations are explored by multi-group analyses (MGAs) (IBM SPSS AMOS), using Maximum Likelihood estimation (tolerant of non-normality, especially with large datasets (Collier, 2020)). All datasets closely match UK average demographics. They are therefore used unweighted in order to simplify interpretation of results for comparative demographics. Most variables are non-normally distributed. Statistical significance is therefore established by Monte Carlo bootstrapping except where stated (1000 resamples for Ofcom data, 2000 for ONS), a method that errs on the safe side (wider confidence limits) and is effective in avoiding Type I errors (MacKinnon et al., 2004). Path analyses optimize the fit of the data to the model by minimizing the differences between the observed and modelled covariance matrices. The software models the covariance matrices from the correlations between variables and the standard deviations, which we entered as data (the individual case raw secure ONS data is not available for analysis by IBM SPSS AMOS).

The interaction effects (moderations) in the conceptual model are assessed using path analysis. In order to determine the significance of interactions between predictors we combine path analysis with multi-group analysis. Thus, for moderations of a particular path to be significant, we demonstrate that the fit of the model with the path constrained equal between groups is significantly different from the fit of the unconstrained model.

5. Results

Confirming our conceptual model, factors strongly associated with internet non-use (in ranked order) are: (1) older age, (2) lower SEC, (3) disability, (4) lower education/qualification, and (5) lower housing tenure. The following are weakly associated with internet non-use: (6) ethnic minority, and (7) urban rather than rural. North/South divide and Gender are not directly significantly associated with internet non-use. Table 1 presents the significant standardised path coefficients from the ONS data, both before and during Covid.

Results from the Ofcom data highlight very interesting reasons behind internet non-use. Young people (aged 16–24) with low or zero hours spent online are significantly more likely to lack confidence in reading and writing than are older people (p < 0.01). There is a significant positive association between reading/writing and older age, meaning that older people are more confident in reading and writing (for the sample overall, $\chi^2 = 155(1)$, p < 0.001 (Monte Carlo). Of those

who use the Internet <2 h per week, **none** of the 16–24-year-olds in the sample are even "fairly" confident in reading/writing. The main reasons that respondents state for not having Internet at home concern lack of interest, complexity and security, totalling 45 % of those who do not use the Internet. Costs and broadband connectivity come some way behind at 8 % each.

Reasons for not using the Internet are similar across all demographic groups **except** that older people cite "too complicated" significantly more than others (F = 4.811(3) p < 0.01; Age skewness = 0.022, kurtosis = −1.33 justifying the parametric test), consistent with previous research (e.g., Friemel, 2016; Rose et al., 2020). There is a significant negative association between low internet use and hours worked (stronger during Covid, Table 1), indicating less production from people who use the internet less or not at all.

5.1. Moderations

(a) Covid

We compare the influence of the four factors hypothesized to be moderated by Covid (age, SEC, disability, and education/qualification). Internet non-use increases almost exponentially with age, such that older age is much more associated with internet non-use for over 65 s than for other age categories, and steeply increases even after age 70 (Table 2 and Fig. 2). On the other hand, internet non-use reduced during Covid, especially for over-65s (Table 1, Fig. 2); in other words, the degree of association between older age with internet non-use became less during Covid compared to the association before Covid (H1).

Lower SEC (H2a), disability (H2b) and lower housing tenure have stronger associations with internet non-use during Covid (i.e., Covid significantly moderates those associations). This indicates that people in lower SECs, with disability or living in rented or social accommodation during Covid are more digitally excluded than before Covid. The association between lower education/qualification and internet non-use became less during Covid, (H2c rejected – reverse), indicating that during Covid, some people with lower education/qualification have started using the Internet. Other moderators investigated include gender, housing tenure (owned vs rented/rent free), urban vs rural, North vs South, and ethnic minority vs white majority. In the moderation results below, we report before and during Covid separately for comparison purposes.

(b) Gender

Gender has minimal effect on internet non-use except as a moderator. Gender moderates the association between older age and internet non-use such that older age is more strongly associated with internet non-use for females than males (H3a). Older females are more likely to be digitally excluded than older males. The findings further indicate that during Covid, the gap between internet non-use of older females and of older males becomes narrower. Females with lower SEC tend to suffer internet non-use more than males with lower SEC. However, this gender differences in internet non-use appeared only during Covid, indicating that lower SEC females have been more affected by Covid than males with respect to internet non-use. As the during Covid results are the more recent, we refer to this finding as H3b mainly supported. The association of disability with digital poverty is similar for males and females (H3c rejected). Lower education/qualification has more influence on digital poverty for males rather than females (H3d rejected – reverse). Hence, males with lower education/qualification are more likely to be digitally excluded than females with lower education/qualification (Table 3).
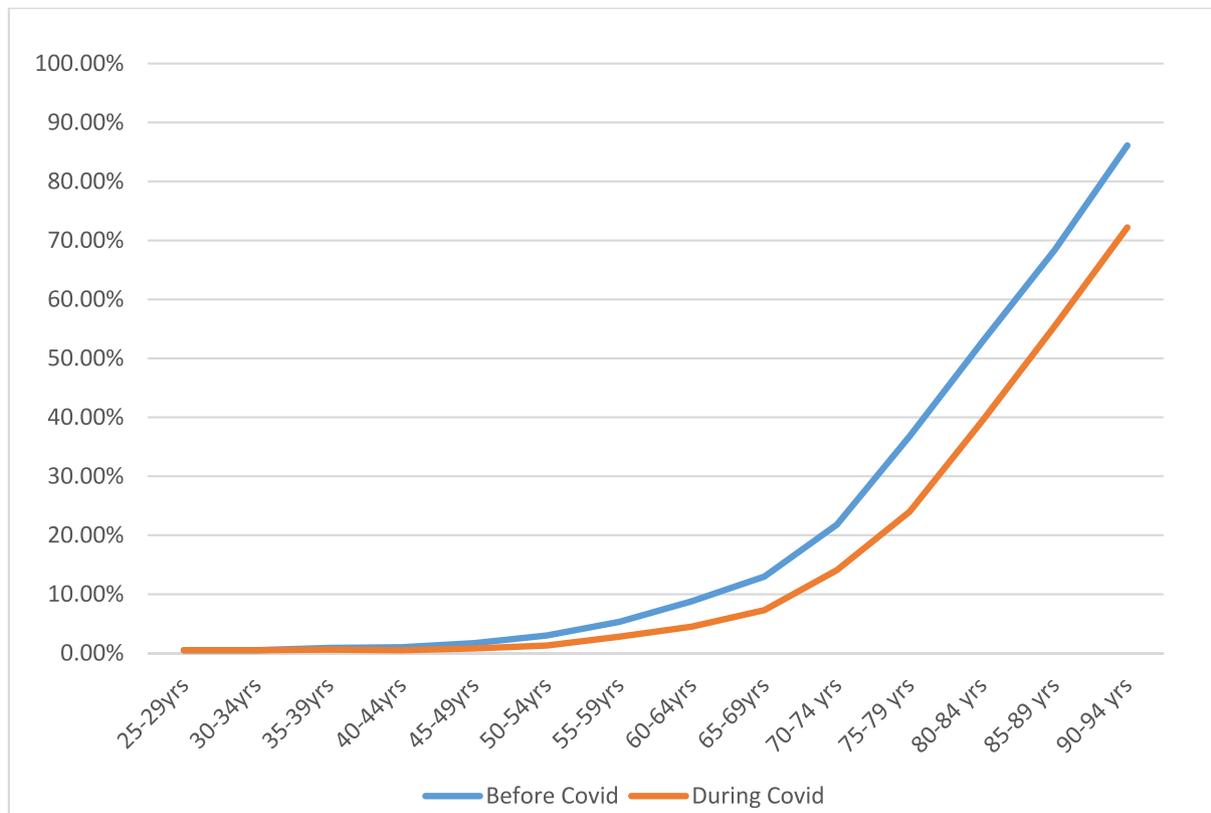
(c) Housing

Older people who live in rented accommodation are much more

Table 2
Internet non-use Index[#] by age categories – during and before Covid.

Age Band	During Covid		Before Covid	
	Number of responses	Internet non-use index[#]	Number of responses	Internet non-use index[#]
Age 16–24	4712	0.31	5911	0.58
Age 25–65	35,419	1.25	38,304	2.08
Age 66–99	16,593	12.54	12,454	18.46
Total	56,724	4.47	56,669	5.52

[#] 0 = no internet non-use, i.e. all respondents would have used the Internet within the previous three months; 100 would mean no respondents had used the Internet within the previous three months.

Datasets used: LFS: before Covid, January – March 2019; during Covid, January – March 2021.

Fig. 2. Internet non-use index[#] by age categories – during and before Covid.
[#]0 = no internet non-use, i.e. all respondents would have used the Internet within the previous three months; 100 would mean no respondents had used the Internet within the previous three months.

likely to be digitally excluded than those living in owned accommodation (H4a). People with lower SEC who live in rented accommodation are more likely to be internet non-users than those living in owned accommodation (H4b). Disability and lower education/qualification are more associated with internet non-use for those living in owned accommodation rather than rented (H4c and H4d rejected – reverse). Our results suggest that once people with lower education/qualification become home owners, they suffer more internet non-use than their home-owning peers who mainly have higher education/qualification (Table 3).

(d) Urban and rural

Older age is also more strongly associated with internet non-use for those living in urban rather than rural locations (H5a). SEC is more strongly associated with internet non-use for those living in urban rather than rural locations but only during Covid, not before (H5b mainly supported). Disability is more strongly associated with internet non-use for those living in urban rather than rural locations but only before

Covid, not during (H5c partially supported). On the other hand, education/qualification is more strongly associated with internet non-use for rural rather than urban residents during Covid (no significant difference before Covid) (H5d rejected) (Table 3).

(e) North and South

Results are consistent with a magnifying effect of residence in the less affluent North on internet non-use (Lloyds Bank, 2021a). First, older age was more associated with internet non-use in the North than the South, but only before Covid (H6a partially supported). Second, the association of lower SEC with internet non-use is slightly greater in the North than in the South of the UK (H6b). Third, disability is slightly more strongly associated with internet non-use in the North than in the South of the UK but only before Covid, not during (H6c partially supported). Finally, education/qualification is associated with internet non-use more in the North than in the South of the UK (H6d) (Table 3).

(f) Ethnicity

Table 3

Path analyses comparing moderators of predictors of low use of Internet and tests of hypotheses H3-H7.

Hypotheses	During/before Covid	Standardised path coefficients (t-values)		Difference between groups Δχ² (1df)	Tests
H3: Gender (female) moderates the association of the variable with internet non-use		**Female** n = 35,908/35,838	**Male** n = 32,746/35,838		
(a) Older age	During	0.300 (53.4)	0.281 (46.4)	22.7	**Supported**
	Before	0.360 (65.2)	0.315 (52.7)	60.7	
(b) Lower SEC	During	0.155 (27.5)	0.135 (22.9)	11.3 *	Partially supported
	Before	0.167 (30.4)	0.158 (27.4)	3.8 ns	
(c) Disabled	During	0.068 (13.3)	0.073 (7.0)	0.8 ns	Rejected
	Before	0.167 (30.4)	0.158 (27.4)	3.8 ns	
(d) Lower education/ qualification	During	0.066 (12.1)	0.092 (15.7)	22.9	Rejected (reverse)
	Before	0.074 (13.7)	0.109 (19.0)	15.4	
H4: Housing tenure (rented) moderates the association between the variable with internet non-use		**Rented** n = 14,309/21,057	**Owned** n = 53,316/47,626		
(a) Older age	During	0.356 (43.0)	0.261 (56.4)	58.8	**Supported**
	Before	0.409 (61.6)	0.282 (61.5)	513.3	
(b) Lower SEC	During	0.161 (18.7)	0.150 (30.3)	21.0	**Supported**
	Before	0.167 (24.7)	0.165 (34.3)	21.3	
(c) Disabled	During	0.080 (17.7)	0.027 (3.4)	4.4 *	Rejected (reverse)
	Before	0.081 (18.4)	0.053 (8.2)	10.5 *	
(d) Lower education/ qualification	During	0.098 (20.3)	0.071 (8.3)	36.3	Rejected (reverse)
	Before	0.092 (19.6)	0.066 (9.8)	4.3 *	
	Before	0.973 0.855	0.980 0.862		
H5: Urban rather than rural areas of the UK moderate the association between the variable with internet non-use		**Urban** n = 55,955/56,312	**Rural** n = 8803/7354		
(a) Older age	During	0.296 (65.4)	0.255 (22.7)	24.4	**Supported**
	Before	0.332 (72.9)	0.300 (24.6)	7.3 *	

Table 3 (*continued*)

Hypotheses	During/before Covid	Standardised path coefficients (t-values)		Difference between groups Δχ² (1df)	Tests
H3: Gender (female) moderates the association of the variable with internet non-use		**Female** n = 35,908/35,838	**Male** n = 32,746/35,838		
(b) Lower SEC	During	0.151 (33.5)	0.102 (9.1)	27.2	Partially supported
	Before	0.134 (30.0)	0.158 (13.2)	1.9 ns	
(c) Disabled	During	0.071 (17.2)	0.073 (7.0)	0.02 ns	Partially supported
	Before	0.086 (21.4)	0.026 (2.3) *	25.1	
(d) Lower education/ qualification	During	0.067 (15.3)	0.129 (11.8)	22.9	Rejected
	Before	0.097 (22.3)	0.102 (8.6)	0.2 ns	
	Before	0.978 0.890	0.977 0.845		
H6: The North/ South divide (North) of the UK moderates the association between the variables with internet non-use		**North** n = 37,848/39,236	**South** n = 18,832/17,433		
(a) Older age	During	0.292 (58.8)	0.292 (40.1)	53.5	Partially supported
	Before	0.345 (71.2)	0.335 (45.5)	68.1	
(b) Lower SEC	During	0.147 (29.8)	0.140 (19.6)	19.4	**Supported**
	Before	0.166 (34.8)	0.160 (22.1)	23.0	
(c) Disabled	During	0.070 (15.3)	0.064 (9.9)	3.6 ns	Partially supported
	Before	0.081 (15.3)	0.062 (9.4)	13.8	
(d) Lower education/ qualification	During	0.087 (18.0)	0.054 (7.7)	29.1	**Supported**
	Before	0.098 (20.9)	0.061 (8.6)	39.1	
	Before	0.981 0.895	0.978 0.877		
H7: Ethnicity (ethnic minority) moderates the association between the variables with internet non-use		**Minorities** n = 5115/7014	**White** n = 63,274/61,631		
(a) Older age	During	0.315 (22.8)	0.288 (67.6)	0.3 ns	Partially supported
	Before	0.376 (32.1)	0.334 (78.4)	170.4	
(b) Lower SEC	During	0.168 (11.3)	0.144 (33.9)	0.1 ns	Partially supported
	Before	0.165 (39.4)	0.144 (33.9)	49.8	

Table 3 (*continued*)

Hypotheses	During/ before Covid	Standardised path coefficients (t-values)		Difference between groups Δχ² (1df)	Tests
H3: Gender (female) moderates the association of the variable with internet non-use		Female n = 35,908/ 35,838	Male n = 32,746/ 35,838		
(c) Disabled	During	0.108 (8.2)	0.067 (17.3)	7.1 **	**Supported**
	Before	0.117 (10.4)	0.072 (18.6)	642.9	
(d) Lower education/ qualification	During	0.072 (2.5)	0.081 (19.5)	3.7 ns	Partially supported
	Before	0.104 (8.6)	0.088 (21.1)	6.1 *	
	Before	0.9760 .877	0.9780 .885		

Notes: Path coefficients and differences significant at p < 0.001 except where stated: ** = p < 0.01; * = p < 0.05; ns = non-significant.
Δχ² = difference in χ² values between models; 1df = one degree of freedom between models. Sample numbers (n) are during/before Covid
Significance testing of path coefficients is by Bootstrapping/Monte Carlo as the variables are not normally distributed.

Older age was more associated with internet non-use for ethnic minorities than the white majority, but only before Covid (H7a partially supported). SEC was significantly more associated with internet non-use for ethnic minorities than the white majority before Covid (H7b partially supported). During Covid the effect is in the same direction but non-significant, indicating that the magnification effect faded during Covid. The most striking finding regarding ethnicity is that for ethnic minorities, disability is much more strongly associated with internet non-use than for the white majority (H7c). Finally, lower education/qualification was slightly more associated with internet non-use for ethnic minorities than the white majority, but only before Covid (H7d partially supported) (Table 3).

(g) Hours worked in the previous week

Internet non-use is significantly negatively associated with hours worked in the previous week (H8) (Table 1).

6. Discussion

6.1. General discussion

Answering RQ1a, attitude factors concerning motivation, complexity and security can explain why some people do not have Internet at home while others with similar (e.g.) financial or older age challenges do. These findings are consistent with RDDT (Helsper, 2017) in that they infer that with appropriate motivation, people can progress from internet non-use to internet use, despite financial and older age challenges.

Our model demonstrates a significant relationship between internet non-use and fewer hours worked, which we consider to be a proxy for lower productivity. Internet non-use is thus associated with lower productivity. The lessened productivity due to internet non-use, as seen during Covid, closes the vicious circle of RAT (van Deursen and van Dijk, 2019) in what Ragnedda et al. (2022b) (without mentioning RAT) dub "the inequality loop" (p.1). Internet non-use leads to lower hours worked and hence lower earnings, leading to internet use becoming even less likely.

Answering RQ1b, the main factors associated with internet non-use in the UK are (1) older age, (2) lower socio-economic classification, (3) disability, (4) lower education/qualifications, and (5) lower housing

tenure. Results extend RAT by exploring magnifying effects of disadvantages, particularly, moderating effects of before/after Covid, gender, housing tenure, urban/rural, North/South divide, and ethnicity, as discussed below. Answers to RQ2 follow below.

(a) Covid

UK older generations tend to use the Internet more after the outbreak of Covid 19, consistent with prior research (Lloyds Bank, 2020; Ipsos MORI and The Centre for Ageing Better, 2020). There are some interventions to deal with older people's internet non-use during Covid, for example, Housing Plus Pilot, giving a tablet and some basic digital training to age over 55 s living in sheltered accommodations (e.g. Casselden, 2022). Such interventions may have assisted older peoples' climbs out of internet non-use. The reduction in internet non-use during Covid, which is particularly striking for older people, indicates that when faced with necessity or at least, a strong enough motivation, many people can find a way.

People in lower SECs, with disability or living in rented or social accommodation during Covid are more likely to be internet non-users during than before Covid. Living in rented accommodation is highly associated with lower income (e.g., Hilber and Schöni, 2021; English Housing Survey, 2022), so that result is consistent with our expectations. People with financial challenges already tended to be digitally disadvantaged even before Covid (e.g., Blank et al., 2020). Covid has widened the disadvantages of internet non-use even further for financially-disadvantaged groups and people with disabilities who are less likely to be able to access support during lockdowns (Allmann and Radu, 2023). On the other hand, during Covid, some older people and people with lower education/qualification have started using the Internet. When necessity demands, people are motivated to take up the Internet (Lloyds Bank, 2021a). The indication is that lower education/qualification is a porous barrier to internet use and therefore digital inclusion.

(b) Gender

Our results find that gender moderates the association between older age and internet non-use, with older females being more likely to be internet non-users than older males. This is consistent with our findings discussed earlier and other studies reporting that older generations have started to use the Internet more after the lockdown (Lloyds Bank, 2020; Ipsos MORI and The Centre for Ageing Better, 2020). During the Covid period, lower SEC females were found to be more affected by internet non-use than males. Our moderation hypotheses are based on predicting a multiplicative effect of disadvantage; from that viewpoint, we conclude that gender is not an additional disadvantage for disabled people with respect to internet non-use. Contrary to our expectations, lower education/qualification had more influence on internet non-use for males rather than females. This could be because men still tend to work in more technical jobs than women (Kenny and Donnelly, 2020), so lower education/qualification may be more of a problem for men in progressing financially than for women.

(c) Housing

Older people living in their own homes may be wealthier than those in rented accommodation, consistent with people who are higher SEC being less likely to be internet non-users than if they own their own homes. In this line of argument, we consider home ownership to be a further indicator of financial opportunity (Bostic and Lee, 2009; Rohe et al., 2002) and thus internet use, additive to SEC. Our results align with our expectation of multiplied disadvantage for people with lower SEC living in rented accommodation. Their higher likelihood of internet non-use is consistent with their broader socio-economic challenges.

The unexpected findings for disability and education/qualification in the context of accommodation type suggest more complex dynamics.

Many disabled people may have been allocated suitably adapted or sheltered rented accommodation (McMahon et al., 2019) and given support, whereas, others may have become disabled while living in their own accommodation and be resistant to such support (Bailey et al., 2019). Higher education/qualification and SEC are strongly associated with home ownership in the UK (Bayrakdar et al., 2019) – it is not the norm for people with lower education/qualification to own their own home – so lower education/qualification may be relatively more of an issue for home owners and therefore more closely associated with internet non-use. Put another way, lower education/qualification is more of a norm for renters, whereas for owners, lower education/qualification is associated with SEC well below the norm.

(d) Urban and rural

Previous research in developing countries reveals that older people in rural areas are more likely to be internet non-users (Ekoh et al., 2021; Yang and Du, 2021). Our findings indicate the reverse in the UK: that older people who live in urban are more likely to be internet non-users than old people who live in rural areas, consistent with prior research indicating that many UK rural dwellers are actually in affluent areas near to towns (Blank et al., 2020). Internet non-use in towns may result from increasing urban isolation (Ali et al., 2021) and growth in one-person households in the UK cities (Stollberg-Barkley, 2005), as people who are isolated may lack digital support.

During Covid, many urban people in higher SECs tended to move to rural areas (Gallent, 2020) while those of lower SEC became even more isolated (Bu et al., 2020), which may have led to the difficulty of obtaining support becoming more of an issue. During Covid, disabled people in more deprived (mainly urban) areas (Agrawal and Phillips, 2020) received more support from neighbours and community than those in less deprived (more rural) areas (Jones et al., 2020). Similarly, people facing financial issues, who are likely to have lower education/qualification (Loopstra et al., 2019), also receive more support than those in less deprived (more rural) areas, which may have helped alleviate internet non-use.

(e) North and South

The Covid-19 pandemic has dramatically altered the landscape of digital engagement, particularly among the elderly. As mentioned previously, many older people were driven by necessity to start using the Internet during lockdown, and the difference between North and South seems to have faded during Covid, along with overall fading of the association of older age with internet non-use. In the less deprived (Noble et al., 2019) South, people and systems may be more resilient to challenges associated with internet non-use. The North is more deprived (Noble et al., 2019) and during Covid, disabled people in more deprived areas receive more support from neighbours and community than those in less deprived (South) areas (Jones et al., 2020), which may have helped alleviate internet non-use for disabled people. In the (possibly more resilient) South, education/qualification does not have as much association with internet non-use as in the North.

(f) Ethnicity

The difference between ethnic minorities and white majority seems to have faded during Covid, along with overall fading of the association of older age with internet non-use. Worryingly, the stronger association of disability with internet non-use among ethnic minorities may result from double prejudice in the provision of support, echoing the effects on health and care (Shah and Priestley, 2001; Vernon, 2002). Our findings before Covid are consistent with those of Helsper and Galacz (2009) who report that the associations between on the one hand, old age, low income and lower education, and on the other hand internet non-use were stronger for ethnic minority in Hungary. In our study, these results did not carry forward to during Covid. As already noted, the adverse effects of older age and lower education/qualification faded during Covid as people in those groups who may have been more resilient were driven online by necessity.

The moderating influence of gender on the effects of age and SEC during the pandemic, particularly accentuating internet non-use for females, is noteworthy. This is paralleled by the influence of housing type and urban dwelling on the same parameters. While the moderation effects of geographic location (North vs South) and ethnicity on age and SEC are less consistent, they underscore the nuanced dynamics of internet non-use. Notably, the hypothesized moderating impacts of disability and education/qualification lack robust support, suggesting the presence of other influential factors.

In sum, the moderation hypotheses are largely supported: gender moderates the effect of older age and also SEC during Covid (more adverse effect for females), which is paralleled by similar moderating effects of rented accommodation and urban residence on age and SEC. The more speculative moderating effects of North (vs South), and ethnicity on age and SEC are more partial and mixed. The speculative hypothesized moderations on the effects of disability and education/qualification are largely rejected or only partially supported, possibly due to the influence of more specific factors, as discussed above. During the pandemic, the adverse impacts of lower education/qualification and older age somewhat receded, indicating that these factors could be mitigated with appropriate motivation and necessity. The study largely substantiates our hypotheses that cumulative disadvantages magnify internet non-use, especially when observing the interactions of gender and housing tenure with age and SEC. However, the effects become more nuanced for disability and are largely unsupported in relation to lower education/qualification. This suggests that both lower education/qualification and older age, while initially perceived as barriers to digital inclusion, can be overcome to some extent when motivation and necessity come into play. The heightened association between disability and internet non-use among ethnic minorities underscores a critical area of concern that warrants further attention.

6.2. Theoretical implications

First, we support RAT (van Deursen and van Dijk, 2019) with a large, representative UK sample, confirming (1) older age, (2) lower SEC, (3) disability, (4) lower education/qualification and (5) lower housing tenure as main antecedents of internet non-use. Our model demonstrates a significant relationship between internet non-use and fewer hours worked, which we consider to be a proxy for lower productivity. Internet non-use is thus associated with lower productivity, closing the RAT vicious circle (van Deursen and van Dijk, 2019).

Second, importantly, confirming our model in Fig. 1, we extend RAT by identifying the magnifying effect of disadvantages. In our conceptual framework and hypotheses, we expected (with varying degrees of confidence) a number of moderating effects, many of which our results confirm. Specifically, the degree of association between older age with internet non-use became less during Covid compared to the association before Covid. People in lower SECs, with disability or living in rented or social accommodation during Covid are more likely to be internet non-users during than before Covid. Gender moderates the association between older age and internet non-use such that older age is more strongly associated with internet non-use for females than males. Older people who live in rented accommodation are much more likely to be internet non-users than those living in owned accommodation. People with lower SEC who live in rented accommodation are more likely to be digitally excluded than those living in owned accommodation. Older age is also more strongly associated with internet non-use for those living in urban rather than rural locations. Lower education/qualification is associated with internet non-use more in the North than in the South of the UK. Strikingly, for ethnic minorities, disability is much more strongly associated with internet non-use than for the white majority.

Finally, drawing upon RDDT, Helsper (2017), emphasises the importance of others such as family and friends. Once an individual understands that they are suffering digital inequality, they are likely to change attitudes and behavior in such a way as to reduce the inequality (Liao et al., 2022). Therefore, if family and friends encourage people who do not use the Internet, they may come to view internet non-use as fixable and worth fixing (Dutton and Reisdorf, 2019), hence potentially becoming digitally included.

6.3. Practical implications

Prior research on the digital divide focuses largely on older age and socio-economic factors and our research confirms these factors to be strongly associated with internet non-use. Many of the barriers to internet use appear to be porous, in that they are less in evidence during Covid than before. We suggest that these barriers might be alleviated by concentrating resources on stimulating motivation through communications (perhaps nudge messages) and supporting digital skills, especially for older people. In line with RDDT, communications might, in addition, be usefully directed towards family and friends of those who do not use the Internet.

In order to improve digital skills of older generations, people with low SEC and those with lower education/qualification, motivation to learn new technology must first be found or established. Such motivation could be initiated by family and/or friends encouraging them to use social media to stay in touch (Eynon, 2021) and perhaps seek support, for example from libraries (Casselden, 2022). These groups can be targeted directly via (e.g.) direct mail using commercially-available demographic/psychographic databases. Such detailed segmentation methods will be particularly appropriate for reaching doubly-disadvantaged groups such as disabled ethnic minorities. Friends, families and carers can be reached via similarly highly-targeted search engine or social media marketing. Future research could investigate how such encouragement could alleviate these specific groups' lack of motivation for learning new technologies.

7. Limitations

In common with most studies on the digital divide, this work is subject to limitations. First, the datasets are secondary data, useful in providing sufficient cases but limited as researchers cannot influence the questions. Accordingly, we study the available single dimension of digital exclusion, i.e., internet non-use. Future research may examine multi dimensions of digital exclusion: Level 1 (access), Level 2 (acceptance, skills and competence) and Level 3 (outcomes and range of applications) (Lythreatis et al., 2022). Variables representing internet non-use are appropriate but not identical across the datasets (ONS: no use of the Internet for three months or never used; Ofcom: no Internet at home and low hours spent online respectively). The first Ofcom dataset is useful in including respondents' reasons for having no Internet at home. The second benefits from containing responses on confidence in reading and writing, which is strongly associated with internet non-use but impossible to rank accurately with the variables identified in the ONS datasets. Second, the associations of factors with internet non-use do not prove causation. In some cases, the reverse can be the case, for example, internet non-use may cause lower economic achievement leading to lower household tenure. On the other hand, lower education/qualification is less likely to be caused by internet non-use, so that factor can be viewed with more confidence as an antecedent of internet non-use. Finally, our model does not seek to model productivity, only suggest a link from internet non-use, and accordingly, we do not link the independent variables directly to hours worked (our proxy measure for productivity). This means that, in effect, the right- and left-hand sides of the model are separate models, both of which are saturated and therefore do not have fit statistics. Future empirical research could model productivity in detail and more accurately evaluate the relative

influence of digital exclusion.

8. Conclusions

This paper presents findings of internet non-use in the UK by analysing data from Ofcom and ONS. A variety of socio-economic factors that impact on internet non-use are examined, and findings confirm that internet non-use negatively impacts productivity. New findings indicate, importantly, that a range of moderators affect the association between a variety of factors and internet non-use. Multiple disadvantages tend to be magnified in their effects on internet non-use. Overall, these moderations paint a general picture of multiplied adverse effects of disadvantages such as older age, lower SEC, lower housing tenure and disability. Some negative multiplied adverse effects such as older age with the North/South divide and also with ethnicity; and lower SEC and lower education/qualification with ethnicity have faded during Covid along with a fading of the older age effect overall and slight reduction in internet non-use overall. One striking, novel finding is the multiplied adverse effect of disability and ethnic minority on internet non-use, which is parallel with prior research on the combined effects of ethnic minority and disability on health and community care (Shah and Priestley, 2001; Vernon, 2002), adding to concerns for the wellbeing of this doubly-disadvantaged segment. Looking on the bright side, our results suggest that there is porosity in some of those barriers that have faded during Covid, including older age and education/qualification, that can be tackled by applying RDDT. While there are various factors influencing internet non-use, this paper primarily focuses on the most important ones as discussed in the literature review. Past research on internet non-use often addresses only one or few factors in a study (Gallistl et al., 2021). Consequently, until now, it was not possible to compare which ones have more impact on internet non-use than others, so comparison of factors were not possible. This research makes a significant contribution by comparing and even ranking the most influential factors of internet non-use among the most important factors.

CRediT authorship contribution statement

Akiko Ueno: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Writing – original draft, Writing – review & editing. **Charles Dennis:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Writing – original draft, Writing – review & editing. **Georgios A. Dafoulas:** Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Resources, Software, Supervision, Writing – original draft, Writing – review & editing.

Declaration of competing interest

None.

Data availability

The authors do not have permission to share data.

Appendix 1. ONS LFS Questionnaire items

Variables	Questions
1. Age	Age of respondent in years from 16 to 99 (respondents outside this range are excluded).
2. Lower SEC	(1) Higher managerial and professional, (2) Lower managerial and professional, (3) Intermediate occupations, (4) Small employers and own account workers, (5) Lower supervisory and technical, (6) Semi-routine occupations, (7) Routine occupations, (8) Never worked, unemployed.
3. Disability	(1) Disabled, (0) Not disabled
4. Lower education/ qualification	(1) Degree or equivalent, (2) Higher education, (3) GCE A level or equivalent, (4) GCSE grades A* - C or equivalent, (5) other qualification, (6) No qualification or don't know.
5. Covid	(1) Before Covid (January to March 2019), (0) During Covid (January to March 2021).
6. Gender	(1) Female, (0) Male.
7. Lower housing tenure	(1) Owned outright, (2) Mortgage or loan, (3) Part rent and part mortgage, (4) Rented, (5) Rent free. For multi-group analysis, recoded: (1) Rented (including part rent), (0) Owned (including mortgage or loan).
8. Urban vs. Rural	(1) Urban, (0) Rural
9. North vs. South	(1) North, (0) South
10. Ethnicity	(1) Minorities (0) White majority
11. Internet low or non-use	Last used Internet: (1) Within the last three months, (2) Between three months and a year ago, (3) More than one year ago, (4) Someone else does it for me (proxy), (5) Never used it or don't know.
12. Productivity	Total hours worked in reference week in main and second jobs

Appendix 2. Summary of hypotheses results

Hypotheses	Results
H1: Covid has influenced (moderated) the association between older age and internet non-use such that the association is weaker during Covid than before.	Supported
H2: Covid moderates the association between (a) lower SEC and (b) disability with internet non-use, such that the association is stronger during Covid than before.	Supported
H2c: Covid moderates the association between lower education/qualification with internet non-use, such that the association is stronger during Covid than before.	Rejected
H3a: Gender moderates the association between age with internet non-use such that the association for females is stronger for older age.	Supported
H3b: Gender moderates the association between SEC with internet non-use such that the association for females is stronger for lower SEC.	Mainly supported
H3c: Gender moderates the association between disability with internet non-use such that the association for females is stronger for disability.	Rejected
H3d: Gender moderates the association between education/qualification with internet non-use such that the association for females is stronger for lower education/qualification.	Rejected – reverse
H4: Housing tenure moderates the association between (a) age and (b) SEC, with internet non-use such that the association with rented accommodation is stronger for older age and lower SEC.	Supported
H4: Housing tenure moderates the association between (c) disability and (d) education/qualification with internet non-use such that the association with rented accommodation is stronger for disability, and lower education/qualification.	Rejected – reverse
H5a: Urban vs rural areas of the UK moderate the association between (a) age with internet non-use such that the association with urban areas is stronger for older age.	Supported
H5b: Urban vs rural areas of the UK moderate the association between SEC with internet non-use such that the association with urban areas is stronger for lower SEC.	Mainly supported
H5c: Urban vs rural areas of the UK moderate the association between disability with internet non-use such that the association with urban areas is stronger for disability.	Partially supported
H5d: Urban vs rural areas of the UK moderate the association between education/qualification with internet non-use such that the association with urban areas is stronger for lower education/qualification.	Rejected
H6: The North/South divide of the UK moderates the association between (a) age and (c) disability with internet non-use such that the association with the North is stronger for older age and disability.	Partially supported
H6: The North/South divide of the UK moderates the association between (b) SEC and (d) education/qualification, with internet non-use such that the association with the North is stronger for lower SEC and lower education/qualification.	Supported
H7: Ethnicity moderates the association between (a) age, (b) SEC and (d) education/qualification, with internet non-use such that the association with ethnic minorities is stronger for older age, lower SEC, and lower education/qualification.	Partially supported
H7c: Ethnicity moderates the association between disability with internet non-use such that the association with ethnic minorities is stronger for disability.	Supported
H8: Internet non-use is significantly negatively associated with hours worked in the previous week.	Supported

Note: Mainly supported = the association is supported only during Covid.
Partially supported = the association is supported only before Covid.

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