

2019-03-11

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<http://hdl.handle.net/10026.1/13496>

10.2196/11386

Journal of Medical Internet Research

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The impact of superfast broadband, tailored booklets for households, and discussions with GPs on personal eHealth Readiness: A cluster factorial quasi-randomised control trial

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ABSTRACT (398 words)

Background: eHealth may improve health outcomes, but many people remain digitally excluded. Personal readiness to use the internet for health may be limited by lack of internet infrastructure, personal skills, social support, service provision, and cost. The impact of interventions to reduce these barriers is unknown. From 2011 the British Government supported implementation of 'superfast' broadband (Superfast) across the rural county of Cornwall. This provided the opportunity to assess impact of structural change and person based interventions.

Aim: We assessed the impact of three interventions on personal eHealth Readiness; (i) implementation of Superfast; (ii) tailored booklets to households providing information to help improve personal skills in eHealth; and (iii) discussions with general practices to encourage greater internet use in health service provision.

Methods: This was a cluster quasi-randomised factorial controlled trial. Implementation of Superfast was monitored and households were classified as having early or late availability. An algorithm selected 78 from 16385 eligible postcodes to minimise possibility of overlap between general practices and ensure balance of urban and rural areas; 1388 households were randomly selected from the 78 postcodes and allocated to the eight (2X2X2) study arms. A modified version of the Personal eHealth Readiness Questionnaire was used to compare scores (0-10) and four components (personal, provision, support, economic) from baseline (Aug 2013) to 18-month follow-up between the eight arms, to assess the impact of interventions. We compared standard deviations of scores to assess changes in eHealth inequalities.

Results: eHealth Readiness improved over 18 months from 4.36/10 to 4.59/10 ($t(235)=4.18$ $p<.001$, $CI=0.13-0.35$) resulting from increases in personal and provision components of the score ($t(255)=3.191$ $p=.002$, $t(258)=3.410$ $p=.001$). However, there were no significant differences between the three interventions, either singly or in combination on an intention to treat analysis. There were increases in proportion of internet users (78% to 82%) and mobile use (50.5% to 64.8%). There was no change in eHealth inequality.

Conclusions: People in Cornwall became more ready to adopt eHealth services, increasing in both their personal ability to use eHealth and their methods of access. The roll out of Superfast may have contributed to this and we are certain that our other two interventions did not. This increased eHealth readiness did not cause a larger digital divide. The study illustrates the complexity of carrying out a randomised controlled trial to assess impact of infrastructure change and variations on our method may be of use to others.

Trial Registration

[NCT02355808](https://www.clinicaltrials.gov/ct2/show/study/NCT02355808)

Keywords

eHealth; randomised controlled trial; digital divide; broadband implementation; eHealth Readiness; eHealth inequalities; tailored booklet; cluster trial.

Background

Setting: Cornwall, a county in south west England is a rural area with a population density of 1.5 persons per hectare vs English average of 4.1 [1]. It has a dispersed settlement pattern of numerous towns, villages and hamlets; 27% of the population live in urban areas, 29% in towns and larger villages, and 44% elsewhere [2]. Access to healthcare, transport, employment, information, and communication technology (ICT), training, community facilities and services such as shops and schools is a problem. Cornwall's population is older than the national average (29.7% aged 60+ compared to 22.3% nationally [1]). Prior to the Superfast Cornwall project (below), internet infrastructure was poor. Maximum download speed averaged 5-6 Mbps in urban areas [11] and some 'not spot areas' had no internet access. Internet reliability was poor, meaning access could often fluctuate during the day.

Superfast Cornwall project: This programme funded by the European Union, British Telecom (BT) and Cornwall Council aiming to provide superfast broadband (*Superfast*) infrastructure to Cornwall and the Isles of Scilly. The programme ran from 2011-2015, by which time fibre optic broadband had been introduced to 95% of homes and businesses [3]. *Superfast*, defined as an infrastructure capable of delivering internet speeds higher than 24Mbps [4], aimed to provide a faster and more reliable service with speeds of up to 330Mbps. Introducing *Superfast* was a significant engineering task costing an estimate £132 million and requiring the installation of 130,000km of fibre optic cable [3].

Benefits of eHealth and digital divide: Systematic reviews have shown the potential positive impact of eHealth [5, 6] in areas such as the management of long-term conditions [7-11], internet delivered cognitive behavioural therapy (eCBT) [12-14], smoking cessation [15, 16] and cost-reductions [17-22]. Some are concerned that as we introduce more eHealth the 'digital divide' will increase. Although the proportion of non-users had declined from 35% in 2003, 22% of the British population had still not used the internet in 2013 [5]. Age remained the biggest predictor of non-use; in 2011, only 33% of those aged 65 years and older in the UK used the internet. People who stay offline have reduced opportunities [23] and this divide could increase with the implementation of 'Digital First' across the NHS [24].

Barriers to eHealth: Differential access to information and computer technologies can be examined at the personal level [25], categorising barriers as: (i) Provision (including the impact of lack of suitable infrastructure), (ii) Personal, (iii) Inter-personal and (iv) Economic.

Provision: Poor internet access is a barrier to eHealth use [26-29]; in 2014 the average broadband speed in some rural dwellings was 5 Mbit/s compared with 27 Mbit/s in urban areas [30]. Slow speed internet obviously compromises viewing of web videos and images [31, 32]. Variation is not just caused by hardware but can result from differences by geography or patient group in NHS services; for example, most renal patients in the UK have had access to their renal medical record online for many years [33] but few, if any stroke patients have such facility [34]. Video consultations had been used for dermatology [22, 35] but not widely adopted in general practice.

Personal: Physical and psychological attributes can also be barriers, such as lack of ICT skills [36-39], distrust of internet [40] or health information it provides [41-43], lack of motivation to access eHealth services [44, 45]. Someone's current health may increase motivation to use the internet for health information [46, 47], while limiting their ability to do so [48]. Although video use is increasing, much internet health information is text based, meaning low literacy populations can struggle to use information effectively [26, 28, 49, 50].

Inter-personal (social): Some factors limiting eHealth use may be moderated if people have social support [34]. Many non-users have some form of indirect access to the internet, via other individuals (proxy users). In the UK in 2013 approximately 70% of non-users reported having access to a proxy user but only 20% actually used them to access the internet [51]. Non-users who do not have access, or choose not to use may lack, a strong support structure to help them to overcome fears and apprehension [52]. With decreased social connection, some may also lack exposure to the internet and other technologies [53]. Furthermore, they may not perceive the usefulness in adopting Internet use or have limited motivation to do so [54, 55].

Economic: UK national figures indicated lower income households were less likely to access the internet [56]. Although homes may be technically capable of internet connection, families may not be able to afford it; someone relying on accessing the internet at their local library may be restricted by transport costs [34]. Women diagnosed with breast cancer were less likely to use the internet for health if they had a lower income, even after controlling for other predictors [57]. Lung cancer patients with higher income were more likely to seek online health information about their condition [58].

Measuring eHealth Readiness: The degree to which people are prepared and able to use eHealth can be termed 'eHealth readiness' [59]. Ehealth readiness has been approached in various ways with some focusing on the readiness of a whole sector or system; Legare et al [60] identified six different assessment tools ([61-66]) for this approach. Others have assessed the eHealth literacy of individuals, for example, the eHealth literacy scale (eHEALS) [67]. Jones [34] took a pragmatic compromise examining eHealth Readiness of individuals – but including in this their opportunities from infrastructure, economics, and social support. The Personal eHealth Readiness Questionnaire (PERQ) [70] was designed to measure the impact of interventions that aimed to improve eHealth Readiness and reduce eHealth inequalities. PERQ uses a similar approach to eHEALS, adopting the use of scales as opposed to a binary measure, but included further variables to cover the full range of individuals from non-internet users through to frequent internet users. PERQ has four sub components: Provision, Personal, Support, and Economic.

Measuring eHealth inequalities: As older people have lower use of ICT some observers assume that the digital divide will disappear with newer generations [29, 68]. However, reduced ability to adopt new technology with age may continue [29]. Economic barriers may remain if ICT costs are too high for future generations of older adults. In addition to the ethical argument for addressing eHealth inequalities, such inequalities make the adoption of more cost-effective health delivery difficult if both eHealth and more traditional services must be provided [34]. We need, therefore, to develop interventions which help reduce eHealth inequalities and have a way of measuring them. The standard deviation of the PERQ eHealth readiness score provides a measure of eHealth inequalities

Assessing the impact of *Superfast* on eHealth Readiness: Although poor internet infrastructure is recognised as a barrier to eHealth, there was no clear evidence that improving internet infrastructure alone is enough to improve uptake of eHealth services. A simple before-after comparison does not allow the attribution of likely improvement to the infrastructure change without some form of 'control group'. However, many would argue that an infrastructure change on its own is unlikely to radically improve uptake of eHealth but that some form of education, awareness raising, behavioural and organisational change is also needed. The implementation of *Superfast* provided an opportunity to assess the impact of an improved internet infrastructure. With limited resources we sought to assess the impact of this infrastructure change in combination with individual and provider level interventions.

Methods

Design: A cluster, quasi-randomised, factorial (2x2x2) controlled trial design was used to examine the impact of three interventions (i) improvement of physical infrastructure (*Superfast*); (ii) tailored booklets to households providing information to help improve personal skills in eHealth; and (iii) discussions with GP practices to encourage greater use of the internet in health service provision. Households within Cornwall were allocated to each of the 8 arms of the study. eHealth Readiness and Inequality were compared pre-and post-intervention to measure the impact (singly and in combination) of each of the three interventions.

The study was approved by the Plymouth University Faculty of Health and Human Sciences Ethical Committee and obtained local research and development approval from the Royal Cornwall Shared Research Management Service. The trial was registered at the US National Institutes of Health (ClinicalTrials.gov) # NCT02355808 on 02/04/2015.

Sampling and randomisation: The initial sampling unit was the postcode. All 20088 postcodes in Cornwall (excluding the Isles of Scilly for practical reasons) were included, 2958 listed as having a population of zero, or where no population data was available were also excluded. To more clearly define the presence or absence of *Superfast* we excluded 745 postcodes with *Superfast* coverage of between 0-49% as these were in the process of receiving *Superfast* at the time of sampling. The remaining 16385 postcodes therefore either had *Superfast* available or did not.

Providing an intervention at primary care level via GP practices introduced the likelihood of contamination between intervention groups. GP practices often serve a large geographical area; any intervention at this level would affect several postcode clusters. This meant that random selection of postcodes, without accounting for the intervention area, would likely allocate postcodes with shared practices to separate intervention groups. The sampling method sought to reduce the likelihood of contamination by eliminating postcode clusters at the practice level.

GP practices were included based on longitude and latitude data from NHS Choices [69]. GPs in Cornwall, and those in Devon on the Cornish border, who were the closest GP to a Cornish postcode, were included.

We designed a method to (i) reduce potential contamination between the eight arms of the study, (ii) account for the rollout of *Superfast*, (iii) ensure similar allocation of urban and rural areas.

The 16385 postcodes that met the initial inclusion criteria were allocated to two separate lists based on their *Superfast* coverage and sorted based on population (highest population at top).

Has *Superfast* (S): Postcodes with coverage $\geq 50\%$ (n=8000)

Did not have *Superfast* (NS): Postcodes with coverage of 0% (n=8385)

The following process of selection and randomisation (using Excel random number generation) then took place until no postcodes remained: (Figure 1)

1. A randomisation took place to identify which list (S, NS) would be selected from first
2. The first postcode (highest population) from the list (S, NS) was selected and was randomly allocated to one of four groups (SA-SD / NSA-NSD).
3. Any postcode which shared the same geographically closest GP practice as the selected postcode was then eliminated.
4. The remaining top postcode on the second list was then selected and randomly allocated to one of the four groups (SA-SD / NSA-NSD).
5. This process was repeated from step one until no postcodes remained on either list.

Through this process, 78 from 16385 postcodes were selected and randomly allocated to one of the four intervention groups within their level of *Superfast* coverage. Using Zoopla [70] all households within the postcode were listed and 18 randomly selected, using Excel number generation, and included within the study. In postcodes with less than 18 households all households were included in the sample. The final sample consisted of 1388 households from 78 postcodes served by 78 different GP Practices.

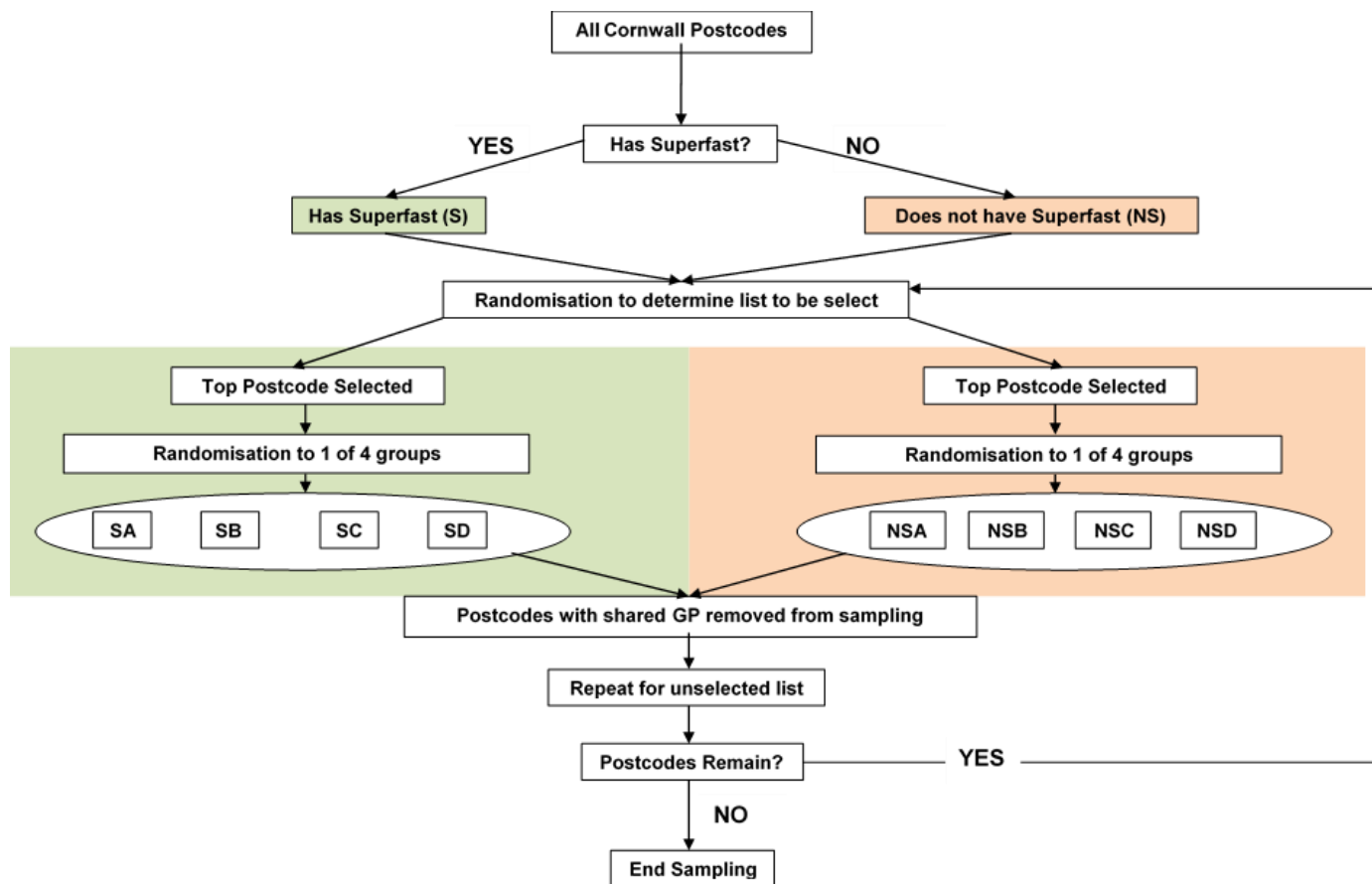


Figure 1. Sampling method

Outcome Measures: A before vs after assessment of eHealth Readiness using the PERQ [34], was conducted on households within the sample over an 18-month period. The PERQ (Appendix 1) was modified slightly improving the wording and layout based on recommendations in the original paper [34]. The four sub components were combined to create an overall eHealth Readiness score (0-9). The standard deviation of Readiness scores was taken to represent eHealth Inequality.

Interventions:

A. Implementation of *Superfast*: Before the implementation of *Superfast*, households were likely to have had internet connectivity ranging from none (not-spots) through to maximum speeds of 5-6Mbps. After implementation *Superfast* Cornwall reported 95% (241,000) premises had *Superfast*, with nearly 90% able to connect at speeds of over 24Mbps [3]. It was not possible for the study to allocate postcodes to receive or not receive *Superfast*. This process was dependent on the *Superfast* Cornwall timescale for the rollout, therefore, this arm of the study was a ‘natural experiment’. Clusters were categorised into areas with or without *Superfast*, based on the rollout at the time of sampling.

B. Tailored household booklet: Participants randomised to the booklet intervention received a tailored eHealth information booklet by post. A total of 16 A5 pages was created using information from national and local services. Some pages were included for all participants others were based on responses to the PERQ. Creation of tailored booklets used a decision tree to identify which A5 pages to include (Appendix 2).

This booklet was addressed to the individual who completed and returned the survey. This process identified individual needs and then tailored a booklet to address those needs. For example, a non-internet user reporting that they would use the internet more for health if they could get someone to help them, received a booklet showing resources such as UK online centres. On the other hand, someone who reported that they lacked confidence in using the internet received information about online based internet training, such as Learn My Way [71].

As a cluster trial all households in the whole of intervention postcodes (clusters) received an eHealth information booklet, those households not randomly selected to complete the PERQ, receiving a general rather than personalised booklet. Tailoring for these households could only use geographical data, for example showing a person what is available in their area based on their postcode. In this case, booklets were addressed to the household as opposed to an individual.

C. GP Intervention: The aim of the GP intervention was to engage selected practices to encourage GPs: (i) to adopt more eHealth services (ii) to actively promote existing services to their patients and aid them in adopting such services. The hypothesis was that achieving these outcomes should impact patients within the area, resulting in increased eHealth Readiness. With this intervention:

(i) The researcher contacted (by post) selected practices in Sept-Oct 2014 to arrange meetings. This letter explained the project and sought permission to attend practice meetings to discuss their use of eHealth services. If this was not possible, the researcher tried to meet with a practice member or establish an e-mail conversation.

(ii) GPs were given suggestions as to how they might expand their current use of eHealth services to use additional eHealth or better promote their existing services, using examples of GPs in their area or nationally.

(iii) GPs were also asked to comment on the services they offered, perceived benefit/detriment and ease of adoption.

Six topics were covered within the meetings that ran for approximately 15 minutes: online appointment booking and repeat prescription; online access to medical records; information prescription; phone triage; and video consultations. Meetings were tailored to consider the current services provided by the GP practice, if discussed services were currently implemented the conversation would focus on the difficulty the GP experienced to implement and any perceived benefits/limitations of the system. Thirty-nine GP Practices were included in the GP intervention arm.

Data Analysis: Data was entered into SPSS version 23 for analysis. The main dependant variable (primary research question) under investigation was eHealth Readiness in the form of a continuous variable, calculated from PERQ responses. Analysis was conducted using parametric tests to analyse eHealth Readiness and

the four sub-variables which contributed to its calculation. On matched data, paired t-tests were used to compare baseline with follow-up. To examine differences between groups, independent t-tests were conducted on the change of continuous variables. Finally, a univariate general linear model was used to investigate the main effect of the three intervention conditions, added as fixed effects, on the change in eHealth Readiness.

Some secondary analyses were conducted. The PERQ contained several categorical response questions which were relevant to the study and provided insight into eHealth behaviour. For categorical data, non-parametric tests in the form of chi-squared tests for independent samples and McNemar, for paired data, were conducted. To provide further insight, in some cases additional categorical variables were created from continuous variables to analyse proportions, for example increased, decreased, no change.

Results

Response rate: Of 1388 households surveyed, 394 (28.4%) responded to the baseline PERQ (October 2013). At follow-up (March 2015) 259 households, 65.6% of original responders, replied to the PERQ.

Change in internet use: The proportion of internet users (n=205, 79.2% at baseline) did not significantly increase, being 81.5% (n=211) at 18-month follow-up. A fifth of respondents who reported that they had not used the internet at baseline (11/54, 20.4%) reported that they had used the internet at follow-up. Only five internet users at baseline (5/205, 2.4%) reported not to have used the internet in the previous three months at follow-up.

More households at follow-up had used their smart phones or mobile devices to access the internet compared to baseline (64.8% (129/199) vs 50.5% (101/199), $p < .001$). Thirty-four internet users who had never used a mobile device to access the internet at baseline, reported using a mobile device for internet access at follow-up. Only six households reporting that they had stopped.

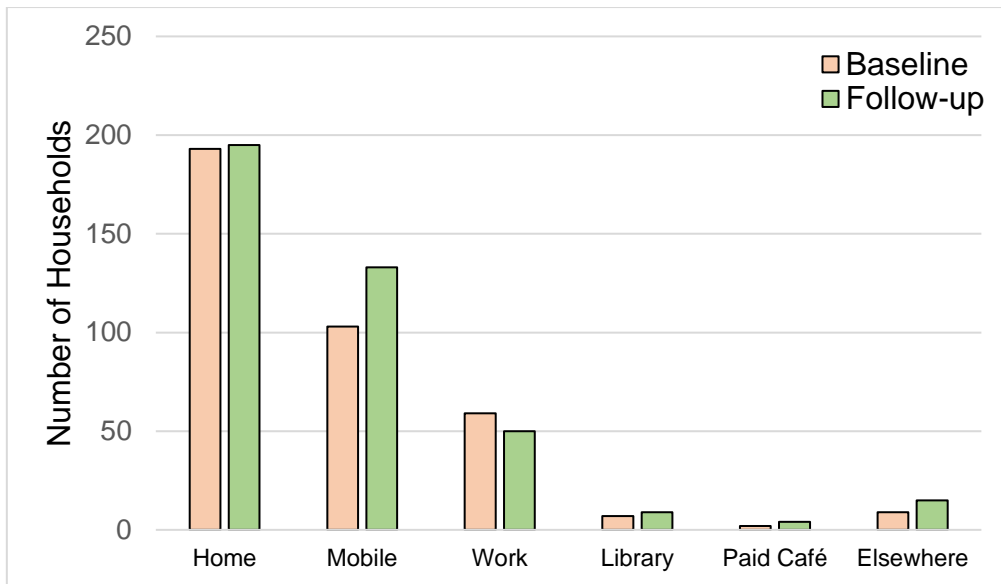


Figure 2 - Where and how 211 internet using households had accessed the internet in the last 3 months at baseline (10/2013) and follow-up (03/2015).

Health related internet use: Most internet using households had used the internet for at least one health related activity; there was no significant difference between baseline (144/205, 70.2%) and follow-up (145/211, 68.7%) for health-related Internet use. However, at follow-up, internet users showed a significant increase in self-reported confidence in using the internet for health related tasks ($M=7.39$ vs $M=7.78$, $t(197)=2.88$ $p=.004$, $CI=0.12-0.65$).

No significant differences were found for the uses of the internet for health-related tasks between baseline and follow-up for internet using households. The most common health-related activity remained, using a search engine to search for health topics (67% vs 66%), followed by using e-mail for health (11% vs 12%) and discussing health topics on a forum (6% vs 6%).

Use of social media for health remained low; only six households (3%) at baseline and four at follow-up (2%) reported use.

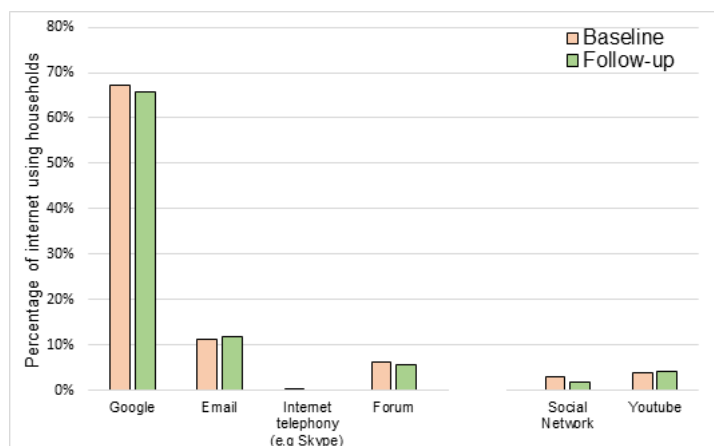


Figure 3 - How internet using households had used the internet for health related activities

Self-perceived barriers: Just over half 128/237 (54.0%) reported that they 'have or would use the Internet for health and have no real barriers to that use'. There was no change at

follow up 139/237 (58.6%). The most common reported barrier at follow-up was 'No need for health information' (27/246, 11.0%) and 'I have no interest in using the internet' (27/246, 11.0%). Only three households (of 246, 1.2%) reported that they 'Would use the internet more for health if I could get a good internet connection'.

eHealth Readiness: Of 236 households with complete data, half (121, 51.3%) showed no change in their eHealth Readiness score, a third 79 (33.5%) increased (maximum increase 3), and 36 (15.3%) decreased (maximum decrease of -3).

Overall eHealth Readiness scores increased significantly from baseline to follow-up for these 236 households (M=4.36 vs M=4.59, $t(235)=4.18$ $p<.001$, CI=0.13-0.35). The standard deviation of Readiness (eHealth inequalities) among responders remained similar (1.72 vs 1.78). Analyses of the four sub-variables which contribute to the calculation of eHealth Readiness scores indicated that both Personal and Provision increased over the 18 months ($t(255)=3.191$ $p=.002$, $t(258)=3.410$ $p=.001$), whereas Economic and Support sub-variables showed no significant change (Table 1)

Table 1 Summary of eHealth Readiness and sub-variables on matched households

	Baseline		Follow-Up		Change	
	MEAN	SD	MEAN	SD	MEAN	SD
eHealth Readiness	4.36	1.72	4.59	1.78	+0.23**	+0.06
Personal	5.49	2.92	5.77	2.94	+0.28**	+0.02
Provision	4.06	1.70	4.26	1.78	+0.20**	+0.08
Support	1.89	1.87	1.88	1.80	-0.01	-0.07
Economic	1.57	0.90	1.67	0.88	+0.10	-0.02

** Significant change

As might be expected, new internet users had higher increases in their Readiness scores compared to continued users (+1.56 vs +0.26, $t(197)=-4.76$ $p<.001$).

Previous users who had stopped using the internet (new non-users) showed the biggest decreases in their Readiness score, with an average reduction of 1.75. These five households had significantly lower Readiness scores at baseline (3.00 vs 5.04, $t(197)=3.78$, $p<.001$) than the 195 who were 'continued users'.

As new adopters of the internet showed the largest increase in Readiness scores, potentially these households alone may have been responsible for the sample increase in Readiness scores. To investigate this, further analysis was conducted on 'continued users', excluding new internet users, this showed significant increases in Readiness scores (M=5.04 vs M=5.30, $t(189)=4.57$ $p<.001$, CI=0.15-0.38).

Interventions

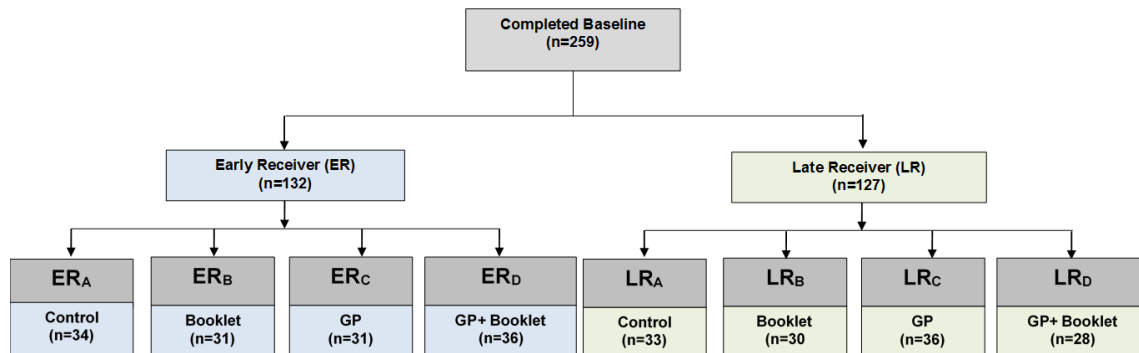


Figure 4. CONSORT diagram of trial numbers for matched households showing early and late receivers of *Superfast*

A. Implementation of Superfast: With the Superfast Cornwall project completed, more accurate rollout data was released to the researcher. This data contained precise ‘go live’ dates for all clusters (postcodes) included in the study, allowing households to be categorised by the number of months *Superfast* had been available in their area. Households in areas where *Superfast* had been available for 24+ months at follow-up were categorised as ‘early receivers’. Areas that had *Superfast* for 23 or less months at follow-up were categorised as ‘late receivers’.

There was no significant difference between the change in Readiness (0.26 vs 0.21) or Provision scores (0.16 vs 0.23), nor between the proportion of households increasing in Readiness scores (X% vs y%) between early and late receivers.

There was no difference in the perception of speed within households between baseline and follow-up (McNemar=2.46, $p > .05$). However, changes in speed perception did significantly differ between *Superfast* arms, with 12 households (of 81, 14.8%) from ‘late receivers’ and five (of 96, 5.2%) from ‘early receivers’ reporting faster internet ($X^2=4.67$, $df=1$, $p=.031$).

B. Tailored household booklet: There was no significant effect of the booklet intervention on the change of Readiness scores. The proportion of households increasing in Readiness scores was 33.5% overall with no difference between those receiving (36.5%) and not receiving the booklet intervention (30.6%).

The PERQ calculates a separate skill score based on responders reported self-ability to complete six internet related tasks. Overall 32% showed an increase in skills scores but there was no difference between those that received a booklet compared to non-receivers.

One area of the booklet focussed specifically on the eHealth services offered by local GPs’ websites, to attempt to increase knowledge and use of these services. At baseline, a total of 56 (27.5%) households reported that they ‘Didn’t Know’ if their local GP had a website, of these, 34 had become aware of their local GPs website and the services it offered, but there was no difference between those receiving or not receiving the booklet.

Only five (5.2%) of households who had received the booklet acknowledged receiving 'a booklet in the post regarding using the Internet for health'.

C. GP Intervention: Of 38 GPs contacted to take part in the study, eight (21%) agreed to take part, three (8%) refused due to busy schedules, and the majority (27, 71%) did not respond. The researcher attended five face-to-face meetings and had email correspondence with the remaining three GPs.

The GP intervention had no effect on household eHealth Readiness, neither when considered as mean score nor as proportion of households increasing in Readiness scores.

Overall 18.7% (38) had been given information to help them use the internet for their health, by a nurse, doctor, or another health care professional, but there was no difference between those in the GP intervention arm and others.

As many GP surgeries did not take part in the study, we did an 'as treated' analysis comparing households from GPs who had agreed to the intervention with other households, but there was still no difference. We also counted the number of practices offering online access to medical records. Only six GPs within Cornwall had started to offer online access to medical records at follow-up, previously none, however there was no difference between those in the GP intervention versus others

Interventions in combination: A univariate general linear model was conducted to investigate the main and combined effect of the three interventions (*Superfast*, Booklet, GP), added as fixed effects, on the change in eHealth Readiness. A full factorial interaction effect was also examined between *Superfast**Booklet*GP for the outcome of change in Readiness. The model showed no significant main effect of either *Superfast* ($p=.677$), Booklet ($p=.928$) or GP ($p=.237$) on the change in Readiness scores. There was also no significant interaction effect between each of the interventions.

Discussion

Overall impact: No one has previously examined the impact of concurrent improvements in internet infrastructure alongside person-based interventions. We assessed the impact of such interventions on personal eHealth Readiness via a cluster quasi-randomised factorial controlled trial. Although eHealth Readiness increased over the course of the study, this change could not be explained by the interventions, either singly or in combination. This could be because there really was no improvement or that the questionnaire approach we used was not sensitive to the change.

Our single booklet posted to a house and short limited discussions with a few practices was very 'low dose'. The implementation of *Superfast* could potentially have more impact but relies on uptake. As a pragmatic randomised controlled trial our analysis was 'intention to treat' so low uptake in all three arms could 'swamp' a possible improvement that might be seen in an 'as treated' analysis.

The use of eHealth relies on three separate but supporting conditions (i) the personal ability to use it, (ii) the presence of systems to provide it and (iii) the infrastructure available to support it. For this reason, despite finding no positive impact of any of the interventions we argue that this study demonstrated a possible method to explore the impact of infrastructure improvements alongside complementary interventions.

Changes across Cornwall in eHealth Readiness and eHealth inequalities: A third of our household respondents improved their eHealth Readiness over 18 months of study, and overall the mean eHealth Readiness had improved without any increase in eHealth inequalities. There was no evidence that it was the already 'eHealth ready' becoming further advantaged over the unconnected, people from across the whole 'scale' had shown improvements.

The increased eHealth Readiness reflected the increase in the proportion of internet users (79% vs 82%) in line with reported change for the UK [72]. One in five non-users at baseline had started to use the internet, while only five people (<3%) had stopped using the internet at follow-up. But the overall increase in eHealth Readiness was not solely due to new internet users. When new users were excluded from the analysis, the increase in Readiness was still significant. This suggests that existing internet users became more ready to use the internet for health.

Despite the increase in level of Readiness to use eHealth, the types of use remained the same. Using a search engine to find health information was the most frequent activity. Although others have proposed that social media could be used more for health [73], few people in this study used it to obtain health information or contact healthcare professionals or organisations.

Implementation of *Superfast*: Our 'intention to treat' analysis examined the impact of *Superfast* regardless of whether a household adopted the service by upgrading their internet supply. On this basis there was no improvement in Readiness scores, between early and late receivers of *Superfast*, during the 18-months of study. However, at our study's follow-up date BT estimated uptake of *Superfast* across Cornwall as still quite low (28%) despite *Superfast* being available for most of Cornwall. It was not possible to obtain data on which households in our sample had adopted *Superfast*, therefore it was not possible to conduct an 'as treated' analysis, that is we cannot tell if households who adopted *Superfast* had higher Readiness scores.

Analysis of categorical responses suggests more subtle changes. More late receivers than early receivers were happy with their internet speed at follow-up. As early receivers had become accustomed to the greater speed/bandwidth both their internet use and expectations of broadband provision are likely to have increased.

Slow uptake of *Superfast* is also seen nationally; Ofcom [74] reported that, by the end of 2015, only 42% of UK households had taken up offered *Superfast* services. This uptake was higher than Cornwall's, but *Superfast* had been available in other parts of the UK for longer. I have deleted this bit because I do not believe your argument. 38% thought cost was a concern – that seems like a good proportion who

might be therefore put off by switching to superfast. We do not know if these people remained with slower speed access rather than take up superfast because of cost.

Only three respondents said they would use eHealth more if they could get a good internet connection suggesting that very few perceived their current internet speed as a barrier to eHealth use. However, at the time of this study no online health services available in Cornwall required a *Superfast* connection. The most common eHealth activity was using Google and much online health information was in simple text and picture format not requiring high-speed connection. At the time of our data collection very few (<5%) reported using health services requiring higher speeds, such as YouTube. Nationally in 2016, the NHS YouTube channel had less than 26000 subscribers. And even video streaming only required modest speed connections of around 500 Kilobits per second [75].

Superfast rollout seemed to have had a measurable impact on people's perception of internet speed, but this did not translate to measurable increases of eHealth Readiness. On the other hand, Cornwall is now structurally more ready to adopt eHealth services such as video calling.

Tailored household booklet: Our study demonstrated how tailored booklets could be produced based on questionnaire and geography. For example, for internet non-users, it provided guides on how to get started. For internet users it provided information on how and where they could find and use online health information. Booklets included information about online services provided by recipients' local GP. However, this one booklet delivered by post and then asked about some x months later was not effective. The recollection of receiving a booklet was extremely low; only five households reporting they had received a booklet. The most likely explanation is that the booklet was perceived as junk mail and never read. The booklet design may be of use for other organisations such as Healthwatch, or if given directly by a GP or practice nurse but as a low intensity intervention delivered by hand to the house it was ineffective.

GP Intervention: The GP intervention was ineffective. Few GPs agreed to meet the lead author and the discussions suggested that these GPs were knowledgeable about eHealth. For example, the researcher raised the potential use of a phone triage system, championed by some GPs [76], but many GPs responded mentioning a recent article in the Lancet [77] that had shown increased workloads. The likelihood therefore was that the researcher was no better informed than the GPs – so unlikely to raise awareness of new digital possibilities.

On the other hand, where the researcher attended larger practice meetings, it was apparent that the views and opinions of GPs differed drastically within the same surgery. In one meeting of note, the topic of information prescription 'sparked' a large debate over its usefulness. Several GPs within the practice were very positive towards information prescription, often directing patients to specific URLs with information on their condition and even printing out online information for those who had limited access. Other GPs had very strong views against using information prescription, preferring that the patient spoke to them only and not use the internet.

This discrepancy in GPs attitude has been well documented [78], and highlights the continued inequalities of service provision.

The difficulty at recruiting GPs has been demonstrated in previous research [79]. The GP intervention was designed to prevent this, by being short in length with minimal requirements for GP participation, although this did not seem effective. The time of year may have prevented a higher participation rate, with many GPs citing a busy flu season impacting their availability. However, it is likely GPs will always be busy [80] and reluctant to participate without keen indication of potential benefits.

Addressing barriers to the implementation of eHealth technology is a complex process that requires support from health services. It is important for policy makers and hospital or practice managers to understand the specific barriers that challenge the practicing GPs and design appropriate interventions to address barriers and promote facilitating factors [81]. Some barriers such as cost associated with the adoption and maintenance of eHealth technology may require incentive [82].

Limitations: The study suffered from a low response rate, responders were disproportionately female, older and came from areas with higher estimated house values. As the *Superfast* rollout was outside the control of the researcher, it was not possible to randomise. Early receivers of *Superfast* were likely from areas in Cornwall which had existing internet infrastructure, and were less rural. Therefore, it is possible that late receivers contained a higher proportion of isolated households. The sampling method, designed to reduce the potential of contamination between arms of the study, removed postcodes with shared GP practices following selection. As the selection of postcodes was ordered by population, a limited measure of rurality, postcodes which shared a GP practice with another more populated postcode, had a much lower chance of being selected. Although this approach was vital to reduce the high risk of contamination between intervention conditions it again meant that highly rural postcodes may have less chance of being included. It is possible therefore that the eHealth readiness from this sample is overoptimistic compared to Cornwall as a whole.

Further Research: This study has provided two measurements of eHealth Readiness within Cornwall over an 18-month period. There is the potential to continue this study to provide a longitudinal view of the change in eHealth Readiness over the coming years. A continued longitudinal study will provide insight into both the change over time and allow for the impact of the *Superfast* rollout to be further assessed. As discussed, the actual uptake figures of *Superfast* are low, estimated at 28%, but these are expected to increase over the coming years. Continued measurement may show a continued increase in eHealth Readiness as the uptake rates increase. Importantly it will also allow for the inequalities in Readiness to be monitored.

With the implementation of *Superfast* across the county, Cornwall has the potential to be a prime location for research into eHealth. The infrastructure improvement has made it possible for Cornwall to support highly demanding eHealth services such as video consultations, or live streaming of health clinics. Presently the county does not provide such systems, but now has the structural groundwork for research in this area. There is the potential for randomised trials of such services to be organised

and conducted. Small trial projects might have to be conducted at the hospital level to show feasibility. This research will help show the potential benefits of such services, which may encourage innovations to be adopted more widely, such as at GP level. In addition, future research in the area will provide further insight into the significant barriers towards eHealth use, with the 'physical' speed barrier removed, other personal and organisational barriers are likely to be further highlighted. This will help researchers examine how to address those barriers and design effective interventions.

Conclusion: Over the 18 month study households in Cornwall became more 'eHealth ready'. It is possible that the roll out of Superfast contributed to this but we were unable to show that definitively. It is unlikely that our other two interventions had any effect. The study illustrates the complexity of trying to assess such interventions by randomised trial and our methods for a cluster quasi-randomised controlled trial may be of use for others.

Acknowledgments

This research was funded with the aid of a studentship from the Superfast Cornwall project, the EU and Plymouth University. Superfast Cornwall, with the help of BT, provided rollout data for use within this study.

Our thanks to the initial steering group; Dr Ellen Helsper, Prof Grant Blank, Katherine Stewart, Dr Andy Neville and Peter Farrell.

Thanks to Paul Hewson for statistical advice and Katie Edwards for her comments on the paper.

Abbreviations

PERQ: Patient eHealth Readiness Questionnaire

RCT: Randomised Controlled Trial

GP: General Practitioner

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