SCOPING REVIEW OF MOBILE PHONE APP UPTAKE AND ENGAGEMENT TO INFORM DIGITAL CONTACT TRACING TOOLS FOR COVID-19

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VERDICT

- Level of, and factors associated with, uptake and engagement with digital contact tracing applications for COVID-19 are unknown.
- Research examining uptake and engagement with health behaviour change apps have identified issues of capability (e.g. knowledge, skills), opportunity (e.g. resources, social norms), and motivation (e.g. perceived usefulness, concerns about its usage).
- The future development and implementation of digital contact tracing applications needs careful monitoring to ensure that such tools do not inadvertently create or exacerbate socio-demographic differences in COVID-19 incidence and mortality.
- There is an urgent need to identify factors associated with the use of digital contact tracing applications for COVID-19 in order to inform their careful design and implementation.

BACKGROUND

While researchers work to develop an effective COVID-19 vaccination, government and healthcare agencies across the world are developing and testing new 'digital contact tracing' technologies to help support the transition from emergency lockdown measures. During this transition phase, it is proposed that people will be able to move more freely, whilst ensuring continual monitoring and rapid action to tackle any new outbreaks of the COVID-19 virus.

Digital contact tracing applications are software that can be installed on a user's personal device, such as a smartphone, to notify the user when they come into contact with person(s) infected with SARS-CoV-2. If contact is made, the user of the application is notified about the potential contact and provided with further instructions (e.g., to self-isolate). Some applications additionally notify the relevant public health authority. At the time of writing, such tools are at different stages of development and testing worldwide, with the NHS contact tracing app (NHSX) currently under development[1].

A recent rapid evidence review from the Ada Lovelace Institute[2] highlights a number of issues that may impact on the effectiveness of digital contact tracing, including whether the use of the application is mandatory or voluntary, the accuracy of the test in terms of detecting contact, how data is collected and accessed and by whom, and how data from the application will be used to inform appropriate actions.

In addition to these technical and practical issues, the effectiveness of this tool depends largely on adequate levels of uptake (e.g. whether the user downloads and registers on the application) and engagement (e.g. the extent of usage of the application or its components over time). It has been estimated that approximately 60% of the population would need to use the NHSX application in order for it to be effective in reducing the spread of COVID-19[3]. It is therefore crucial that we understand the level of, and factors influencing, uptake and engagement with digital tracing applications in order to put appropriate measures in place to mitigate those issues.

Understanding the barriers and facilitators requires that we consider the full range of factors that might influence all relevant application uptake and engagement behaviours (see Appendix). According to the COM-B framework [4], in order for a behaviour (b) to occur (e.g. downloading the digital contact tracing application), people need the capability, opportunity, and motivation. Capability (C) involves psychological (e.g. knowledge, comprehension and skills) and physical factors (e.g. dexterity, disability). Opportunity (O) involves social (e.g. social norms) and physical factors (e.g. time and resources). Motivation (M) includes reflective (e.g. belief in the benefits of the app and its safety) and automatic processes (e.g. emotion and habit).

To date, four different types of digital contact tracing applications have been implemented in Singapore, India, Israel, and South Korea[2] and the NHS app has been under testing at a UK Royal Air Forces base in North Yorkshire. As COVID-19 digital contact tracing applications have only recently been implemented, data on user-level uptake and engagement is likely to be limited. However, there are a substantial number of mobile applications currently in use for individuals to address health behaviour change (e.g. smoking, physical activity, diet, disease

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management). Understanding the key barriers and facilitators associated with uptake and engagement with existing health-based applications may help us inform the future design and implementation of digital contact tracing applications.

Objectives

1. To quantify the current data on COVID-19 digital contact tracing applications
    a. Uptake and engagement of COVID-19 digital contact tracing applications
    b. Examine whether uptake differs between countries
    c. Identify any predictors or correlates of uptake and engagement
2. To conduct two scoping reviews to identify key barriers and facilitators influencing engagement and uptake of
    a. COVID-19 digital contact tracing applications
    b. Health behaviour change applications, including government approved applications, from academic literature and behaviour change guidelines

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CURRENT EVIDENCE

Objectives 1abc: Current data on COVID-19 digital contact tracing applications

Databases (including preprint databases, Google and Google Scholar) were searched for literature on uptake of, and engagement with, digital contact tracing applications during the COVID-19 pandemic (see search strategy, pg11).

Uptake and engagement with COVID-19 digital contact tracing applications

No peer-reviewed, published data on level of, and factors influencing, uptake and/or engagement with COVID-19 digital contact tracing applications were available.

It is important to note that several newspaper articles have reported on digital contact tracing uptake. For example, approximately 10-20% of the population in Singapore has downloaded the 'Trace Together' application [5;6]. Similarly, there are reports that 17% of the population in Israel has downloaded the 'HaMagen' application [7]. However, the data should be treated with extreme caution as the primary sources are not available and the data cannot be verified.

Objective 2a: Scoping review of facilitators and barriers to use of COVID-19 digital contact tracing applications

Databases (including preprint / open science databases, PubMed and PsycInfo) were searched for literature on the uptake of and engagement with digital contact tracing applications during the COVID-19 pandemic (see search strategy below).

Information from application design papers

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The majority of the literature has focused on the barriers and enablers for digital contact tracing adoption from the point of view of the application designer. Application designers have highlighted a number of concerns they perceive the general public might have and how an application needs to be designed in order to mitigate those issues. Concerns from the application developers that they believed could impact on uptake were [8-20]:

- *Privacy* (e.g., from snoopers, from being identifiable as a virus carrier by contacts either directly or through influence, from government / tech companies having access to data) [8-20]
- *Potential misuse of data* (e.g., spamming, stalking) [9,17]
- *Cybersecurity* (e.g., due to vulnerability of immature software; and the privacy concerns if hackers did control your device regarding making false reports, leaks of personal information such as phone numbers) [10;11;17]
- *Data accuracy* (e.g., false positives due to GPS problems, false positives due to misreporting, false reports due to malicious reporting) [8;11-13;17;18]
- *Creating or exacerbating social inequalities* (e.g. whether there are potential socioeconomic, demographic or geographical restrictions to accessing the service). [16]
- *Ethical and legal implications of the tool* (e.g., civil liberties impinged upon and risk of greater surveillance post pandemic) [11,16]

These results should be treated with caution. The identified concerns were based on the issues raised by application developers and not based on data from users who may hold different and/or additional concerns.

Information from surveys of potential users

One large representative survey of the UK population (*N* = 1055) examined hypothetical scenarios of digital contact tracing application uptake and usage [21]. The authors claim there is wide support for these tools; however this was based on whether people indicated whether they would "definitely install" or "probably install". This is a measure of behavioural intention, not actual behaviour. There is a wealth of behavioural science research demonstrating that people do not always act on even the firmest good intentions [22]. Advice based on measures of behavioural intention is likely to overestimate actual uptake and should therefore be treated with caution.

Objective 2b: Scoping review of facilitators and barriers to use of general health behaviour change applications and government approved mobile applications

Databases were searched for literature reviews on uptake of, and engagement with, health behaviour change applications and individual studies on government approved mobile applications (see search strategy below). An additional search for frameworks and guidelines was also conducted.

There is wide variation in reported data from <1% to 100% engagement with applications. We therefore do not report statistics for uptake and engagement behaviour because this heterogeneity probably reflects differences between the form and function of the individual applications. We have instead focused on the *key* barriers and facilitators associated with uptake and engagement

across a *range* of diverse health behaviour change applications. It is likely that many of the identified issues are relevant for the uptake and engagement with digital contact tracing applications, but that there will be additional barriers and facilitators associated with uptake and engagement with COVID-19 digital contact tracing applications. The following section reports data from reviews of the relevant literature and frameworks / guidelines.

Uptake of health behaviour change applications

Two systematic reviews identified several issues that influenced application uptake [23; 24].

The following motivational issues negatively affected application uptake:
- *Privacy and confidentiality* concerns [23; 24]
- Lack of perceived *usefulness* of the application [23; 24].
- Lack of perceived *benefits* of the application [23;24].

Socio-demographic factors that impacted on an individual's motivation to download and use applications were also identified:

- Confidence in one's own ability with respect to use of technology was lower in *women* and *older people* [24]

Socio-demographic factors that impacted on an individual's opportunity to download and use applications were also identified

- *Older people* were less likely to have a mobile phone [24].

One report noted that most health management applications are downloaded fewer than 500 times and only half of phone users download applications [25].

Uptake of government mandated/ recommended applications

There were few studies regarding uptake of government mandated / recommended applications.
- "Carrot Rewards" (i.e., designed to increase health knowledge and promoting health behaviour through completion of educational quizzes) reported low uptake; the application was used at least once by only 17% of those who downloaded it [26].
- Socio-demographic factors were also identified that may impact on application uptake. Higher levels of uptake were influenced by:
  - *Age* (mainly 25-34 year olds)
  - *Gender* (mainly women)
  - *Education* (mainly post-secondary)
  - *Location* (mainly urban)
  - No association was reported with *income*.

A qualitative study exploring the views of young people about the "NHSGo" app (i.e., containing physical and mental health advice across nine behaviours; including sex &

relationships, puberty, sleep, smoking, drugs & alcohol)][27] reported that application usage was associated with:

- *Social justice* (e.g., meeting needs of ethnic groups)
- *Perceived usefulness* of the application
- *Privacy and convenience*
- *Social norms* (e.g. promotion by "social influencers")

Several barriers for the uptake of general health applications were identified, including:

- *Lack of access to vulnerable cohorts* (e.g., poor eHealth literacy in elderly, language barrier in non-English-speaking populations) [28; 29]
- *Privacy concerns* [28]
- *Confidentiality and security.* [28]

Engagement with behaviour change applications

Several barriers and facilitators were identified.

Physical and Psychological Capabilities
Barriers

- Forgetfulness (e.g. if the user needs a password) [30]

Facilitators

- Self-regulation (e.g. self-monitoring increased use and also helped people be aware of their behaviour) [31]
- Knowledge of the behavioural outcome of interest (e.g. disease management) may impact as those with little knowledge may use the tool more to gain knowledge [24]
- Compatibility with own behavioural routine (e.g. engagement increased if compatible) [30]

Physical and Social Opportunities
Barriers

- Owning a device [24].
- High system demands resulting in slow process [30; 32]
- Malfunctions (e.g., not receiving notifications, freezing system, losing power/restarting) [30]
- High impact on battery life [30; 31]
- Features such as reminders received at wrong time [30] or too often [33]
- Poor connectivity and WiFi problems [30]
- Professional support (e.g. phone calls from a clinician) [33]
- Lack of credible source (e.g., clinical endorsement) linked to poor engagement [34]

Facilitators

- General features include tailoring (e.g., customised advice) [30; 32]; gamification or interactive features [32; 33], fun games [35]; personalisation, [33; 35]; option to control

features [33]; automation of functions and little manual input [36], novel features [33], social role, social support and sharing [30; 33; 34; 36; 37]
- Inclusion of behaviour change techniques such as personal feedback (especially in real time) [30; 31; 33; 37], ability to self-monitor [33; 35;36]; advice [35; 36], rewards (e.g., monetary, praise) [30; 33; 34; 36], reminders (e.g., prompts, notifications), [23; 30; 34; 36],
- An attractive look and feel of the app including larger fonts, clearer colour contrasts, intuitive scroll bars and buttons (this may differ by demographics e.g, teens prefer bold graphics and colours) [23], and visual images/aesthetics [35;36]
- Good functionality [36]; i.e., simple and clear language (e.g., plain English, short paragraphs) [32], easy to navigate and learn [30;33;35;36], clear information [30], low effort (especially preferred by young people) [36]
- Privacy; i.e., privacy settings [36] opt in and opt out of features [30]
- Available for devices people already carry around [23] [30]
- Accuracy (e.g., tracking for physical activity) [36]
- Low system demands resulting in fast speed [30]
- A clear purpose about what app will do [36]
- Perceived as a norm (e.g., if family member uses the app then more likely to keep using it) [31]
- Credibility (e.g., development of content by experts [36]
- Practical support to use the app [30; 33; 37]

Reflective and automatic motivations
Barriers
- User goals: e.g. people may cease use once personal goals have been met [31].
- Preference: e.g. some people may prefer not to use apps [31].
- Stress, emotional state, beliefs about disease can be additional stressors that impact on the use of apps if they are seen as an additional source of stress [24].
- Boredom [30].
- Perceived ease of use: e.g. people may stop or reduce usage if the app is not easy to use [31] or it is difficult to use [32].

Facilitators
- Intrinsic motivation: e.g. internal desires/enjoyment [30].
- Expectations: e.g. that their goals will be met with increased engagement [33].
- Relevance: e.g. they perceived the app to have high perceived personal relevance [33].

Demographic and clinical factors that influence individuals' capabilities, opportunities, and motivations to engage with health behaviour change applications.

Barriers
- Gender: Males show poor adherence to use of applications [34]
- Low educational level [34] that may be due to worry that they might not be able to understand how to use applications [23]
- Low eHealth literacy [29; 34]

- Lack of smartphone experience / use of applications (this impacts on initial engagement but could be overcome with support); conversely those with experience may ditch an app for a better commercial one [31]
- Poor connectivity (e.g, may have problems storing data if in rural location) [23]
- Older people are less likely to engage [30] which may be due to less experience with applications/ less availability of equipment [24] and being less likely to persist when problems arise[24]
- Health status (e.g., poorer mental and physical health) [33] and use may decline further as health status declines [30]. Conversely, those with high wellbeing may also be less likely to engage[33]

Facilitators
- Gender: there is mixed evidence as reports state that both males [30] and females have the highest app engagement [33]. Males are more confident in their ability to use technological tools/ have more experience [24].
- Older age [33] however this was also reported as a barrier [24; 30]
- Culturally relevant applications [30]
- Higher educational level [30] [33]
- Lower income [30]
- Higher health literacy [33]
- Higher eHealth literacy: those who used computer or tablets more frequently found applications more usable [23]

CONCLUSIONS

● There is no evidence on the level of uptake and engagement with COVID-19 digital contact tracing applications.

There is a strong need to identify the specific behaviours that are important for optimising the effectiveness of COVID-19 digital contact tracing applications. This includes (but is not limited to): application download; identifying and recording COVID-19 symptoms; responding to appropriate advice and guidance if isolation measures are needed. Identifying the relevant behaviours is important in order to measure them accurately and to assess how to address non-adherence if needed. Different barriers and enablers are likely to influence these different types of behaviours [4].

● There is a dearth of evidence regarding the barriers and facilitators to uptake and engagement with COVID-19 digital contact tracing applications.

As it currently stands, there is no evidence on the barriers and facilitators for digital tracing application uptake and engagement. Future research needs to identify the psychological influences on behaviours required to optimise the use of COVID-19 digital contact tracing applications through careful design and implementation.

● The health behaviour change literature suggests a number of barriers and facilitators associated with uptake and engagement with applications.

Some of these barriers and facilitators are likely to be applicable to digital contact tracing applications. The results demonstrate that there are issues of capability, opportunity, and motivation associated with health behaviour application uptake and engagement.

There is research to suggest that COVID-19 mortality risk is higher in certain countries [39] and populations, including people who are older [40]. There are also key socio-demographic differences in health behaviour change application uptake and engagement. If COVID-19 digital contact tracing applications are to be readily accepted by individuals, it is crucial that their introduction does not inadvertently create or exacerbate inequalities in COVID-19 incidence or mortality. Uptake and engagement with such applications across different socio-demographic groups needs to be monitored.

Importantly, not all of the barriers and facilitators associated with health behaviour change application usage may be applicable to digital contact tracing tools, due to the pandemic context and the novel features of the application. There is a strong need to identify an individual's *capability, opportunity, and motivation* relating to digital contact tracing application usage and engagement. As it currently stands, these factors are unknown and comparisons with existing health behaviour change tools needs to be treated with caution. Key issues which need to be considered are:

- Capability (C): Do users have the knowledge and the skills to be able to identify COVID-19 symptoms, use the tool to record these symptoms or diagnoses, and appropriately act upon and adhere to the advice or guidance provided?
- Opportunity (O): What are the social norms relating to the usage of these tools? What physical resources do people need?
- Motivation (M): What are individuals' beliefs and attitudes (and associated emotions) towards the use of these tools? What are an individual's emotional reactions to the app?

The relationship between socio-demographic factors and these COM factors needs to be closely monitored to ensure that any socio-demographic differences in COVID-19 incidence or mortality are not unintentionally created or exacerbated through the introduction of these novel tools.

PUBMED LINK

End.

Disclaimer: The article has not been peer-reviewed, the findings are preliminary having been produced in only four days; it should not replace individual clinical judgement and the sources cited should be checked. The views expressed in this commentary represent the views of the authors and not necessarily those of their host institutions, the NHS, the NIHR, the Department of Health and Social Care or the British Psychological Society. The views are not a substitute for

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SEARCH TERMS

Digital Contact Tracing Applications Current Data and Scoping Review

Databases:

PsycInfo (0)
Pubmed (21)
arxiv.org (24)
healthevidence.org (0)
osf.home: (28) restrict to preprints (8), and projects (7 - 1 is a duplicate of a preprint)

Search Terms:

Filter for technology: app OR application OR smartphone OR mobile
Filter for condition: COVID OR coronavirus
Filter for app type: contact tracking OR contact OR track OR trace
Filter for year: 2019-2020

These database searches were supplemented with additional searches in Google and Google Scholar to identify any official documents on digital contact tracing application uptake and engagement for countries that have implemented such tools (Israel, Singapore, South Korea, India).

Health Behaviour App Scoping Review

Databases:

- PUBMED (975)
- PsychInfo (660)
- healthevidence.org (21)
- Google search for frameworks

Search Terms:
Filter for technology [title / abstract]: app OR application OR smartphone OR mobile OR technology OR device OR mhealth OR ehealth OR digital

Filter for behaviour [all fields]: "health behav*"

Filter for outcome [title/abstract]: engag* OR adherence OR attrition OR download

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APPENDIX

Behavioural Science and Success of the Proposed UK Digital Contact Tracing Application for COVID-19

The digital contact tracing application for COVID-19 requires at least four inter-related behaviours to occur:

Download app	Carry functional phone at all times	Report Covid19 symptoms on app	Respond to app messages to self-isolate

For a behaviour to occur one must have the capability AND opportunity AND motivation to do so. Likely barriers and facilitators include:

Capability	Opportunity	Motivation
• Knowledge about the app and what it is for • Having the skills to download and use • Being able to identify COVID-19 symptoms accurately • Knowing when and how to report symptoms • Knowing what to do if alerted to exposure to COVID-19 • Memory to do behaviours	• Having a device suitable to download the app • Having sufficient memory space on device for a new app • Having the means to carry phone so it's with you all the time • Needing to use more than one phone (e.g. for work) • Having sufficient battery/means to charge • Being encouraged by others to download and use • Social norms for use	• Beliefs in the value of the app • Perceived ease of use • Wanting to be able to alert others to COVID-19 risk and to know about own COVID-19 exposure • Concerns about data usage and data privacy • Concerns about outcomes (e.g., being instructed to self-isolate) • Previous experience of rewards/disadvantages of being alerted to COVID-19 exposure • Emotions • Identity

A large majority of the UK population need to download and use the app, so its success depends on understanding and addressing specific barriers so that suitable features can be built into the design (e.g. ease of use, ability to opt out of certain features), and into communications. While research on other health-related apps may provide some information about relevant factors, this will not be sufficient for the current context. There is an urgent need for researchers to address:

1. What are the barriers and facilitators for each of the four app-related behaviours?
2. How do these differ between the following different groups?
   a. Occupation and current work role
   b. Women versus men
   c. Socio-economic group and ethnicity
   d. Age groups including children
   e. Groups with different levels of risk for severe COVID-19 disease