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Antecedent, behaviour, and consequence (a-b-c) of deploying the contact tracing app in response to COVID-19: Evidence from Europe

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ABSTRACT

In response to the current coronavirus (COVID-19) pandemic, countries have or intend to deploy contact tracing apps as a way of containing and or reducing the community spread of the virus. Whilst a few studies have so far been conducted on the acceptability of the app, little is known about the antecedent, behaviour, and consequence (a-b-c) of deploying the app and its success thereof. This study, therefore, proposes and validates an integrated a-b-c and technology acceptance model of deploying the contract tracing app in four European countries. The study adopts a quantitative approach and uses publicly available cross country survey data from the Center for Open Science. An extract of 2512 data is analysed using SEM-PLS. The results confirmed the integrated a-b-c and technology acceptance model that underpins the study and revealed that the chance of achieving a positive outcome with citizens complying with recommendations of the app was only 17.1 % or $R^2 = 0.171$ (± 0.020) whilst the chance of negative consequent or deviant response of uninstallation of the app by the citizens was 54.3 % or $R^2 = 0.543$ (± 0.021). The results have huge implications for governments and public health institutions in their attempt to deploy the contract tracing app.

1. Introduction

The efforts to control, manage and reduce the coronavirus (COVID-19) pandemic have been unprecedented. This includes huge investments by countries in the development of vaccines, massive social policy intervention in some countries, lockdown measures, social distancing policies, capacity mobilising in terms of building emergency health facilities (Kwon et al., 2020), and recruitment of healthcare personnel. One interesting area of intervention in fighting the pandemic has been the development and deployment of digital solutions (Ågerfalk et al., 2020) including automatic body temperature readings, automatic disinfection systems at entrances of facilities (Kim and Lee, 2020), and the use of contact tracing app (Phan et al., 2020). Digital technologies have become so pervasive (Rajaraman, 2018; Tehranipoor et al., 2018), and, can, as has always been, leveraged as a tool to help combat the challenges faced with the COVID-19 pandemic. Such an app will not only leverage the functionalities of smartphones, connectivity, and analytic power of digital technologies but will promote information sharing for better management of the pandemic. Apps are tied to and driven by a backbone of databases, APIs, and Information System (IS) applications and this emphasises the relevance of IS (Schryen, 2013) in our daily life including this era of the COVID-19 pandemic (Ågerfalk et al., 2020). However, the extent to which the potential deployment of the contact tracing app will exude consequent positive actions to help combat the spread of the COVID-19 pandemic is unknown.

The adoption of technology has received considerable attention in the literature (Davis, 1986; Davis, 1989a,b; Davis, 1993; Venkatesh and Davis, 2000; Venkatesh et al., 2003; Gefen et al., 2003), and the use of digital solutions is not new to healthcare services (Beldad and Hegner, 2018; Safi et al., 2018; Apolinário-Hagen et al., 2019). However, the contact tracing app for COVID-19 is new and specifically developed in response to the COVID-19 pandemic. Hence its adoption and success in terms of consequent behaviour of citizens are not very well documented. Whilst the development of the apps presumably incorporated user interface design (UI), user experience (UX) factors, security and privacy settings, the technology itself is one thing, whilst the users (citizens) are another thing. Furthermore, the success of the intervention by deploying the app can only be measured by the expected positive actions or consequent behaviour of the citizens who would use the app and help the public health units of the government and for that matter public institutions to trace, test and act to help contain and reduce the spread of the virus. Consequent actions of the citizens are thus more relevant and fundamental than ever. There is, therefore, the need to explore the

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relationship between the technology (contact tracing app), the user (citizen), and especially the consequent actions which are fundamental to combating the spread of the virus. As a result, this study attempts to understand the adoption of the contact tracing app from the antecedent, behaviour and consequent perspective which is critical to gauging the potential success rate of deploying the app in the selected countries namely the United Kingdom (UK), Italy, France, Germany, and those other countries that plan to do deploy such apps.

The study is set within four European countries namely UK, Germany, France, and Italy. These countries share similar socioeconomic characteristics and until Brexit, which has resulted in the UK's planned exit, were all members of the European Union (EU). Generally, all four countries have a high technological backbone, good ICT (Information and Communications Technology) penetration with a large number of their population being technology savvy (ITU, 2019). Whilst the adoption of the contact tracing app is not expected to pose major challenges for these European countries, due to the good ICT penetration, little is known about how such socio-political intervention would be received by the citizens and what the success of the deployment would look like in terms of their response. In a departure from previous technology adoption studies that have relied on the traditional TAM (Technology Acceptance Model), UTAUT and its variants (Davis, 1989a,b; Venkatesh and Davis, 2000; Gefen et al., 2003), this study adopts a behavioural approach based on the assumption that extremely critical to curbing the spread of the virus is the consequent actions of the citizens after they have accepted the contact tracing app. The antecedent-behaviour-consequent (ABC) model (Kahn, 1999; Maag, 2004) is therefore used as the theoretical underpinnings of this study to understand how socio-political factors impact the acceptability of the app and this intend influences some consequent actions of the citizens. The ABC model posits that antecedent factors will trigger acceptability behaviour leading to some consequent actions. The ABC model is therefore integrated with the TAM model to providing an overarching framework to understand both the acceptance and user behaviour following the acceptance.

The contact tracing app is expected to be helpful in some areas and to have several applications, from informing users of the infections with the virus, to managing the infection, self-isolation, tracing and treating the infected persons, enforcement of social distancing measures (Phan et al., 2020), to managing and reducing the spread of the virus. However, just like any new technology and one that is driven by strong political policy, it is important to understand how critical issues like citizen's trust and perception of the government impact the acceptability of the app and how this affects the consequent actions of the citizens. The research question addressed by this study is, what is the relationship between the antecedent, behaviour, and consequent factors in the deployment of the contact tracing app in the selected European countries? Structural equation modelling (SEM) is applied to data extracted from a public dataset on a survey of contact tracing app to test eight hypotheses based on the ABC model. The rest of the paper consists of the theoretical background and hypotheses, the methodology, results, and discussion. The paper ends with conclusions, limitations, and future research directions.

2. Theoretical background, conceptual framework, and hypotheses

The adoption, acceptance, and use of new technologies have been driven by several theories notably the social exchange theory (Shiau and Luo, 2012), theory of planned behaviour (Allam et al., 2019), technology acceptance model or TAM (Davis, 1986; Davis, 1989a,b; Davis, 1993) and its variants including the unified technology acceptance and use theory (UTAUT) and UTAUT2 (Venkatesh et al., 2003; Venkatesh and Davis, 2000; Gefen et al., 2003), and stimulus-organism-response (S-O-R) framework (Peng and Kim, 2014; Kaur et al., 2017; Wakefield, 2015; Choi, 2019). However, for this study, we find these theories quite limited in explicitly understanding and modelling the success of deploying the contact tracing app in the form of the likelihood of citizens complying with the recommendations of the app for example to self-isolate and get tested, among other things. For example, TAM and its variants UTAT2 focuses more on perception, attitude, and intention issues related to the technology itself (Wu and Du, 2012), whilst social exchange theory focuses more on the exchange of value between the provider of the technology and the user. The limitation of the theory of planned behaviour can be pinned to the idea of a pre-determined behaviour of the user to a potential solution. Also, the S-O-R model (Mehrabian and Russell, 1974) assumes the presence of stimuli that is expected to trigger a behaviour leading to a response. The elements of stimuli are not evident or reflective of the antecedent variables (i.e. trust and perception of Government) used in this study. Hence the inadequacy of this S-O-R model as well. Consequently, the researcher adopted and adapted the Antecedent-Behaviour-Consequent model as the theoretical underpinning for this study. Within the last five years (2015–2019), the use of the ABC model of Attitude has received a limited application in the study of mobile apps (e.g. Hsu and Lin, 2016) as noted by Zolkepli et al. (2020). However, its suitability for this study is very significant. It was therefore prudent to integrate the ABC model with the TAM model to understand not just the acceptance of the app but also the behavioural response of the user after the acceptance of the app.

The developments in technology, the digital interconnectedness, and the emergence of new technologies come with several issues (Picard, 2000) across the five phases of a technology's lifecycle (Kendall, 1997). However, the 'technological acceptance' phase is usually characterised by several issues ranging from degree of uncertainty (Sollie, 2007; Von Schomberg, 2011), ethical concerns (Moor, 2001; Brey, 2012), autonomy and deception (Cowie, 2015), persuasion, coercion, responsibility, and cultural differences (Stahl et al., 2016a), ethics, privacy, surveillance (Stahl, 2011; Stahl et al., 2016b) and security (Wright et al., 2011; Brey, 2012). This study is not immune to these issues and many others due to the urgency and speed of development and deployment of the app.

Digital solutions have become more pervasive and as more data becomes readily available (De Capitani Di Vimercati et al., 2012), there is a threat to privacy (Grote and Korn, 2017). Privacy is an indispensable human right that needs to be protected and preserved (Peissl, 2011). The right to privacy is documented in Article 12 of the Universal Declaration of Human Rights and Article 8 of the European Convention on Human Rights. Although the concept of privacy is broad and multifaceted (Sololove, 2008), it covers issues related to freedom of speech, right over personal data and information, the right to be free from surveillance, the ability to have control over personal information, and one's freedom of speech. The adoption of technology especially mobile apps such as the contact tracing app seems to be characterised by the 'privacy paradox' (Gerber et al., 2018) at some point in the lifecycle of the technology. The privacy paradox posits that even though users have privacy concerns about technology, they behave otherwise. This situation suggests the phenomenon of the "technology acceptance paradox", where users would still adopt technology even when they have negative concerns about the technology.

Another ethical issue raised by technology is surveillance (Ågerfalk et al., 2020). Whilst surveillance for the good of society in this current pandemic, such as enabling contact tracing of users infected with COVID-19, an app is susceptible to hacking leading to surveillance by unauthorised third parties (Stahl et al., 2016b). For example, the Cambridge Analytica scandal. This study is based on a high assurance by governments, developers, and all other owners of the app, which posed the 'problem of many hands' (Van de Poel et al., 2012). It is therefore assumed that every effort has been made to avoid any ethical and security breaches (Stahl et al., 2016a). The privacy of users is guaranteed and not considered to be a significant concern of potential users of the contact tracing app. Also, the study did not focus on issues related to ethics, security, privacy, and legal concerns. It is assumed that the process of development and deployment of the contact tracing app follows the tenets of Responsible Research and Innovation (Von Schomberg, 2011; Stahl et al., 2016b).

2.1. Antecedents (A) - perception and trust

Citizen's trust in governments is influenced by several factors including but not limited to *socio*-demographic variables, effective economic & social policy (Tanny et al., 2019), citizen's perceptions of government (Sibley et al., 2020; Güzel et al., 2019; Wang, 2014) among others. Lower trust in governments reduces citizen's rates of compliance with rules and regulations (OECD, 2013). In effect, where citizens have positive opinions or perceptions about the government, their trust in the government is likely to be high (Pechar et al., 2018; Dzandu et al., 2022). Therefore, perceptions affect trust (Beshi and Kaur, 2020; Lee and Yu, 2013; Himmelstein et al., 2011; Chanley et al., 2000; Wang, 2014) and trust affect perceptions (Sibley et al., 2020; Beldad and Hegner, 2018; Echavarren et al., 2019; Güzel et al., 2019). Gao and Waechter (2017) reported that perception affects initial trust in mobile apps, hence H1.

H1. : There is a positive relationship between citizens' perception of the government's handling of the contact tracing app and their trust in the government doing the right thing in introducing the contact tracing app.

2.2. Antecedents and behaviour (A-B): perception and trust; and acceptability of the app

Trust has been shown to have a significant relationship with acceptance of technology in general (Fukuyama, 1995; Faqih, 2011; Safi et al., 2018; Heijden et al., 2003) and mobile apps in particular (Zhang et al., 2018). The trust considered in most studies can be distinguished into trust in the technology and trust in the owners of the technology (Wang, 2014; Söllner et al., 2016; Beldad and Hegner, 2018), even when not specified, this could be implicit. For this study, there are several owners, but the intervention (COVID-19 contact tracing app) is primarily an initiative of the government. Therefore, trust in the government (OECD, 2013) is expected to have a significant relationship with the acceptability of the app (Faqih, 2011) either by the voluntary installation or "forced" acceptability where the government automatically installs the app on the mobile phones of the citizens in the country through mobile phone network service providers. Therefore:

H2. : There is a positive relationship between citizens' trust in the government doing the right thing in introducing the contact tracing app and their voluntary acceptance of the app.

H3. : There is a positive relationship between citizens' trust in the government doing the right thing in introducing the contact tracing app and their forced acceptance of the app.

Attitude towards technology influences its acceptance (Davis, 1986; Venkatesh et al., 2003; Gefen et al., 2003) and so does perception (Davis, 1989a,b; Venkatesh and Davis, 2000); and perception influences attitude which in turn affect the acceptance of technology (Davis, 1993) such as mobile apps (Hew et al., 2015; Kim et al., 2016). Citizen's perception of government influences their acceptance of government policies and interventions (OECD, 2013). Studies have demonstrated that when citizens have positive opinions about the government and are involved in collaborative initiatives with the government, the citizens tend to be more accommodating, develop trust, and tend to be receptive and supportive of government programmes (OECD, 2013). Both perception and trust have been found to have a significant impact on the acceptance of technology (Faqih, 2011). There is also evidence to suggest that, where citizens have a positive perception about the government, the citizens are also likely to tolerate or accept some interventions or policies forced upon them by the government. Perception and attitude affect the acceptance of mobile apps (Liu et al., 2015; Gao and Waechter, 2017; Zhang et al., 2018; Verkasalo et al., 2010). Hence hypotheses H4 and H5 are put forward for testing.

H4. : There is a positive relationship between citizens' perception of the government's handling of the contact tracing app and their voluntary acceptance of the app.

H5. : There is a positive relationship between citizens' perception of the government's handling of the contact tracing app and their forced acceptance of the app.

2.3. Behaviour and consequent (B-C)-deviant/positive response to the adoption of the app

Several studies (e.g. Kim et al., 2016; Zolkepli et al., 2020) have demonstrated that acceptance of technology triggers positive consequent actions such as the intention to use mobile apps technology (Zhang et al., 2018; Chopdar et al., 2018), effective response (Van Noort and Van Reijmersdal, 2019; Groß, 2015) among others. The positive responses often lead to a positive impact of technology deployment. However, where technology is imposed on users, the likelihood of resistance and negative consequences tend to be high (Ramhotul, 2015; Safi et al., 2018). User involvement enhances the acceptability of mobile apps technology (Kim et al., 2017) and the converse is also true. In line with these, hypotheses H6 is put forward for testing:

H6. : There is a positive relationship between citizens' voluntary acceptance of the contact tracing app and their positive response towards the adoption of the app.

The acceptability of the app (behaviour) is expected to yield consequent actions that would help with efforts to contain and reduce the spread of the virus. However, where the government imposes the app on the citizens (forced acceptance), it is likely to be met with equal resistance (Ramhotul, 2015) or opposition from the citizens. Studies such as Safi et al. (2018) have demonstrated that citizens were strongly opposed to interventions and policies forcefully implemented government. It is therefore hypothesised that:

H7. : There is a positive relationship between citizens' forced acceptance of the contact tracing app and their deviant response towards the adoption of the app.

The assessment of the deployment of mobile apps is usually carried out by evaluating the level of awareness of the technology, knowledge of the technology, attitude towards adoption of the technology (Venkatesh et al., 2003; Gefen et al., 2003), the ratings, downloads, reviews, and recommendations (Zolkepli et al., 2020) using the TAM. However, for this study, an integrated ABC-TAM model is used to assess the deployment of the contact tracing app in four European countries to understand both the acceptance and behavioural response to the acceptance of the app.

2.4. The conceptual framework

The contact tracing app for COVID-19 is a responsive technology application being developed by several countries to help deal with the current virus pandemic. It is highly driven by governments and involves several stakeholders including technology firms, mobile app developers, IS platforms owners, public health institutions, and the citizens. However, due to its political push, and the citizens' reaction to political interventions, there are some crucial issues related to citizen's trust in government, perception of the government, as well as privacy, surveillance, among others that need attention. The need to assess the potential acceptability of the app is critical to understanding its successful deployment. In addition, the study posits that the success of the app is tied to citizen's consequent or behavioural actions after accepting the app.

There are indications to suggest a relationship between the antecedent factors (trust and perception), behaviour (acceptability), and the consequence (positive/deviant response to the adoption of the app). Using six key constructs, seven hypotheses (H1, H2, H3, H4, H5, H6 and H7) are formulated and tested. The research model (Fig. 1) shows the relationships between the key constructs.

This study considers trust and perception or opinion of the government as antecedents of citizens behaviour of accepting the contact tracing app. On the evidence of the data, two sets of behaviours namely voluntary installation of the app by citizens and government-directed automatic installation of the app by mobile networks are considered. The expectation is that citizens would respond to these behaviours differently. For example, citizens will deliberately uninstall the app where it has been automatically installed by mobile phone network service providers based on a government directive. It is thus expected that the automatic installation of the app by the government would be met with a negative response by way of refusal to comply with any recommendations of the app to the citizens to self-isolate when necessary. A measure of the success of the deployment of the contact tracing app would be a consequent positive behaviour by the citizens including but not limited to complying with the recommendations of the app such as to self-isolate if the app detects that a user is infected with COVID-19.

3. Dataset and method of analysis

The study adopts a quantitative approach to analyse data from a cross-country quantitative survey conducted in the US, and four European countries namely UK, Germany, France, and Italy, and publicly available from the Centre for Open Science (2020). The data on the US was not available online as of 4 May 2020 when the data extraction was done and since the US is not a European country, it was not included in the analysis. The original survey was commissioned by the University of Oxford Economics Department and form the basis of the studies by Altmann et al. (2020) and Abeler et al. (2020) in their surveys on contract tracing apps which were carried out between the 20th and 27th of March 2020. Seven hypotheses based on the a-b-c model are developed and tested using structural modelling (Saunders et al., 2012).

The constructs were developed based on the original questionnaire used by Altmann et al. (2020) by extracting those reflective items (Chin, 1998) most indicative of the constructs. The questions were mostly closed-ended (Leedy and Ormrod, 2016) and all the items of the constructs used were either reduced to or measured on a 5-point Likert scale after data pre-processing and cleaning without changing the original semantics of the items. There were a few open-ended questions to allow the respondents to give reasons for some of the options chosen. There were also questions about the socio-demographic background of the respondents.

The antecedent constructs were two, trust and perceptions of government. The citizen's perception about the government's handling of the contact tracing app was measured with two items. The citizen's trust in the government's handling of the contact tracing app was measured with one item. There were two behavioural constructs namely “voluntary acceptance” and “forced acceptance” of the app. The voluntary acceptance of the app was measured with three items whilst forced acceptance of the app was measured with four items. For the consequences construct, there were two items one each representing positive and deviant responses to the adoption of the app. The deviant response and positive (complaint) constructs were based on the work of Bhattacherjee et al. (2018). The positive consequence was “complying with recommendations of the app” and the deviant response was “deliberate uninstallation of the app”. Except for the question on deviant response, the initial scoring of all the other items was reversed to reflect higher scores close to “5” representing more positive opinions and lower scores close to “1” representing less positive opinions. The response “neither agreed nor disagree” and “unsure” were scored 3 on the 5-point Likert scale. A summary of the constructs and items extracted from the original dataset from the Centre for Open Science (2020) is shown in Appendix I.

The original dataset of 4130 was then pre-processed by deleting non-response or incomplete answers. A valid dataset was one for which the row of data had all the questions for the selected items fully answered. This reduced the number of usable datasets to 2512 representing a response rate of 50 %. Several survey studies such as Barr et al. (2017) reported 41 %; and Boyle et al. (2001) reported 42 % total usable responses (Condon, 2004) which are less than our reported usable responses of 50 %. Therefore, there is no known or anticipated potential selection bias in this study. The final sample consisted of 623 participants from Germany, 683 participants from the UK, 567 from France, and 639 from Italy (Table 1). The personal characteristics (gender and age) of the respondents show a disproportionate distribution among the gender, and the age groups of 71 years + (4.6 %) compared with the age groups for the18–60 year olds (Table 1).

The final dataset was analysed using partial least squares - structural equation modelling (PLS-SEM) software, SmartPLS (Ringle et al., 2015). PLS-SEM was suitable based on its support for the design of models, statistical robustness, and ability to analyse relationships simultaneously (Hair et al., 2017).

4. Results

Following the suggested guidelines for PLS-SEM analysis by Hair et al. (2017), the measurement model was first assessed. The assessments of the construct reliability and validity showed composite reliability (CR) values of at least 0.881 for all the constructs whilst the Cronbach's Alpha (CA) values were at least 0.739 (Table 2). The reliability measures thus exceeded the 0.70 criterion; hence the constructs were reliable. Also, the convergent validity of the constructs is confirmed by the average variance extracted (AVE) scores of at least 0.788 which is greater than the recommended value of 0.5. The constructs are therefore valid for the model.

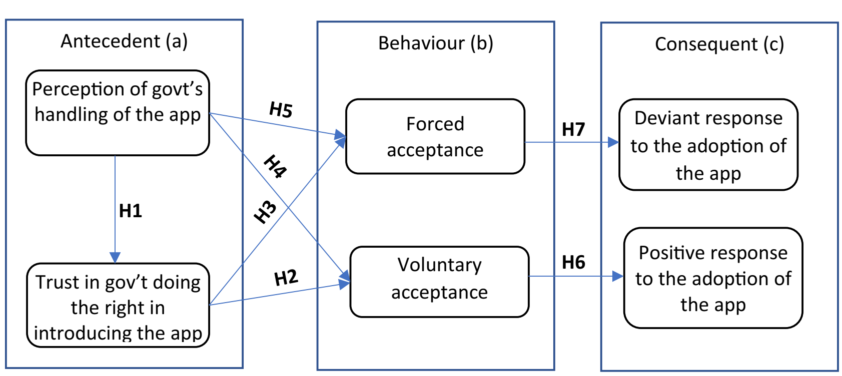

Fig. 1. Integrated A-B-C and TAM model of deployment of the COVID-19 contact tracing app.

Table 1
Personal characteristics of the participants.

Gender	Germany	UK	France	Italy	Total
Female	312 (50.1 %)	319 (46.7 %)	280 (49.4 %)	308 (48.2 %)	1219 (48.5 %)
Male	309 (49.6 %)	360 (52.7 %)	287 (50.6 %)	330 (51.6 %)	1286 (51.2 %)
Other	2 (0.3 %)	2 (0.3 %)	–	1 (0.2 %)	5 (0.2 %)
Prefer not to say	–	2 (0.3 %)	–	–	2 (0.1 %)
Total	*623*	*683*	*567*	*639*	*2512*
Age (years)					
18–30	124 (19.9 %)	120 (17.6 %)	142 (25.0 %)	103 (16.1 %)	489 (19.5 %)
31–40	158 (25.4 %)	137 (20.1 %)	138 (24.3 %)	105 (16.4 %)	538 (21.4 %)
41–50	125 (20.1 %)	165 (24.2 %)	118 (20.8 %)	128 (20.0 %)	536 (21.3 %)
51–60	139 (22.3 %)	119 (17.4 %)	84 (14.8 %)	130 (20.3 %)	472 (18.8 %)
61–70	62 (10.0 %)	97 (14.2 %)	77 (13.6 %)	126 (19.7 %)	362 (14.4 %)
71 +	15 (2.4 %)	45 (6.5 %)	8 (1.4 %)	47 (7.4 %)	115 (4.6 %)

NB: Older than 80 yrs had only 4 respondents and has been merged with the 71–80 as 71 yrs+.

Discriminant validity was checked by using the Fornell-Larcker Criterion, examining the construct cross-loadings of the items on the key constructs as well as the HTMT values. A check of the square root of the construct's AVE showed values greater than the correlation with the other constructs (Table 2). The loadings and cross-loadings of items on their respective constructs and correlations with the other constructs were also assessed for multicollinearity. The results showed that the items loaded very highly on the respective constructs with values ranging between 0.847 and 1.00 (Table 3) after some highly correlated items were dropped.

Also, the HTMT values were all greater than zero (Table 4). Therefore, discriminant validity was not a concern in this study.

All the VIF values were <5 (Hair et al., 2017) hence multicollinearity is not a concern in this study.

The predictive relevance of the model was determined using the blindfolding approach. The explanatory power (R^2) of the dependent variables ranged between 0.171 and 0.543 (Table 5). Trust explains only 0.243 (±0.017) of the variation in the citizens' perception of the Government, whilst forced acceptance of the app explains 0.489 (± 0.017) of the variations in the citizens' trust and perception of the way the government is handling the introduction of the app. Similarly, the voluntary acceptance of the app explains 0.401 (±0.018) of the variation in the citizens' trust and perception of the government in handling the introduction of the app. Surprisingly, only 0.171 or 17.1 % (±0.020) of the variation in the citizens' positive response (i.e. willingness to comply with the recommendations of the app) can be explained by the antecedents and behavioural factors. Contrary to expectation, the citizens' deviant response of uninstalling the app could be explained by 0.543 or 53.4 % (±0.021)) of the behaviour of the government to automatically install the app (forced acceptance) and the antecedent factors. The overall model has a significant ($p < 0.05$) predictive relevance.

Table 4
HTMT values of the key constructs.

Constructs	FA	PR	PG	TG	DR	VA
Forced acceptance (FA)	–					
Positive response (PR)	0.350					
Perception of Gov (PG)	0.782	0.277				
Trust in gov't (TG)	0.307	0.115	0.574			
Deviant response (DR)	0.737	0.357	0.651	0.282		
Voluntary acceptance (VA)	0.835	0.430	0.744	0.268	0.758	

Table 5
Summary of test of significance of the explanatory power (R^2) of the key constructs.

Construct	R square	Error (±)	T statistics	p values
Forced acceptance	0.489	0.017	28.979	0.000
Positive response	0.171	0.020	8.623	0.000
Trust in gov't doing the right thing in introducing the app	0.243	0.017	14.160	0.000
Deviant response	0.543	0.021	26.488	0.000
Voluntary acceptance	0.401	0.018	22.805	0.000

Table 2
Construct reliability and discriminant validity with correlations and $\sqrt{AVE}$ test.

Constructs	CA	CR	AVE	FA	PR	PG	TG	DR	VA
Forced acceptance (FA)	1.000	1.000	1.000	1.000					
Positive response (PR)	1.000	1.000	1.000	0.350	1.000				
Perception of Gov (PG)	0.739	0.881	0.788	0.698	0.249	0.888			
Trust in gov't (TG)	1.000	1.000	1.000	0.307	0.115	0.493	1.000		
Deviant response (DR)	1.000	1.000	1.000	0.737	0.357	0.578	0.282	1.000	
Voluntary acceptance (VA)	0.915	0.947	0.855	0.802	0.414	0.631	0.258	0.726	0.925

NB: CA - Cronbach's Alpha, CR - composite reliability, AVE - average variance extracted.

Table 3
Loadings and cross loadings of the items with key constructs.

Items/ constructs	Forced acceptance (FA)	Positive response (PR)	Perception of gov (PG)	Trust in the gov't (TG)	Deviant response (DR)	Voluntary acceptance (VA)
FA1	**1.000**	0.350	0.698	0.307	0.737	0.802
PR1	0.350	**1.000**	0.249	0.115	0.357	0.414
PG1	0.450	0.154	**0.847**	0.430	0.390	0.448
PG2	0.747	0.270	**0.927**	0.448	0.606	0.645
TG1	0.307	0.115	0.493	**1.000**	0.282	0.258
DR1	0.737	0.357	0.578	0.282	**1.000**	0.726
VA1	0.739	0.405	0.606	0.253	0.678	**0.938**
VA3	0.807	0.401	0.610	0.251	0.693	**0.933**
VA4	0.671	0.337	0.528	0.208	0.641	**0.903**

NB: Values in bold show the highest loading values of each item unto their respective construct.

The seven hypotheses developed based on the conceptual framework were tested using the standardised path coefficients (Fig. 2). The criterion of 0.20 was used for meaningful consideration (Chin, 1998) of the path coefficient, and for that matter the hypotheses.

The data for the study showed a positive and significant relationship between the citizens' perception of the government's handling of the app and the trust in the government's handling of the introduction of the contact tracing app ($\beta = 0.493$, $p < 0.05$). The results further showed a significant and negative relationship between the citizens' trust in the government doing the right thing in introducing the contact tracing app and the voluntary acceptance of the contact tracing app ($\beta = -0.070$, $p < 0.05$). Similarly, the relationship between citizens' trust in the government doing the right thing in introducing the contact tracing app and forced acceptance of the app was negative and significant ($\beta = -0.049$, $p < 0.05$). But these were not considered meaningful since the coefficients were <0.20 (Chin, 1998). The citizen's perception of the government handling of the app showed a positive and significant relationship with the acceptance of the contact tracing app. It was observed that the citizen's perception of the government's handling of the app had a positive and significant relationship with forced acceptance of the app ($\beta = 0.722$, $p < 0.05$). Similarly, the citizen's perception of the government showed a positive and significant relationship with voluntary acceptance of the contact tracing app by the citizens ($\beta = 0.665$, $p < 0.05$).

The consequent actions of the citizens after the acceptability of the contact tracing app were also tested for significant relationships (Table 6).

The results showed a positive and significant relationship between voluntary acceptance of the app and positive response (i.e. compliance with recommendations of the app ($\beta = -0.372$, $p < 0.05$). There was also a positive and significant relationship between forced acceptance and deviant response (i.e. citizen's action of deliberate uninstallation of the app ($\beta = -0.732$, $p < 0.05$).

Although not part of the original aim of this study, a multi-group analysis (MGA) was carried out to ascertain if group-specific path coefficients were significantly different (Henseler et al., 2009). Differences were considered significant when the p-value is smaller than 0.05 or larger than 0.95 (Sarstedt et al., 2011; Hair et al., 2018). Using the

Table 6
Summary of the test of significance of the path coefficients for the key constructs.

Path	β	T statistics	p values	Hypothesis
Perception of Gov - > Trust in Gov't doing the right thing in introducing the app	0.493	28.006	0.000	H1 supported
Trust in Gov't doing the right thing in introducing the app - > Voluntary acceptance	−0.070	3.655	0.000	H2 not supported*
Trust in Gov't doing the right thing in introducing the app- > Forced acceptance	−0.049	2.918	0.004	H3 not supported*
Perception of Gov - > Voluntary acceptance	0.665	43.101	0.000	H4 supported
Perception of Gov - > Forced acceptance	0.722	54.369	0.000	H5 supported
Voluntary acceptance - > Positive response	0.414	17.098	0.000	H6 supported
Forced acceptance - > Deviant response	0.737	53.232	0.000	H7 supported

NB: * - Hypothesis not supported, also $\beta < 0.20$ (Chin, 1998) for meaningful consideration.

bootstrapping method, the path coefficients were found to be positive and significant for five out of seven paths for all the countries (Table 7a) and negative for two paths related to trust similar to what was observed in Table 6.

A comparative analysis of the country-level differences (if any) on the acceptance and behavioural response to the covid-19 contact tracing app revealed that at least two out of the four countries showed significant specific group differences on five out of the seven paths in relation to the hypotheses (Table 7b). However, the differences were all down to the relative magnitude of the beta-coefficients. This was probably because all the four countries were Europeans and therefore had the same or similar cultural characteristics.

The path coefficients (β) for the age groups were found to be positive and significant for five out of seven paths for all the age groups (Table 8a) and negative for two paths related to the trust constructs

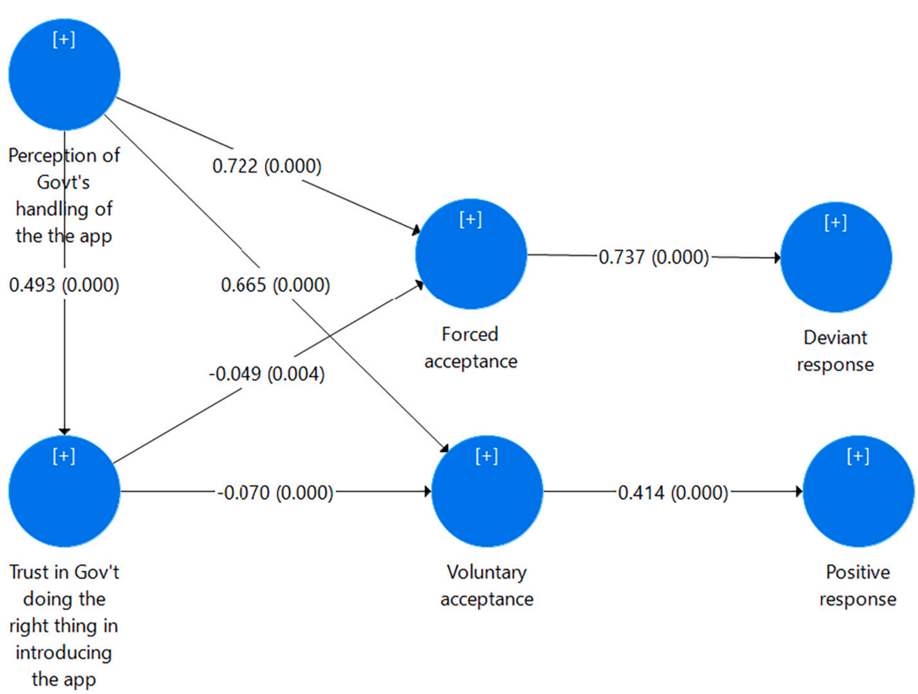

Fig. 2. Path coefficients of the relationship between the key constructs.

Table 7a
Bootstrapping for the test of significance of the path co-efficient by countries.

Paths	β (France)	β (Germany)	β (Italy)	β (UK)
Perception of Gov't handling of the app - > Trust in Gov't doing the right thing in introducing the app	0.517 [t = 15.125] (0.000)	0.497 [t = 12.847] (0.000)	0.427 [t = 11.338] (0.000)	0.499 [t = 15.058] (0.000)
Trust in Gov't doing the right thing in introducing the app - > Voluntary acceptance	−0.166 [t = 3.986] (0.000)	−0.041 [t = 1.187] (0.235)	−0.007 [t = 0.208] (0.836)	−0.050 [t = 1.382] (0.167)
Trust in Gov't doing the right thing in introducing the app - > Forced acceptance	−0.102 [t = 2.668] (0.008)	−0.029 [t = 1.050] (0.294)	−0.016 [t = 0.462] (0.644)	−0.023 [t = 0.731] (0.465)
Perception of Gov't handling of the app - > Voluntary acceptance	0.668 [t = 18.894] (0.000)	0.753 [t = 29.488] (0.000)	0.623 [t = 19.811] (0.000)	0.625 [t = 19.417] (0.000)
Perception of Gov't handling of the app - > Forced acceptance	0.674 [t = 20.413] (0.000)	0.820 [t = 46.019] (0.000)	0.673 [t = 21.973] (0.000)	0.716 [t = 26.523] (0.000)
Voluntary acceptance - > Positive response	0.306 [t = 6.304] (0.000)	0.488 [t = 11.226] (0.000)	0.209 [t = 4.532] (0.000)	0.452 [t = 10.042] (0.000)
Forced acceptance - > Deviant response	0.705 [t = 21.607] (0.000)	0.789 [t = 38.855] (0.000)	0.671 [t = 18.443] (0.000)	0.727 [t = 26.607] (0.000)

NB: (p-values), [t-Values], β is significant when p-value <0.05.

similar to what was observed in Table 6.

Similarly, a comparative analysis of the acceptance and behavioural response to the covid-19 contact tracing app between the various age groups showed significant specific group differences (Table 8b). Whilst the acceptance was higher among the younger age groups than the older age groups, the chances of deviant behaviour were equally higher among the younger age groups than the older age groups. Due to multi-collinearity issues, and zero variance for the variables for some of the age groups, the initial six age groups were reduced into only three to facilitate the PLS-MGA.

5. Discussion and implications

Technology in the acceptance phase is often characterised by several factors, some of which serve as enabling factors and others as inhibiting factors. The acceptance of apps in different settings and circumstances such as the current COVID-19 pandemic may be driven by the government of the nation. As a result, the antecedent factors considered in this study were citizen's perception of the government and trust in the government. The results confirmed the hypothesis (H1) that "There is a positive relationship between citizens' perception of the government's handling of the contact tracing app and their trust in the government doing the right thing in introducing the contact tracing app". This is consistent with studies by OECD (2013) who reported that consistent and better citizen's opinions of government are a strong basis for citizen's trust in their governments (Pechar et al., 2018; Wang, 2014). The results further reiterate Altmann et al. (2020) and Abeler et al. (2020) reports that the majority of the respondents had a positive opinion of the government and trust the government regarding issues related to the COVID-19 pandemic (Sibley et al., 2020) including the contact tracing app. It must, however, be noted that citizens' trust in the government doing the right thing in introducing the contact tracing app explains only 0.243 (24.3 %) of the variation in the citizen's opinion of the way the government is handling the introduction of the app. Thus, about 75.7 % of the variations in the citizens' trust in the government stem from factors other than their perception of the government's handling of the app. The finding implies that the government can enhance the citizen's trust in them by undertaking measures, interventions, policies, and actions

Table 8a
Bootstrapping for the test of significance of the path co-efficient by countries.

Path	β (18-30 yrs)	β (31-40 yrs)	β (41 + yrs)
Perception of Govt's handling of the app - > Trust in Gov't doing the right thing in introducing the app	0.552 [t = 15.457] (0.000)*	0.611 [t = 19.657] (0.000)*	0.398 [t = 15.507] (0.000)*
Trust in Gov't doing the right thing in introducing the app - > Voluntary acceptance	−0.076 [t = 1.604] (0.109)	0.037 [t = 0.930] (0.353)	−0.044 [t = 1.662] (0.097)
Trust in Gov't doing the right thing in introducing the app - > Forced acceptance	−0.026 [t = 0.666] (0.506)	−0.025 [t = 0.566] (0.572)	−0.039 [t = 1.614] (0.107)
Perception of Gov't handling of the app - > Voluntary acceptance	0.591 [t = 14.492] (0.000)*	0.618 [t = 18.148] (0.000)*	0.482 [t = 19.910] (0.000)*
Perception of Gov't handling of the app - > Forced acceptance	0.737 [t = 24.027] (0.000)*	0.684 [t = 19.355] (0.000)*	0.521 [t = 20.609] (0.000)*
Voluntary acceptance - > Positive response	0.266 [t = 5.630] (0.000)*	0.275 [t = 7.765] (0.000)*	0.438 [t = 9.581] (0.000)*
Forced acceptance - > Deviant response	0.707 [t = 25.093] (0.000)*	0.561 [t = 17.713] (0.000)*	0.521 [t = 14.919] (0.000)*

NB: (p-values), [t-Values], β is significant when p-value <0.05.

Table 7b
Summary results of the PLS-MGA for all the possible specific group differences.

Paths	β-diff (| Italy - France|)	β-diff (| Italy - Germany|)	β-diff (| Italy - UK|)	β-diff (| France - Germany|)	β-diff (| France - UK|)	β-diff (| Germany - UK|)
Perception of Gov't handling of the app - > Trust in Gov't doing the right thing in introducing the app	0.091 (0.962)*	0.070 (0.902)	0.073 (0.926)	0.021 (0.344)	0.018 (0.352)	0.003 (0.522)
Trust in Gov't doing the right thing in introducing the app - > Voluntary acceptance	0.158 (0.002) **	0.033 (0.252)	0.043 (0.199)	0.125 (0.991)**	0.115 (0.982) **	0.010 (0.421)
Trust in Gov't doing the right thing in introducing the app - > Forced acceptance	0.086 (0.047) **	0.014 (0.379)	0.008 (0.436)	0.073 (0.937)	0.079 (0.943)	0.006 (0.556)
Perception of Gov't handling of the app - > Voluntary acceptance	0.045 (0.829)	0.130 (0.999)*	0.002 (0.512)	0.085 (0.977)*	0.043 (0.183)	0.129 (0.001)*
Perception of Gov't handling of the app - > Forced acceptance	0.001 (0.511)	0.148 (1.000)*	0.043 (0.854)	0.146 (1.000)*	0.042 (0.833)	0.105 (0.000)*
Voluntary acceptance - > Positive response	0.097 (0.927)	0.279 (1.000)*	0.243 (1.000)*	0.182 (0.997)*	0.147 (0.987) *	0.035 (0.283)
Forced acceptance - > Deviant response	0.034 (0.758)	0.118 (0.998)*	0.056 (0.892)	0.084 (0.987)*	0.022 (0.692)	0.062 (0.031)*

NB: β = Path Coefficients, (p-values), * - significant (sig.), **-significant but contradicts stated hypotheses.
Result is significant if 0.95 < p-value <0.05 for difference in group-specific path coefficients.

Table 8b
Summary results of the PLS-MGA for all the possible specific group differences.

Path	β-diff (|18-30 yrs. - 3-40 yrs.|)	β-diff (|18-30 yrs. - 41 + yrs.|)	β-diff (|31-40 yrs. - 41 + yrs.|)
Perception of Gov't handling of the app - > Trust in Gov't doing the right thing in introducing the app	0.059 (0.894)	0.154 (0.000)*	0.213 (0.000)*
Trust in Gov't doing the right thing in introducing the app - > Forced acceptance	0.001 (0.512)	0.012 (0.395)	0.014 (0.387)
Trust in Gov't doing the right thing in introducing the app - > Voluntary acceptance	0.113 (0.965)**	0.031 (0.720)	0.082 (0.045)**
Perception of Gov't handling of the app - > Voluntary acceptance	0.027 (0.693)	0.109 (0.013)*	0.136 (0.001)*
Perception of Gov't handling of the app - > Forced acceptance	0.053 (0.129)	0.215 (0.000)*	0.163 (0.000)*
Voluntary acceptance - > Positive response	0.009 (0.557)	0.171 (0.996)*	0.162 (0.997)*
Forced acceptance - > Deviant response	0.145 (0.000)*	0.186 (0.000)*	0.040 (0.195)

NB: β = Path Coefficients, (p-values), * - significant (sig.), **-significant but contradicts stated hypotheses.
Result is significant if 0.95 < p-value <0.05 for difference in group-specific path coefficients.

that can change the citizen's opinions about them.

Trust is fundamental to every human activity and citizen's trust in government is a key and necessary condition for the acceptability of government programmes, projects, and interventions including the deployment of the contact tracing app (Avgerou et al., 2007; Dzandu et al., 2022). However, contrary to expectation, there was a negative relationship between citizens' trust in the government doing the right thing in introducing the contact tracing app and their voluntary acceptance of the app (H2); and a negative relationship between citizens' trust in the government doing the right thing in introducing the contact tracing app and their forced acceptance of the app (H3), therefore H2 and H3 were not confirmed by the study. The negative relationships observed indicate that the citizens had mistrust in their government's doing the right thing in introducing the app, but they were willing to accept the app (whether voluntary or forced), for the collective good of the society to help fight the COVID-19 pandemic. But although acceptability of the app construct explained between 0.401 and 0.489 of the variations in the antecedent constructs (i.e. citizens' trust in the government doing the right thing in introducing the contact tracing app and citizens' perception of the government's handling of the contact tracing app), the β coefficients were <0.20 (Chin, 1998) for meaningful consideration. A notable explanation for this situation and for not considering the hypotheses on trust was because trust was measured with a single item against the widely held opinion that trust is a multifaceted concept. The use of a single-item measure of constructs is however not new (e.g. Jen et al., 2009). These notwithstanding, the findings reiterate the role of trust in the acceptability of technology (Safi et al., 2018; Söllner et al., 2016; Vannucci and Pantano, 2019; Heijden et al., 2003), trust not in the technology but the persons or institutions deploying the technology. Thus, mistrust or low level of trust negatively affects the acceptability of technology as shown by the outcomes for H2 and H3, therefore government or institutions deploying new technologies should positively engage users at every point of the journey to enhance user trust, and then leverage the trust to enhance the adoption of new technologies especially during pandemics such as the COVID-19 (Dzandu et al., 2022).

The role of trust in the acceptability of technological interventions such as the contact tracing app by the public and individuals in response to health-related issues (e.g. COVID-19) cannot be overemphasised (Mbunge, 2020; Dubov and Shoptawb, 2020; Akinnuwesi et al., 2022). Trust must not be an afterthought of any technological interventions including the contract tracing app. Every activity of the stakeholders (government, regulators, technologists, health experts) from the ideation, through the development and deployment of the contact tracing app, must provoke trust in the public and individuals especially as the issue at stake bothers on health. Studies such as Stahl (2011) have demonstrated and indeed provided a framework for integrating ethics, politics, and technological innovations to instill trust and confidence in users, and this can be extended to the contact tracing app. For example, government communication on the pandemic and the contact tracing app must be clear and unambiguous to ensure public understanding and trust in the government (Mbunge, 2020; Saheb et al., 2022; Akinnuwesi et al., 2022) and in the technology (Ejdys, 2020). Anything short of transparent and adequate communication would affect public trust in the government (Kumagai and Iorio, 2020; Saheb et al., 2022; Dzandu et al., 2022), and trust in the contact tracing app (Kaspar, 2020). There is a need for the government to ensure equitable access to the contact tracing app to enhance the public and individual trust in the app for acceptability. Inadequate provision for access to contact tracing apps would not only marginalise certain groups of people but will create mistrust in both the technology and the government and ultimately affect its adoption. Therefore, trust in technological interventions (Ejdys, 2020) such as the contact tracing app would thrive on adequate digital infrastructure, fairness in access and inclusion of all groups of individuals both able and disabled (Vergallo et al., 2021; Dubov and Shoptawb, 2020).

Another key precondition for generating public and individual trust and enhancing the acceptability or adoption of technological interventions such as the contact tracing app is a legal and ethical framework (Mbunge, 2020; Whitelaw et al., 2020; Stahl et al., 2016a, b; Akinnuwesi et al., 2022). Whilst, in some developed countries, there are established legal and ethical frameworks, that underpin the adoption and use of digital technologies and technological intervention in health (World Health Organization, 2021), such frameworks are non-existent in developing countries (Mbunge, 2020; Akinnuwesi et al., 2022). For example, in the United Kingdom and across Europe, there is the General Data Protection Regulation or GDPR (General Data Protection Regulation, 2016; Data Protection Act, 2018), and there is the European Data Protection framework (The European Data Protection Board, 2020; Dubov and Shoptawb, 2020) which provides governance and regulatory framework to assure stakeholders including individuals and the public of the legal and ethical liabilities concerning the deployment of digital technologies (Riemer et al., 2020; Stahl et al., 2016a, b). This ultimately instills trust in individuals and the public to understand their obligations, the boundaries of the technological interventions and the government's commitments in deploying the contact tracing app. In effect, stakeholders must act trustworthy, communicate and engage with the public and individuals at all levels to build trust not only in the government but also trust in the technological interventions such as the contact tracing app to enhance its acceptability (Kaspar, 2020; Saheb et al., 2022; Vergallo et al., 2021; Kumagai and Iorio, 2020). The challenge with the acceptability of digital technologies including the contact tracing app have bordered on privacy invasion, data security, ethics, legal, and trust (Ejdys, 2020; Saheb et al., 2022; Zarifis et al., 2021; Mbunge, 2020; Dubov and Shoptawb, 2020; Mbunge et al., 2021; Akinnuwesi et al., 2022). Therefore, the establishment of the necessary governance, legal and regulatory framework before the introduction of the technological intervention would be useful in securing public trust in the technology to enhance its acceptability.

Another key antecedent used in this study was citizens perceptions about how the government is handling the introduction of the app. Consequently, the data for the study confirmed the hypotheses that there would be a positive relationship between citizens' perception of the government's handling of the contact tracing app and their voluntary acceptance of the app (H4); and, that there would be a positive relationship between citizens' perception of the government's handling of the contact tracing app and their forced acceptance of the app (H5). The acceptability of the contact tracing app, whether voluntary acceptance or forced acceptance is highly dependent on the citizens' perception of how the government is handling the introduction of the app. Thus, although acceptability of the app only explained up to 48.9 % (±0.0169) of the changes in the citizens' perception about the way government is handling the introduction of the app, the more positive opinion the citizens had about the way government is handling the introduction of the app, the more likely they were to accept the contact tracing app. Evidence from studies by Safi et al. (2018), Liu et al. (2015), Gao and Waechter (2017), Zhang et al. (2018) all support the assertion that positive perception influences the acceptance of mobile apps. It is, therefore, imperative that owners of new technologies engage in activities and campaigns that can enhance user's perception about them so that they can exploit the users' positive opinions about them to improve the acceptance of new technologies. Furthermore, it is equally important for the owners of new technology to explore tangible factors that can affect the acceptability of new technologies. This may include, but not limited to, the physical features of the technology, usability, functionalities, and complexity.

Behaviour and its consequences are very crucial for assessing the impact of an intervention such as the deployment of a contact tracing app to contain and stop the spread of COVID-19 pandemic. In line with this, the study tested the relationship between behaviour (acceptability) of the app and the two consequent actions namely uninstallation of the app and compliance with the recommendations of the app (e.g. to self-isolate). The results of the study confirmed the hypothesis that there would be a positive relationship between citizens' voluntary acceptance of the contact tracing app and their positive response towards the adoption of the app (H6). This is consistent with studies such as Zhang et al. (2018); Chopdar et al. (2018); Van Noort and Van Reijmersdal (2019) and Groß (2015) who reported a positive relationship between acceptability and positive response to mobile app technologies. If the positive response of complying with the recommendations is to be used as a measure of the success of the contact tracing app, then the expectation is that the deployment of the contact tracing app in the European countries will achieve an estimated success rate of 17.1 % (±0.0199) based on the proportion of the variations in the antecedents (trust and perception of government) and the behaviour of accepting the app. This is not so different from the reported success rate of 19.3 % of the contact tracing app in Singapore (Wiertz et al., 2020). The success rate of the contact tracing app is therefore very low but can complement other efforts to help contain and stop the spread of the COVID-19 in the selected European countries and those other countries.

The study also assessed the probability of deviant response to the adoption of the contact tracing app i.e. deliberate uninstallation of the app from their mobile phones after it has been automatically installed by mobile network service providers. Consequently, the results confirmed the hypothesis (H7) that there will be a positive relationship between citizens' forced acceptance of the contact tracing app and their deviant response to the adoption of the app (i.e. the action of the citizens to uninstall the app). The data for the study thus provides evidence that if any government tries to impose the contact tracing app on its citizens, the citizens were about 54.3 % (±0.0205) of the time likely to rebel by uninstalling the app. This finding is consistent with studies that show that, where a government impose interventions on its citizens, there is a likelihood that the citizens would reject or not fully support the government initiatives even if it will inure to their benefits. This reiterates the importance of user involvement in the development and deployment of technology to speed up its acceptance.

It must be pointed out that ethical issues which are key considerations in the development of new technologies and innovation (Cowie, 2015; Grote and Korn, 2017) were not explicitly explored in this study. The entire study assumed that the privacy of the user is fully guaranteed (Altmann et al., 2020). However, even if ethical issues, were critical concerns for users, evidence of a phenomenon similar to the “privacy paradox” where the users' perceptions differ from their behaviour (Gerber et al., 2018) was observed. Thus, although the citizens had concerns about trust in the government, they were still willing to accept the contact tracing app if it were deployed by the government. This indicates the concept of “technology acceptance paradox” (TAP), which hitherto has not been defined in the current literature. TAP describes the situation where users are prepared to trade-off their genuine concerns over new technologies for some perceived benefits of the technologies and in effect accept the technologies. Thus, the citizens were willing to accept the contact tracing app for the benefits of containing and reducing the COVID-19 pandemic.

This study extends the TAM by looking at socio-political constructs namely trust in the government doing the right thing in introducing the contact tracing app and citizens' perception of the government's handling of the contact tracing app and how these impact citizens potential acceptance of and behavioural response to the deployment of the covid-19 contact tracing app. Not only has the study proposed these socio-political constructs, but it also integrates TAM and ABC model thereby contributing new perspectives into technology acceptance studies. This study remains the first and only approach that compliments the adoption of technology with a model that helps explain the potential behavioural response to the technology. Another contribution of this study is the introduction of the concept of “forced acceptance” as a construct against most of the available acceptance models in the literature that focuses on voluntary acceptance of technology. To the best of my knowledge, there is currently no study that specifically investigated the “forced acceptance” of mobile apps or contact tracing apps in particular although some studies have explored instances of people being forced to use technology (Keller, 2006; Bhattacherjee et al., 2018; Jung et al., 2008), mandatory use (Brown et al., 2002) or the concept of “forced adopters” (Zhou, 2008). In all these studies, “forced acceptance” was not measured as a key construct and/or as a dependent variable as was considered in this study. Besides, no study has yet explored voluntary and forced acceptance concurrently in a single study other than this study.

This study for theory implies that further studies could use the proposed integrated ABC-TAM model of behaviour to assess the acceptance of new or emerging technologies and understand the potential behavioural response of users to the new technology and not just the acceptance of the technology. This study provides an opportunity to explore and extend technology acceptance to social, economic, and political constructs which could serve as a guide for governments in implementing technology-based interventions to their citizens such as e-voting apps, electronic tax filing apps, e-government systems, and other emerging technologies. Practically, governments would need to cave their information campaign messages to garner trust and positive perceptions by the citizens if their interventions such as the COVID-19 tracing app is to receive the needed acceptance and trigger a positive behavioural response by the citizens to help realise the aim of reducing the spread of the virus. The specific recommendations for consideration by governments and health institutions attempting to deploy the contact tracing apps are citizen involvement, openness, and fulfilment of promises to the citizens to enhance citizens' trust; voluntary adoption rather than imposition to encourage acceptance, and strong behavioural strategies and COVID-19 information campaigns to appeal to the citizens and increase compliance.

6. Conclusions and limitations

This research developed and tested an integrated A-B-C and TAM model to ascertain whether the deployment and acceptability of the contact tracing app in response to the COVID-19 pandemic will have any impact on the actions of the users. The study specifically tested whether the antecedents (i.e. trust and perception of the government) could affect the acceptability of the app and whether acceptability will provoke some consequent actions by the users. The study achieved this aim by extracting key datasets and developing constructs from a publicly available cross-country survey on the acceptability of the contact tracing app in four European countries. The resultant structural model not only confirmed the integrated A-B-C and TAM model but also provided evidence of the potential success of the contact tracing app which is estimated to be about 17.1 % (±0.0199) i.e. using compliance with recommendations of the app as a proxy. The study also revealed evidence of the "technology acceptance paradox" where despite concerns (i.e. low level of trust in the government), users were still willing to accept the new technology (the contact tracing app). Furthermore, there was evidence of potential rebellion by the citizens by way of uninstallation of the app if the government were to impose the app on the citizens through automatic installation by mobile phone network service providers. The acceptance of the contact tracing app is tied to the citizen's trust in the government and the opinions of the citizens about the government given that ethical concerns such as privacy are guaranteed.

One limitation of the study is that it was exploratory, and it was conducted before the actual introduction of the contact tracing app in the various selected countries. The study used a hypothetical scenario and the respondents were asked to answer the questions on the assumption that such an app has been developed (see Questionnaire in Appendix I & Centre for Open Science (2020)). Therefore, a future study that collects data from actual users and non-users of the COVID-19 contact tracing app in the selected countries or those other countries after its introduction would give more data-driven outcomes that can inform more actionable follow-up by the respective countries to enhance their implementation of the app, which has so far recorded very low success rates across the world. These, limitations, notwithstanding, the findings are valid, relevant, and based on the evidence of the data for the study. However, the generalisation of the findings and any implementations based on the outcomes of this study would have to be contextual within the exigencies of the respective countries and with caution. For example, none of the selected countries was from Eastern Europe, hence any generalisations of the findings to these countries, if at all, should be done with extreme caution. The researcher did not have control over the selection of the countries and the sampling of the participants vis-à-vis the population of the respective countries as the dataset was extracted from a publicly available source from the Centre for Open Science (2020). Also, it would have been good if all the constructs were measured with multiple reflective items instead of single items as in the case of the "Trust in the government" construct. Also, it would have been good if there were a few more constructs for the antecedents and consequents components of the model. These limitations should be addressed in future studies.

It is acknowledged that the 50 % missing data (and the non-imputation of those missing data), even with the resultant large sample size of 2512, could potentially make the final data used in the analysis prone to selection bias. For example, the cases with missing data that were deleted might be significantly different from those with complete data who were included in the study, and it is possible that some groups of respondents might have been systematically deleted (Hair et al., 2017). However, after careful consideration of the various methods of handling missing data such as mean value replacement, casewise deletion, and pairwise deletion (Allison, 2001; Ringle et al., 2015; Little and Rubin, 1987; Hair et al., 2017; Barladi and Enders, 2010), the casewise deletion was adopted. This led to the deletion of all cases that include missing values in any of the indicators as per the suggestion of Hair et al. (2017). This is consistent with the general rule of thumb that when the missing data exceeds 15 %, such observations should naturally be deleted (Hair et al., 2017). Also, the casewise deletion method is considered superior to the mean replacement and pairwise deletion method based on the high proportion of missing data (Hair et al., 2017). In addition, the casewise deletion method is considered a very conservative missing data handling strategy (Ringle et al., 2015). It is, however, acknowledged that the use of the casewise deletion method for treating the missing data perhaps reduced the precision power of the final model (Ringle et al., 2015), but not the validity of the results.

Despite the limitations of the study, the findings make unique contributions to the literature on information systems (IS) in the era of pandemic specifically on the acceptance of new technology (i.e. contact tracing app) by proposing and validating an integrated ABC and TAM model. The study uses and extends the A-B-C model to understand the acceptance of technology (i.e. contact tracing app) which has received limited attention in the new technology adoption literature. The proposed integrated A-B-C and TAM model over the traditional technology acceptance model and its variants (TAM, UTAT, UTAT2) offers a divergent perspective to new technology acceptance literature with emphasis on the consequences (actions) after the behaviour (acceptability) phase something very crucial in this instance in helping to contain and reduce the spread of the deadly COVID-19 pandemic. The proposed integrated model also emphasises the complementary role of user behaviour to the acceptability of the technology. In other words, it is not just about the acceptability of the app, but the actions taken thereafter which could be a key metrics in assessing the success or otherwise of the deployment of any new technology such as the contact tracing app for COVID-19.

CRediT authorship contribution statement

Michael D. Dzandu: Conceptualization, Methodology, Data curation, Analysis and Writing- Original and Revised Manuscript preparation. Validation, Reviewing and Editing.

Data availability

Data will be made available on request.

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Appendix I. Questionnaire items extracted from the original survey available at *Centre for Open Science (2020)*.- *NB: Data is available on request*

The current coronavirus epidemic ("COVID-19") is all over the news.

People can get infected if they are in close contact with someone who has the virus. People do not notice when they get infected. They only notice when they start having a fever or a cough, perhaps a week later. Imagine there was an app that you could install on your mobile phone. This app would automatically alert you if you had been in close contact for at least 15 min with someone who was infected with the coronavirus. Such an app does not exist yet in the UK. But we, are interested in understanding what you would think about such an app. You can only continue the survey if you answer all questions correctly. The app would be developed by the NHS. You would need to install the app by simply clicking a link. Once installed, the app would register which other users are close to you. The app would do this by using Bluetooth and your location. The app would not access your contacts, photos, or other data held on your phone. Only the NHS would have access to the data collected.

Voluntary acceptance

VA1. If such an app like the one described before exists, I would

1) Definitely install - 5
2) Probably install - 4
3) May or may not install/Don't know – 3
4) Probably won't install - 2
5) Definitely won't install - 1

VA2. Suppose *someone in my community* had been infected with the virus, I would

1) Definitely install -5
2) Probably install -4
3) May or may not install/ Don't know - 3
4) Probably won't install - 2
5) Definitely won't install -1

VA3. Suppose *someone I personally know* had been infected with the virus, I would

1) Definitely install - 5
2) Probably install - 4
3) May or may not install/ Don't know - 3
4) Probably won't install - 2
5) Definitely won't install - 1

VA4. Generally, I would….

1) Definitely install - 5
2) Probably install - 4
3) May or may not install/ Don't know - 3
4) Probably won't install - 2
5) Definitely won't install - 1

Forced acceptance

To what extent would you then agree, or not, with the above statement?

"The government should ask mobile phone providers to automatically install the app on all phones."

FA1. Generally, I would

1) Fully agree - 5
2) Somewhat agree - 4
3) Neither agree nor disagree - 3
4) Somewhat disagree - 2
5) Fully disagree - 1

FA2. Supposing someone in my community had been infected with the virus, I would

1) Fully agree - 5
2) Somewhat agree - 4
3) Neither agree nor disagree - 3
4) Somewhat disagree - 2
5) Fully disagree - 1

FA3. Supposing someone I personally know had been infected with the virus, I would

1) Fully agree - 5
2) Somewhat agree - 4
3) Neither agree nor disagree - 3
4) Somewhat disagree - 2
5) Fully disagree - 1

Trust

To what extent do you agree with the following statement with regard to the introduction of the app:

TG1. "I generally trust government to do what is right."?

1) Fully agree - 5
2) Somewhat agree - 4
3) Neither agree nor disagree - 3
4) Somewhat disagree - 2
5) Fully disagree - 1

Perception

PG1. "My opinion or perception about the government handling of the introduction of such an app is improved/high"?

1) Fully agree - 5
2) Somewhat agree – 4
3) Neither agree nor disagree - 3
4) Somewhat disagree - 2
5) Fully disagree - 1

PG2. "My opinion about the government would improve if they asked mobile phone providers to automatically install such an app on all phones to maximise the chance of stopping the epidemic."?

1) Fully agree - 5
2) Somewhat agree - 4
3) Neither agree nor disagree - 3
4) Somewhat disagree - 2
5) Fully disagree - 1

Deviant response to acceptance

DR1. If the government asked the mobile phone providers (Vodafone, EE, etc.) to automatically install the app on all phones. I would……

1) Definitely keep - 1
2) Probably keep - 2
3) May or may not keep/ Don't know - 3
4) Probably uninstall - 4
5) Definitely uninstall - 5

Positive response to acceptance

PR1. How likely would you be to comply with the recommendation of the app to self-isolate at home for 14 days if you had been in close contact with an infected person?

1) Definitely comply -5
2) Probably comply -4
3) May or may not comply/ Don't know - 3
4) Probably won't comply -2
5) Definitely won't comply -1

Demographics

Q. How old are you?

1) 18–30 2) 31–40 3) 41–50 4) 51–60 5) 61–70 6) 71–80 7) Older than 80

Q. What is your gender? 1) Female 2) Male 3) Other 4) Prefer not to say

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