

## **Exploring Willingness to Adopt Contact Tracing Applications: A Study with Norwegian Citizens**

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### ***Abstract***

Amid discussions on the efficacy of digital contact tracing (DCT) during COVID-19, the Norwegian Institute of Public Health's application, Smittestopp, faced criticism for perceived privacy intrusions. Despite its relaunch without GPS-tracking, skepticism persisted due to initial issues. This study proposes a model to assess DCT adoption, focusing on Norwegian citizens' privacy concerns, trust, and risk beliefs, particularly towards Smittestopp. The moderating role of emotions is also examined. Findings indicate that privacy concerns inversely affect trust and enhance risk beliefs. Trust and perceived advantages bolster the intention to use the application, while risk beliefs reduce it. Negative emotions moderate the relationship between risk beliefs and intention to use, whereas positive emotions amplify the influence of perceived benefits on app usage intention. Intention to use led to actual utilization of the Smittestop app. These insights increase our understanding of how DCT apps are perceived in a country in which citizen trust in government is high, while offering significant implications for managing future crises and contagion spread.

**Keywords:** digital contact tracing, information privacy concerns, human emotions, COVID-19, quantitative research

## 1. INTRODUCTION

Digital contact tracing (DCT) is a technology utilized by many countries and has been an important asset in the fight against the COVID-19 virus (Sun & Viboud, 2020). Governments across the world tried to develop DCT-applications as a public health practice to track, identify and notify victims of the COVID-19 disease. According to a simulation model at the time, COVID-19 is a pandemic that can only be stopped if at least 10% of the population is tested every day under highly regulated testing conditions (Cebrian, 2021). With this being hard to accomplish, many different DCT-solutions were proposed instead. These have been shown to vary in efficiency, privacy, and data collection implications (Riemer et al., 2020). For example, Germany invested significantly in their Corona-Warn-app, France supervised a free easy-to-use StopCovid-app and Ireland released an application with a notably high uptake (Martin et al., 2020). An extensive study has been conducted on Australia's own DCT-solution, the COVIDSafe-app, focusing on the citizens' willingness to adopt the application and share personal information (Lin et al., 2021). The Australian application, COVIDSafe, raised privacy concerns amongst its national citizens despite the application enforcing personal information and privacy protection (idem). The pandemic led to the transformation of different fields within work and life, with new digital tools and services being developed (Dwivedi et al., 2020), while raising the need for more responsible digital transformations (Pappas et al., 2023). As the world is moving on from the pandemic, it is important to get a better understanding of how citizens respond to digital tools based on emerging technologies (Lu, 2021; Pappas et al., 2018), especially ones designed for the public good (Pappas et al., 2023), since recent studies show that citizens are likely to resist using tools for DCT (Prakash & Das, 2022), even though there is a general consensus that they are useful and successful in contact tracing. Contact tracing, followed by isolation or treatment is a crucial preventive measure in the fight against infectious diseases. It has the potential to be quite effective in circumstances when there are not many people affected. This is why it is frequently employed in the fight against novel invasive infections and sexually transmitted diseases (Cebrian, 2021; Eames and Keeling, 2003). As a response, this study has focused on the Smittestopp-app, which is Norway's DCT solution, to investigate Norwegian citizens' perception of digital contact tracing applications in Norway.

Though Norway and other countries are now more experienced in handling a global pandemic, it is important to examine previous instances and evaluate the effectiveness of measures taken to prevent the disease, as new waves are to be expected (Osuchowski et al., 2020). By examining how DCT was utilized during the pandemic, greater preparations can be made in a post-pandemic world for future emergencies. Research has shown that individual differences influence uptake more than application design (Li et al., 2021). Some policies have been proposed to increase uptake, but whether they have had an effect remains to be seen (Chen & Thio, 2021). Lin et al. (2021) highlight the need for more research on contact tracing applications in different countries and its impact on willingness to utilize them by further exploring citizens' privacy attitudes. As there is currently a lack of research regarding privacy and trust beliefs in online and governmental services after COVID-19 (Prakash & Das, 2022), we draw on existing studies and the Internet Users' Information Privacy Concerns (IUIPC) model, to examine the adoption of the Smittestopp-application in Norway. We have conducted a conceptual replication (Dennis & Valacich, 2014) of the work by Lin et al. (2021), as we adopt part of their model and test it in a different context. Also, we extend that model by testing the moderating effects of emotions. Without people partaking in using these apps, such solutions are inevitably deemed unsuccessful. Thus, we propose the following Research Question (RQ): *"How do privacy concerns, trusting and risk beliefs, relative advantage, and emotions affect citizens' willingness to adopt contact tracing applications?"*

To address our RQ, we designed a study with citizens from Norway in order to examine their perceptions regarding privacy and trust, as well as their emotions in regard to the adoption of DCT applications. In our study we include users who adopted the government contact tracing application Smittestopp, as well as those who ignored it or refused to use it. We regarded all Norwegians as suitable contributors to this research as the application was designed for everyone living in the country. We drew on existing theories by surveying questionnaire answers regarding IUIPC, awareness, collection, control, relative advantage, trusting/risk beliefs and human emotions. Our findings show that both trust and relative advantage from using the application increase intention to use it, while risk beliefs reduced intention to use the application. Additionally, we found that negative emotions moderate the relation between risk beliefs and intention to use, while positive emotions moderate the relation between relative advantage and intention to use.

The paper is structured as follows: the next section describes the Smittestopp-application in Norway and offers the theoretical background of the study. Next, we present our research model and hypotheses, followed by the research method and findings. The paper concludes with a discussion and an outline of the contribution to relevant research on DCT for future studies.

## **2. BACKGROUND**

### **2.1 Smittestopp**

The first iteration of Smittestopp, the official Norwegian DCT-application, was launched on April 16th 2020 after a relatively rushed development by the Norwegian Institute of Public Health (FHI) (Lintvedt, 2021). This iteration of Smittestopp used Bluetooth and Global Positioning System (GPS) technology, in contrast to most other contact tracing applications, which only use Bluetooth. Along with GPS data, this iteration of Smittestopp also stored operating system numbers, phone models and details of registered encounters. FHI stored any data about users' movement anonymously and was only accessed by authorized personnel of FHI (Martin et al., 2020). Centralized data storage, along with location-based data, was considered to be large-scale surveillance and monitoring of the Norwegian population (Lintvedt, 2021). The first version of Smittestopp was deactivated on June 16th 2020 due to the rising privacy concerns and lack of transparency for citizens (Martin et al., 2020). Other concerns included low user friendliness, downloading errors and high battery use even when the application was not actively being used (Sandvik, 2020).

The Ministry of Health and Care Services in Norway released a second version of the application on December 21st 2020, which was a new application under the same name 'Smittestopp', built on the GAEN-framework and Danish source code from Denmark's Smittestop-app (Lintvedt, 2020). The focus of this iteration of Smittestopp was decentralization and the protection of personal privacy, removing the GPS-technology previously used, only relying on Bluetooth, and storing data locally. The development process was considered open, with external developers and activists being invited onto the project, and the source code being available publicly on GitHub (Lintvedt, 2020). FHI themselves rendered this approach as a brand-new technological solution, and emphasized the point that, despite the identical name, these two iterations had almost nothing in common (Folkehelseinstituttet (2022). The first iteration of Smittestopp raised concerns about being harmful, while the second iteration was criticized for being both harmless and useless (Lintvedt, 2021, p. 69). There is now a third and current iteration of Smittestopp, with mostly performance related upgrades and quality of life improvements.

### **2.2 Related work**

Recent studies in the area have examined the use of DCT applications in order to understand the underlying reasons for their adoption or resistance. It was found that the main impediments to the adoption of DCT apps are concerns about security and privacy, a lack of trust in the government, the cost of installation, inability to install apps/activate Bluetooth, lack of access to a smartphone or compatible OS, and a lack of willingness to go into quarantine, to test or to report results (Altmann et al., 2020; Blom et al. 2021; Kaspar, 2020; Sharma et al., 2020). Additionally, protection of family and friends, responsibility to the community, knowing the risk, reducing deaths, etc. were reasons for their adoption, while concerns about surveillance; the risk of hacking, concerns about disclosing information about location/people in contact, difficulty in installation, etc. were reasons against the use of DCT app (O'Callaghan et al., 2021).

The main determinants of adoption concern technical factors, usability and use outcomes. Specifically, technical factors include relative advantage, design and compatibility (Huang et al., 2022; Lin et al., 2021; Trang et al., 2020) Outcome beliefs and usability factors concern self-oriented and societal benefits, trusting beliefs, effort expectancy, performance expectancy, the value of information disclosure and social influence (Lin et al., 2021; Kaspar, 2020; Sharma et al., 2020; Walrave et al., 2021; Hassandoust et al., 2021; Fox et al., 2021). The stronger the perception of crisis severity, the efficacy of the app and personal capabilities, the higher the likelihood of adoption (Kaspar, 2020; Sharma et al., 2020; Walrave et al., 2021; Trkman et al., 2021). There is also a correlation between attitude towards the DCT app use and the expected personal and community-related outcomes of sharing information (Sharma et al., 2020).

Adoption intention can also depend on individual differences, such as innovativeness and voluntariness (Hassandoust et al., 2021; Trang et al., 2020), as well as situational factors, such as facilitating conditions, social influence, and personal hygiene (Saw et al., 2021). However, neither demographic nor situational factors were significantly associated with app downloads (Saw et al., 2021).

We present the findings of some recent studies on the usage of DCT in Table 1. Those studies were used to bring a theoretical foundation into our study when developing our hypotheses.

**Table 1. Overview of Recent Studies on Digital Contact Tracing**

Author (year)	Objective/Context	Methodology	Theory	Results/Findings
Munzert et al. (2021)	To measure actual usage of a DCT and find the differences in uptake among different groups, as well as examining reasons for higher uptake.	Quantitative Survey, SEM	Randomized Intervention	Higher rates of uptake were revealed among respondents with increased risk of severe illness, but lower for those with a heightened risk of exposure to the disease. Informative and motivational video messages have a very limited effect on uptake, but more findings suggest that small monetary incentives strongly increase uptake of DCT.
Garousi et al. (2022)	Identify main problems users report in regards to DCT apps and focus on the “software in society” aspects of the apps.	Qualitative review analytics tool	UTAUT	Users are generally dissatisfied with the apps that were studied, except for the Scottish app. Issues reported were mostly related to doubts that the DCT apps actually work and high battery consumption.
Oldeweme et al. (2021)	To investigate how uncertainty reduction measures increase adoption of DCT apps and how their use affects perception of different risks.	Quantitative Survey	URT	Uncertainty reduction measures like transparency dimensions, disclosure and accuracy, as well as trust in government and social influence, foster the adoption process. The use of DCT apps reduced the perceived privacy and performance risks, but did not reduce social risks and health related pandemic concerns.
Li et al. (2021)	To investigate the effects of app design choices and individual differences on DCT app adoption intentions.	Quantitative Survey	Privacy Calculus	Individual differences played a more important role than app design choices. Certain app designs could lead to inequality of acceptance from people. Analysis showed that someone’s perception of the public health benefits offered by the app and the adoption willingness of other people had a larger effect in explaining the observed effects of app design choices and individual differences than their perception of the app’s security and privacy risks.
Chen & Thio (2021)	To characterize DCT systems developed around the world and compare uptake rates with different technologies and more.	Qualitative Study	MAST framework	Drivers and barriers are found and discussed. Suggestions for policymakers are also made in regards to how to influence barriers and drivers in order to increase uptake.

**2.3 Theoretical Background**

This study applies and extends the Informational Unified Privacy Concerns (IUIPC) model by examining the impact of privacy concerns, trust, and risk beliefs on the intention to use digital contact tracing applications, specifically the Smittestopp app in Norway. It also explores the moderating role of positive and negative emotions on these relationships. The study aims to validate and generalize the original model in a different cultural and application-specific context, contributing to the understanding of technology adoption dynamics.

The construct of Internet Users' Information Privacy Concerns (IUIPC) consists of three dimensions, *awareness*, *collection*, and *control*. These three dimensions each represent different types of concerns (Malhotra et al., 2004). Awareness refers to the degree to which a consumer is concerned about their awareness of organizational information privacy practices. Collection describes a person’s concern about the amount of individual-specific data that others may possess in relation to the benefits that are received. Control refers to whether a person has control over their personal information by having the power to modify, approve or opt out of a service (Malhotra et al., 2004). A recent study using IUIPC shows that Chinese users prefer the collection of personalized data, while German and Americans highly prefer anonymity (Utz et al., 2021). The IUIPC model has also been used in studies when extracting users’ thoughts from Twitter and other social media sites to uncover privacy concerns during COVID-19. (Bhatt et al., 2022). We draw on the recent work of Lin et al. (2021), and seek to examine the role of IUIPC, which has been shown to be a good tool to explain variance in a

person's willingness to interact with and use different technologies and services (Bélanger & Crossler, 2011), on citizens trust and risk beliefs, as well as on their intention to use a DCT-application.

Trust is considered both a fundamental and critical constituent of all human relationships, and various conceptualizations of trust have been defined, including positive beliefs, personal traits, action, and social structure (Das & Teng, 2004). Trust beliefs have often been discussed in literature that touches upon technology acceptance and are typically found to be positively related with the intention to use technology in various contexts (Beldad & Hegner, 2018; Shin, 2021; Oldeweme et al., 2021). Some studies have also found that a successful launch of mobile applications to fight the pandemic relies strongly on citizens' trust in the technology itself (Parker et al., 2020). Trust has often been conventionally linked to risk, as the logic of risk occupies an indisputably important position in defining trust (Das & Teng, 2004). Studies have disagreed on conceptualizations of risk, but most definitions suggest ideas such as uncertainty and/or variance in outcomes (especially losses) of some significance (Das & Teng, 2004). Risk beliefs have often been divided into performance risks, privacy risks and social risks (Oldeweme et al., 2021). Finally, relative advantage was described as the degree to which an innovation is perceived as being better than the idea it stems from, often guaranteeing economic profitability (Rogers, 1995). Relative advantage has been found to be positively related to intention to encourage knowledge sharing in an IT support climate and has been found to positively affect intention to use COVIDSafe (Lin & Lee, 2006; Lin et al., 2021).

Emotions have an important role when making decisions and individuals may turn to their emotions as a source of information, in the absence of clear information (DeSteno et al., 2004). Sudden changes in society have also been shown to affect one's emotions, with recent studies examining the role of emotions during the pandemic COVID-19 in order to get insight into public sentiment regarding governmental management policies (Choudrie et al. 2021). Furthermore, various studies have examined their role in influencing users' behavioural intentions in various types of e-services, either directly, indirectly, or as a moderator (Chang et al., 2014; Pappas et al., 2016; 2017). We have measured the emotions of our participants in regards to the Smittestopp-application through an initial statement to examine if they moderate the effect of other constructs on intention to use the application. Similar to past studies (Pappas et al., 2020), emotions here were divided into two basic categories, positive and negative, which will allow us to obtain a more complete understanding of how individuals felt regarding the use of the Smittestopp-app.

### 3. RESEARCH MODEL AND HYPOTHESES

Trust factors, such as the ability to trust and integrity, are affected by privacy violations (Martin, 2018). Willingness to disclose information to a service mediates the relationship between trust and the service (Kumar et al., 2018). If a user has had a positive or negative experience with the service, trust has been shown to be affected accordingly. Consumers will have different privacy boundaries for different types of personal information that they are required to share; there is a negative relation between trust and privacy concerns (Xie & Karan, 2019). We argue that it is important to examine this relationship in the context of DCT considering the type of data (e.g., proximity data, health data, location data, timestamps) required for such apps to be able to function properly. IUIPC defines several concerns and has been shown to have negative relations to trust (Malhotra et al., 2004). By examining the impact of IUIPC on trusting beliefs regarding DCT-adoption, we aimed to uncover why Norwegians are hesitant to download and use Smittestopp to mitigate the spread of COVID-19. We propose the following hypothesis:

*H1. Citizens' information privacy concerns will have a negative effect on their trusting beliefs regarding the use of contact tracing applications.*

Consumers' privacy concerns are typically expected to affect their risk beliefs in various contexts when it comes to different types of e-services that are directly aimed to the end user (Maseeh et al., 2021; Pappas, 2018; Pappas et al., 2013). As internet users' information privacy concerns are based on a person's awareness of, control over and thoughts about collection, there is ample reason to believe that risk beliefs will be affected. For example, when examining social media applications, findings show that users' privacy concerns were significantly related with their risk concerns related to the possibility of their private information being revealed (Fakey et al., 2020; Lankton & Tipp, 2013). A person's awareness of a technology may affect their view of the risks involved with using it, but this will depend on the type of technology and the context in which it was used. With this, we propose:

*H2. Citizens' information privacy concerns will have a positive effect on their risk beliefs regarding the use of contact tracing applications.*

Lin et al. (2021) reaffirmed support for their own hypothesis on trusting beliefs having a negative impact on risk beliefs, having found that trust had a negative effect on risk, and instead increased the intention to use the Australian COVIDSafe application. Most of the prior studies that touched upon trust beliefs did not suggest that beliefs had any correlation with trust (Hassandoust et al., 2021; O'Callaghan et al., 2021; Duan & Deng,

2021). Trust in government and social influence have previously fostered the adoption process of DCT-applications, and that usage of the said applications reduced perceived privacy and performance risks (Altmann et al., 2020; Oldeweme et al., 2021). For example, when examining the factors that determine the motivation for using the DCT apps it was found that trust in the app was associated with app usage (Kaspar, 2020). Another study found that trusting beliefs increase adoption intentions (Lin et al., 2021). Also, Touzani et al. 2021 found that trust in political representatives was also associated with the willingness to use DCT apps. Thus, we propose the following:

*H3. Trusting beliefs will have a negative effect on risk beliefs.*

Several studies found that risk concerns and beliefs have a negative impact on intention to download and utilize a DCT-application (Hassandoust et al., 2021; O'Callaghan et al., 2021; Duan & Deng, 2021). Risk is often mentioned as a factor of concern regarding privacy and security (Altmann et al., 2020) as well as concerns surrounding self-disclosure leading to the possibilities of getting hacked, or data getting leaked (O'Callaghan et al., 2021). Using the application could mean protecting yourself, family, and friends from COVID-19 (Hassandoust et al., 2021), while not adopting the application could also imply protecting your family and friends from potential personal data leakage and privacy violations (O'Callaghan et al., 2021). Thus, we propose:

*H4. Risk beliefs will have a negative effect on citizens' intention to use the Smittestopp-app.*

Several studies suggest different findings are divided on whether trusting beliefs have a positive or negative influence on intention to use. It was found that a general lack of trust in government, as well as concerns about privacy and security, were the main impediments against the use of DCT-applications (Altmann et al., 2020). Contrarily, other researchers have argued that trust in technology, as well as in the application itself, was associated with adoption intentions for DCT-applications (Lin et al., 2021; Kaspar, 2020). For instance, the disclosure of transparency dimensions and accuracy, as well as trust in government and social influence were found to foster the adoption process (Oldeweme et al., 2021). Trust in political representatives was also found to be associated with the willingness to use DCT apps (Touzani et al., 2021). The severity and vulnerability of data misuse were also associated with motivation to use the DCT app (Kaspar, 2020). Trust in government and technology have been major determinants on intention to use DCT to reduce infection spread (Prakash et al., 2021). Thus:

*H5. Trusting beliefs will have a positive effect on citizens' intention to use the Smittestopp-app.*

Relative advantage and perceived self-benefits have been shown to positively influence individuals' willingness to download and use DCT-applications in the past (Lin et al., 2021; Walrave et al., 2020; Trang et al., 2020). Lin et al. (2021) concluded that relative advantage would increase intention to use, as most Australians would be willing to embrace mobile digital technology instead of manual paper-based solutions. Munzert et al. (2021) found that even the smallest amounts of monetary incentives could strongly increase the uptake and usage of DCT-applications. If a user can perceive self-benefits as a result of adopting Smittestopp, they might also absorb the benefits that Smittestopp brings to the society. With this prior knowledge, we propose:

*H6. Relative advantage will have a positive effect on citizens' intention to use the Smittestopp-app.*

Intention to use has previously been shown to affect the use of a DCT-app (Oldeweme et al., 2021). For example, one study found that the importance of individual differences over app design decisions was greater on DCT app usage intention. Certain app designs may result in differences in usage intention (Li et al., 2021). Other studies found that high convenience design influences DCT app usage intention (Trang et al., 2020) and perceived crisis severity also impacts DCT app usage (Trkman et al., 2021). It is expected that a person's intention to use a service increases the possibility of them engaging with the service by downloading and using it, as it has been well documented in the technology acceptance literature. Intention to use should not be confused with actual use. Exploring this relation can uncover whether the intentions of Norwegian users reflect the actual uptake of Smittestopp. All the previously defined theories and hypotheses are expected to ultimately affect intention to use, as seen in Figure 2. For this research to further benefit DCT-research and societal needs, it is important to see if all these intentions lead to actual use. We then propose:

*H7. A citizens' intention to use the Smittestopp-app will have a positive effect on downloading and using the Smittestopp-app.*

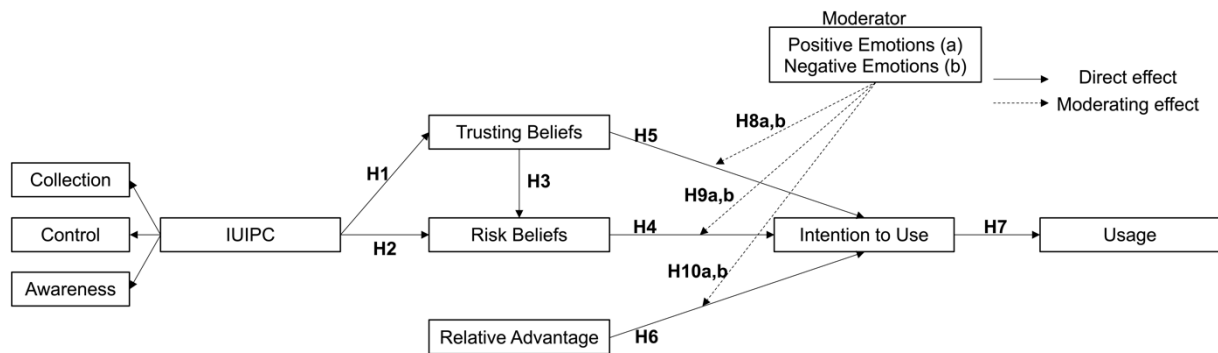
Emotions have been shown to affect intention to use and the adoption of technology in various contexts (Beaudry & Pinsonneault, 2010; Pappas et al., 2016). The moderating role of positive and negative emotions has been discussed in previous studies (Pappas et al., 2017) in the context of e-service adoption. Negative emotions have had significant effects on intention to adopt new systems (Zheng & Montargot, 2021). Furthermore,

positive emotions have been shown to be related to perceived benefits (Ding & Chai, 2015). As previously noted, relative advantage is a user’s perception of the advantages that come with using a DCT-app, also known as perceived benefits. We seek to explore and examine the moderating role of positive and negative emotions on the relationship among trusting beliefs, risk beliefs, relative advantage, and intention to use. Thus, we propose the following hypotheses:

*Positive emotions will moderate the relationship of a citizen's (H8a) trust beliefs, (H9a) risk beliefs, and (H10a) relative advantage with their intention to use.*

*Negative emotions will moderate the relationship of a citizen's (H8b) trust beliefs, (H9b) risk beliefs, and (H10b) relative advantage with their intention to use.*

**Figure 1. Research Model with Hypothesis Indicators**



## 4. RESEARCH METHOD

### 4.1 Sampling

Using a deductive approach, we undertook a literature review, from which we gathered recent relevant theory. We conducted a conceptual replication (Dennis & Valacich, 2014) of the work by Lin et al. (2021), as we adopt part of their model and test it in a different context. Also, we extend that model by testing the role of positive and negative emotions as a moderator. Thus, we propose 13 hypotheses, 6 of which are sub-hypotheses of H7 and H8. To obtain data to test these hypotheses, we conducted a survey. Aiming to reach a large and broad sample, we developed an online questionnaire to collect sufficient data. Data collection lasted from February 2022 to March 2022, following a convenient snowball sampling method. The questionnaire was first administered to a small number of friends and colleagues, as a pre-test. In this way, we were able to correct typos and mistranslations, reformulating the questions which were unclear to many. Then, we distributed our survey to even more participants, distributing them to friends, family, and colleagues, who in return distributed the survey to people they knew as well. We also released it on different social media and Norwegian online communication channels to garner widespread attention on platforms where background and demographics would differ. Data cleaning was conducted to remove incomplete surveys. We ended up with 189 respondents to our questionnaire.

**Table 2. Users' Demographic Profile**

Age	Frequency	Population of municipality	Frequency
< 24	67 / 35.5%	100 – 999	2 / 1.1%
25 - 34	66 / 34.9%	1 000 - 4 999	24 / 12.7%
35 - 44	36 / 19.0%	5 000 - 9 999	12 / 6.3%
45 - 54	12 / 6.3%	10 000 - 19 999	23 / 12.2%
55 - 64	5 / 2.6%	20 000 - 39 999	17 / 9.0%
65 - 74	1 / 0.5%	40 000 - 99 999	44 / 23.3%
75 or older	2 / 1.1%	100 000 or more	67 / 35.4%
<b>Gender</b>		<b>Owns a smartphone</b>	
Female	76 / 40.2%	Yes	187 / 98.9%
Male	111 / 58.7%	No	2 / 1.1%
Other	2 / 1.1%	<b>Used Smittestopp</b>	
<b>Education</b>		Yes	89 / 47.1%
Primary school	4 / 2.1%	No	100 / 52.9%
High school	46 / 24.3%	<b>Risk group</b>	
Vocational school	14 / 7.4%	Yes	72 / 38.1%
University or college	124 / 65.6%	No	117 / 61.9%
Did not want to share	1 / 0.5%		
<b>Functions turned off</b>			
Wifi	31 / 16.4%		
Bluetooth	76 / 40.2%		

As seen in Table 2, most of the participants are between 18 and 34 years old. Among our participants, about 47% had used the Smittestopp-app before. With this split, we explored whether previous usage of the app impacted the users' privacy concerns and emotions. The split between risk group respondents was also usable as we have an almost 40/60 split, with the lower percentage belonging to those who are at risk.

#### 4.2 Measures

First, we collected data on demographics and asked some general questions regarding the use of contact tracing applications to control for their previous experience. The second part of the questionnaire included questions based on theories described in the background section. We adapted most items and questions from Lin et al. (2021), as well as their IUIPC model when constructing our questionnaire. Items for positive and negative emotions were adopted from past studies that have examined emotions in different online settings (Pappas et al, 2017; Pappas et al., 2020). The questions were translated and rewritten to fit the Norwegian government, using Smittestopp as the contact tracing application instead of the Australian COVIDSafe-app. The last set of questions in the survey presented a statement, followed by 20 emotions to capture how respondents felt about using the application. The participant could resonate with the emotion by answering anything from strongly disagree (1) to strongly agree (7) on a 7-point Likert scale. For clarification, some items from trust, risk, and emotions, were removed due to low loadings. Each of our used items can be found chronologically in Table 3, along with the questions asked and the analyzed data loadings.

**Table 3. Measured Items with Related Loadings**

Measures	Questions	Loadings
<b>Awareness (AWAR)</b>		
AWAR1	The Norwegian government seeking information online should disclose the way the data are collected, processed, and used.	0.81
AWAR2	A good consumer online privacy policy should have clear and conspicuous disclosure.	0.80
AWAR3	It is important to me that I'm aware of and knowledgeable about how my personal information is used.	0.80
<b>Control (CONT)</b>		
CONT1	Citizen online privacy is a matter of consumers' right to control their decisions about how their information is collected, used, and shared.	0.74
CONT2	Citizen control of personal information lies at the heart of consumer privacy.	0.83
CONT3	Online privacy is invaded when control is unwillingly reduced as a result of a marketing transaction.	0.81
<b>Collection (COL)</b>		
COL1	It bothers me when the Norwegian government asks me for personal information online.	0.90



COL2	When the government asks me for personal information, I sometimes think twice before providing it.	0.83
COL3	It bothers me to give personal information to many Norwegian government agencies.	0.92
COL4	I'm concerned that the Norwegian government collects too much personal information about me.	0.80
<b>Trust (TR)</b>		
TR1	The government is trustworthy in handling Smittestopp information from Smittestopp-app	0.84
TR2	The government tells the truth and fulfill promises related to (my information) provided by me.	0.91
TR3	I trust that Norwegian government keeps my best interests when handling my personal data	0.88
<b>Risk (R)</b>		
R1	In general, it is risky to give (my information) to the Smittestopp-app.	0.81
R2	There is high potential for loss associated with giving (my information) to the Norwegian government.	0.79
R3	There is much uncertainty associated with giving personal info to the Norwegian government.	0.87
R4	Providing the Norwegian government with (my information) will involve unexpected problems.	0.83
<b>Relative Advantage (RA)</b>		
RA1	Downloading Smittestopp enhances the Norwegian government's effectiveness with contact tracing.	0.83
RA2	Downloading Smittestopp improves the quality of contact tracing.	0.94
RA3	Downloading Smittestopp enables the government to trace coronavirus cases more quickly.	0.91
RA4	Overall, I find downloading Smittestopp to be advantageous for contact tracing.	0.90
<b>Intention to Use (INT)</b>		
INT1	It is worth it to download Smittestopp	0.94
INT2	I will strongly recommend others to download Smittestopp	0.93
<b>Usage</b>	Have you used the Smittestopp application during the COVID-19 pandemic? (Yes/No)	
<b>Emotions</b>		
<b>Downloading and using the Smittestopp-application makes me feel:</b>		
<b>Positive Emotions (POS)</b>	Pleasure	0.85
	Joy	0.89
	Pride	0.89
	Amusement	0.76
	Relief	0.86
<b>Negative Emotions (NEG)</b>	Anger	0.83
	Shame	0.70
	Regret	0.91
	Guilt	0.90
	Fear	0.92

## 5. DATA ANALYSIS AND FINDINGS

### 5.1 Analysis and validity

For the analysis, we used SmartPLS 3.0. For content validity, we determined the importance of the questionnaire content by ensuring face validity, as Lin et al. (2021) had already successfully used several of these questions. We also examined construct reliability and discriminant and convergent validity. Reliability testing, based on the Cronbach alpha indicator, shows acceptable indices of internal consistency since all constructs exceed the cut-off threshold of 0.70. The AVE for all constructs ranges between 0.534 and 0.882, exceeding the cut-off threshold of 0.50. Finally, all correlations are lower than 0.80 and square root AVEs for all constructs are larger than their correlations. Our findings are presented in Table 4.

**Table 4. Descriptive statistics and correlations of latent variables**

Construct	Mean	SD	CR	AVE	Construct				
					IUIPC	Intention	Relative advantage	Risk	Trust
IUIPC	5.37	1.37	0.85	0.534	<b>0.659</b>				
INT	3.65	1.62	0.86	0.882	-0.183*	<b>0.939</b>			
RA	4.86	1.59	0.92	0.809	-0.102*	0.755**	<b>0.899</b>		
Risk beliefs	3.48	1.59	0.87	0.729	0.594**	-0.393**	-0.274**	<b>0.854</b>	
TR	4.86	1.72	0.89	0.829	-0.361**	0.522**	0.413**	-0.601**	<b>0.910</b>

Note: Diagonal elements (in bold) are the square root of the average variance extracted (AVE). Off diagonal elements are the correlations among constructs (all correlations are significant, \*\* $p < 0.01$ ; \* $p < 0.05$ ). For discriminant validity, diagonal elements should be larger than off-diagonal elements. IUIPC, Internet Users Information Privacy Concerns; INT, Intention to Use; RA, Relative Advantage; R, Risk; TR, Trust, POS; Positive Emotions, NEG; Negative Emotions

Regarding emotions, our sample showed on average relatively low positive and negative emotions, with mean values of 2.77 (S.D. = 1.56) and 2.55 (S.D. = 1.62), respectively. For actual usage, which was measured with a single item and a yes/no question, about half of the sample reported that they had used the application. The estimated path coefficients of the structural model were examined to evaluate our hypotheses. Figure 2 presents the analysis of the research model.

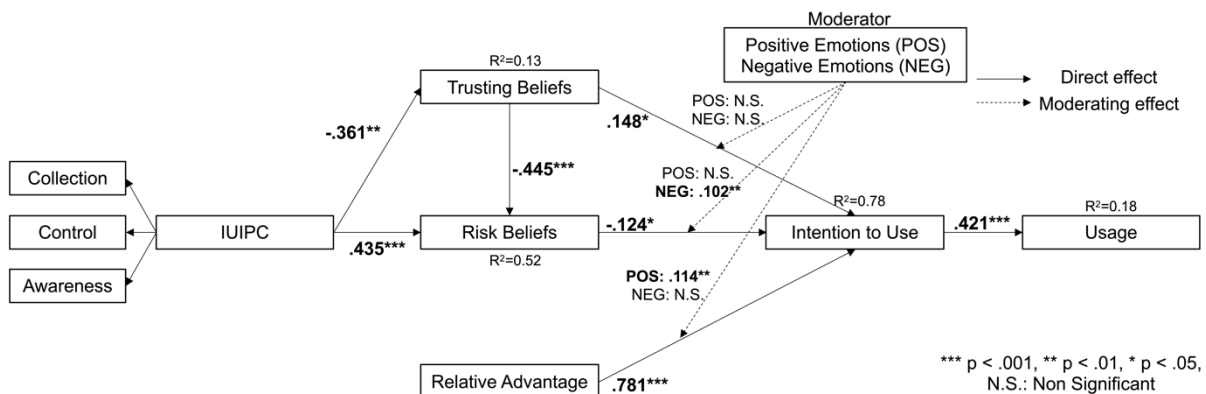
**5.2 Tested hypotheses**

The findings offer support for H1-H7, related to the direct effects, while the moderating effect of emotions is significant only in 2 (H9b, H10a) out of 6 relations. The findings are presented in Figure 2. In detail, internet users' information privacy concerns (IUIPC) have a negative effect on trusting beliefs (-0.361,  $p < 0.01$ ) (H1), while they have a positive effect on risk beliefs (0.435,  $p < 0.001$ ) (H2). Further, trusting beliefs have a negative effect on risk beliefs (-0.445,  $p < 0.001$ ) (H3). In turn, risk beliefs have a negative effect on intention to use the Smittestopp-application (H4), while trusting beliefs (H5) and relative advantage (H6) both have a positive effect on citizens' intention to use the Smittestopp-application. Finally, intention to use had a positive effect (0.421,  $p < 0.001$ ) (H7) on the actual use of the Smittestopp-application. Square multiple correlations ( $R^2$ ) are presented in Figure 2 as well. The  $R^2$  for trusting beliefs is 0.13, for risk beliefs it is 0.52, for intention to purchase it is 0.78, and for usage it is 0.18. Values higher than 0.26 imply a high effect of the predictors of the aforementioned factors.

Regarding the moderating effects, positive emotions have a moderating effect on the relation of relative advantage with intention to use (H10a), but not on the relation of trust beliefs and risk beliefs with intention to use, respectively (H8a, H9a). Negative emotions had a moderating effect on the relation of risk beliefs with intention to use (H8b), but not on the relation of trust beliefs and relative advantage, with intention to use, respectively (H9b, H10b).

In short, all the hypotheses were accepted except for H7a/H7c and H8a/H8b. Despite some low coefficients, all the accepted hypotheses are still significant enough to support the hypotheses. With the lowest coefficient at 0.102 and the highest at 0.781 there are varying degrees of effect. The t-values reflect the path coefficients well, with the lowest value of 2.212 and the highest value at 16.426.

**Figure 2. Research Model with Path Coefficients**



## **6. DISCUSSION**

The potential and development of DCT to slow the spread of a disease had been quietly explored for over a decade before the COVID-19 pandemic thrust the technology into the spotlight. However, real life social networks and the complexity of humans has made this potential hard to achieve (Cebrian, 2021). This paper has explored Norwegian citizens' concerns, trust, and risk beliefs regarding the adoption of digital contact tracing (DCT) applications, more specifically the Smittestopp-app. We drew on recent studies which called for more research on DCT-applications (Prakash & Das, 2022), and proposed a model based on the work by Lin et al. (2021), who conducted a study in Australia. We applied their model in a different context, that is in Norway, and extended it by considering the moderating role of emotions, as they have been shown to be important in decision making and the adoption of e-services in different contexts (Lu et al., 2021; Pappas et al., 2017).

Our findings show that all the direct relations are significant, with UIPC having stronger effects on trusting and risk beliefs, showing that that privacy concerns play an important role in citizens' trusting beliefs, which in turn can reduce their risk beliefs. The above findings are in accordance with prior studies and reflect the interrelations among privacy, trust, and risk (e.g. Kaspar, 2020). The effects of trusting and risk beliefs on intention to use are both significant, but the effect size is smaller. This can be explained, by the fact that the effect of relative advantage on intention to use is very large (0.781). Also, the very high R-square (0.78) suggests that these factors explain intention to purchase well. They show that Norwegian citizens will have high intentions to use DCT applications if they perceive strong benefits. The weaker effects of trust and risk could also be explained by the fact that since Norwegians typically have high trust in the government (OECD, 2017), their personal trusting and risk beliefs will have a weak effect on an application that is developed and recommended by the government. Indeed, even though Norway performed well in handling this crisis (Christensen & Lægred 2020), and citizens' intention to use the DCT app was high, this did not translate into actual usage, since the effect of intention to use on actual use was significant but relatively weak. This may suggest that due to all the measures taken by the government leading to a relatively good control of the crisis, citizens did not feel the need to use the DCT app.

Further, we examined the moderating role of emotions on three relations. In detail, we examined both positive and negative emotions and tested how they influence the relations of trusting beliefs, risk beliefs, and relative advantage on intention to use the DCT app. Positive emotions moderate only the relation between relative advantage and intention to use, suggesting that any gains or benefits from using the app will only be enhanced if a citizen has an overall positive attitude towards the app. On the other hand, negative emotions only moderate the relation between risk beliefs and intention to use, indicating that if someone feels anger or fear when using the app, their uncertainty will increase, thus their intention to use it will drop further. The above findings may be explained by the relatively low values for positive and negative emotions, showing that citizens in our sample did not experience strong positive or negative emotions related to the use of the Smittestopp app. In addition, the high trust in the government (OECD, 2017) may explain why emotions do not influence the effect of trust on intention to use.

### **6.1 Research implications**

Lin et al. (2021) called for research to test the UIPC model, and, accordingly, we expanded the research to Smittestopp and Norway, a country in which citizens' trust in the government is not only high, but also higher than in many other countries (OECD, 2017). We conducted a conceptual replication of their work, adopted part of their model and tested it in a different context. Also, we extended that model by testing the role of positive and negative emotions as a moderator. Thus, our study provides partial external third-party validation of the results of the original study towards a generalization of the original contribution into a different context. The findings show that not all results are replicated, suggesting that it may not be possible to generalise some of these in the context of Norway, raising the need for additional replication activities in this area.

Comparing our findings with previous studies, we found that information privacy concerns relate to trust and risk regarding technology acceptance (Bélanger & Crossler, 2011; Oldeweme et al., 2021). We found that trust led to the intention to use DCT-applications, which can be backed by similar studies (Lin et al., 2021; Kaspar, 2020). Risk beliefs, on the other hand, had a negative impact on intention to use, supporting previous studies (Hassandoust et al., 2021; O'Callaghan et al., 2021; Duan & Deng, 2021). Nonetheless, in our study, risk did have a negative impact on intention to use. This is unlike Lin et al. (2021), where that hypothesis was not supported. This difference could be because of differences between the Norwegians' and Australians' values and beliefs, or differences in the two DCT-applications' reputation and design. Relative advantage also increased the intention to use DCT-apps, supporting studies where superior innovative solutions encouraged information and knowledge sharing (Lin & Lee, 2006; Lin et al., 2021).

We differ from the study of Lin et al. (2021) by adding the concepts of positive and negative emotions and we obtained significant results in 2 out of 6 sub-hypotheses, thus, extending their findings with new insight. Testing for moderating effects, we found that emotions indeed had significant effects on risk beliefs (negative emotions), and relative advantage's relation to intention to use (positive emotions). By exploring positive and

negative emotions (Chang et al., 2014; Pappas et al., 2016; 2017), our study shows that emotions can indeed be integrated into research models as moderators. Additionally, our implications support previous studies where risk beliefs negatively influenced the adoption of DCT-apps (Hassandoust et al., 2021; Duan & Deng, 2021), in some cases to protect communities and other people (O'Callaghan et al., 2021). Our findings also strengthen studies where negative emotions have impacted the use of new systems (Zheng & Montargot, 2021). Since the initial outbreak of COVID-19, individuals experienced huge amalgamations of 85 thought processes and emotions due to big changes financially, physically and to the society (Choudrie et al., 2021). Our research implies that emotions regarding users' information privacy concerns and Smittestopp are results of these sudden outbursts of feelings originating from the pandemic. In future research, other human aspects could be taken into consideration when investigating reasons for technology-adoption.

## **6.2 Practical implications**

This study contributes to the work conducted at the Norwegian Institute of Public Health (FHI) by showing the important role of privacy concerns, advantages and emotions on intention and use. Privacy is paramount, thus managers designing and implementing digital contact tracing apps need to prioritize user privacy, as concerns over privacy have a significant impact on user trust and perceived risks. By addressing privacy concerns proactively, managers can build user trust and mitigate risk beliefs, thereby encouraging app adoption and use. Next, it is important to emphasize the benefits. The study found that the perceived benefits or advantages of using a DCT app have a strong influence on the intention to use it. Managers should thus clearly communicate the benefits of using the app to potential users, including how it contributes to public health efforts and personal safety. Also, managing emotions can influence the overall adoption of DCT apps. The influence of positive and negative emotions on app adoption suggests that managers need to consider emotional factors in their design and communication strategies. For example, fostering positive emotions about the app can enhance its perceived benefits, while addressing potential sources of negative emotions, like fear or uncertainty, can prevent these feelings from discouraging use.

By answering our RQ we see how Norwegians perceive DCT-applications. However, these findings may point to how citizens perceive innovative digital solutions as a bigger concept. The Norwegian government should look at Smittestopp as an important experience, and plan digital solution strategies ahead of time. In this way, the population can be sufficiently prepared, well-informed and encouraged to adopt innovative digital technology to circumvent potential global calamities in the future. Policy makers should understand that high levels of trust in government can influence citizens' willingness to adopt and use government-endorsed technologies like DCT apps. Therefore, maintaining and promoting public trust, through transparency, regular communication, and effective crisis management, can enhance the effectiveness of public health initiatives that rely on technology adoption.

## **6.3 Limitations and recommendations**

The study suffers from some limitations, as with every empirical study. The survey questions may be considered as too complicated. To address this issue, the first version of the questionnaire was pre-tested and corrections to the wording were made to reduce possible misunderstandings or unclear parts. Occasionally we received some feedback from people who needed further explanation on the questions. Further, most of our respondents were young adults already exposed to online behaviour and they might not be representative of the Norwegian population. However, our sample includes participants from all age groups and with different experiences. Also, our results are based on self-reported data, so citizens' actual behaviour might be different. Future studies should include other methods of data collection.

From our newfound experience from research on DCT-adoption, we propose the following recommendations for research: Firstly, we suggest other researchers use and refine the research model used in this study. They may explore other human factors as well as human emotions, as similar factors determined our results. Researchers may also utilize a mixed methods approach, for instance a survey with questionnaire and follow-up interviews. Semi-structured interviews can highlight the knowledge of different individuals. Also, the findings could be applied in different contexts that relate to crisis management (Nizamidou and Vouzas, 2018) to capture users' perceptions. Further, in our study we have a relatively small sample considering that this application is aimed at all citizens in the country. Thus, future studies should aim for a larger and more representative sample. However, to partially remedy this, we have included in our study users that downloaded the application as well as users that declined to use it. Future studies may also consider focus groups, for instance based on geographical differences or age groups, then compare the findings from the different focus groups. Focus groups can help practitioners design better marketing strategies, such as by following stealth marketing techniques, to increase the adoption of such services and applications (Manika et al., 2021). Adjusting the research accordingly based on the pandemic situation is also important. This research may not be limited to COVID-19 alone and can be used for similar major crises in the future.

By following these recommendations, new knowledge could collectively contribute to a better understanding of citizens' willingness to adopt DCT-applications and help governments and organizations to enhance their services. This, in turn, could benefit the population, and possibly save countless lives, depending on the situation. One can only speculate how many lives could have been saved if Smittestopp was a perfect DCT-app used by everyone in Norway from the beginning.

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