Original Paper

Development and Acceptance Evaluation of a Scenario-Based Prototype of a Digital Contact Tracing System in Geriatric Care Facilities: Results From an Exploratory Literature Review, Focus Groups, and a Survey Study

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Abstract

Background: During the COVID-19 pandemic, older adults living in geriatric care facilities were especially limited in their social interactions because of their vulnerability. Care homes often preferred broad isolation measures to avoid the risk of infection among residents. Digital contact tracing systems (DCTS) developed during the COVID-19 pandemic have the potential to overcome the practice of general isolation in geriatric care facilities, but a prerequisite for their successful implementation is acceptance among nursing staff.

Objective: This study aimed to investigate nursing staff's acceptance of such wearable devices for use within geriatric care facilities and the conditions the technology must meet to increase the likelihood of nursing staff's acceptance, based on a scenario-based prototype for a digital, wearable-based contact tracing system.

Methods: The study used a sequential mixed methods design. Initially, an exploratory literature review provided the foundation for conceptualizing the prototype for the contact tracing system. In the next step, focus groups were conducted among nursing staff with and without prior experience with digital contact tracing at work. Building on those results, a survey study on the prototype's acceptance was conducted among nursing staff in Germany. The focus group interviews, as well as the survey study, were based on the Unified Theory of Acceptance and Use of Technology (UTAUT).

Results: Based on the few studies that focused on nursing staff's acceptance of digital contact tracing in medical occupations and the results of the focus group interviews, the scenario-based prototype was developed as a wearable with varying characteristics for nursing staff and residents of geriatric care facilities. The prototype was evaluated as generally favorable by the nursing staff participating in the survey study (n=329), specifically under high-threat pandemic preparedness conditions. Furthermore, the survey study indicates that nursing staff's intention to use the wearable-based contact tracing system was significantly associated with performance expectancy (β=0.291; P<.001), as well as choice of wearable (β=0.174; P<.001), and usefulness under threatening conditions (β=0.251; P<.001). Extending the UTAUT model by context-specific predictors explained 51.6% (R^2=0.516; $F_{7,321}$= 50.973; P<.001; Bonferroni-Holm [BH] corrected P=.001×6=.006) of the variance in the intention to use DCTS in geriatric care facilities. This marks a significant increase of explained variance of 7% (ΔR^2=0.074; $\Delta F_{3,321}$=16.699; P<.001) in comparison to the standard UTAUT model (R^2=0.446; $F_{4,324}$= 66.954; P<.001; BH-corrected P=<.001).

Conclusions: Nursing staff perceived the proposed scenario-based prototype of a DCTS to be especially useful when no other protective measures, such as vaccines or tests, are available, which is a highly probable scenario. Therefore, preparedness strategies should consider digital contact tracing as one potential component of future pandemic preparedness.

Trial Registration: OSF Registries osf.io/82TVA; https://osf.io/82tva

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Introduction

Overview

Despite the relief of returning to normalcy after the COVID-19 pandemic, the risk that an infectious disease might cause further epidemic or pandemic outbreaks remains [1,2]. According to Jaquis and Schneider [3], this development is expected to materialize in the near term rather than the distant future. Regarding COVID-19 and the "Continuum of Pandemic Phases" [4], the world has entered the interpandemic phase.

An important lesson learned from the COVID-19 pandemic is that older adults are a highly vulnerable group [5], especially those living in (geriatric) care facilities [6,7]. It has been estimated that every second death associated with SARS-CoV-2 in Europe and several US states occurred among people in need of care or residing in (geriatric) care facilities [7,8]. To protect this vulnerable group during the pandemic, hospitals and (geriatric) care facilities were required to close to visitors and restrict contacts with patients and residents. Isolation and quarantine have substantial side effects for both patients/residents and nursing staff, since they are associated with increased risks of depressive, anxiety, and stress-related disorders [9]. This highlights the need for better protective measures.

As the first simulation and real-world studies on COVID-19 contact tracing via mobile devices yielded promising results in preventing the spread of SARS-CoV-2 [10,11], digital contact tracing applications for the general public were introduced widely [12]. By 2021, they were used in 48 countries worldwide, including 27 European countries, and in 30 states in the United States as a way to detect infection chains faster and initiate targeted isolation measures in a timelier manner [13,14]. Accordingly, as their benefits in preventing the spread of infectious (airborne) diseases, such as SARS and tuberculosis [15,16], had already been highlighted years before the COVID-19 pandemic, the potential for integrating digital contact tracing systems (DCTS) using sensor technology—like mobile devices or wearable devices—into hospitals or geriatric care facilities has also been underscored [17]. Early systems have already been introduced [18,19].

Despite this, little research has been published investigating nursing staff's acceptance of DCTS, particularly in geriatric care facilities, which could help guide the design and implementation of such systems. The present research aims to develop and test a scenario-based prototype of a DCTS for use in geriatric care facilities.

Theoretical Background

Acceptance of Digital Contact Tracing Applications

Several studies examined the acceptance of contact tracing applications by the general public at the time countries released tracing applications for SARS-CoV-2 [20-24]. In the general population, significant associations with the acceptance of contact-tracing applications were found for performance expectancy [20,22,23], effort expectancy [23], social influence [20,22,23], and facilitating conditions [20,23], as well as for the context-specific predictors of perceived privacy [20,22,23] and data security risks [20,23]. Mixed results were identified for the association with threat appraisal [22,23]. Furthermore, Kahnbach et al [21] found application quality to be associated with adoption rates of European contact tracing applications.

However, findings from studies on the acceptance of contact tracing applications in the general public might not apply to nursing staff's technology acceptance. Meta-analyses by Chauhan and Jaiswal [25] and Chong et al [26] revealed significantly different patterns regarding the relative importance of predictors of eHealth application acceptance between patients and the general public, considered as one group, and medical staff, considered as another. Furthermore, research has underlined the importance of focusing on the needs of people working in health care, as it appears that their commitment is crucial for the full potential of digital tools to be actualized [27-29]. Therefore, nursing staff's technology acceptance of DCTS in geriatric care facilities should be assessed carefully to facilitate later implementation.

Nursing Staff's Technology Acceptance

To assess nursing staff's technology acceptance, we applied the Unified Theory of Acceptance and Use of Technology (UTAUT) [30], a framework well established in nursing contexts [31-34]. The model posits that performance expectancy, effort expectancy, and social influence explain usage intentions, while actual usage is explained by intention and facilitating conditions [30]. In specific usage scenarios, facilitating conditions can act as a predictor of usage intention [35]—a finding that was also integrated into prior technology acceptance research among health care personnel [36]. By taking additional predictors into account, the UTAUT model can be adapted to the context. Venkatesh et al [37] adapted the UTAUT to health care when they investigated doctors' acceptance of electronic medical records. Van der Waal et al [23] emphasized the benefits of an extended UTAUT model to explain the public's intention to use digital contact tracing

applications. Additional predictors associated with nursing staff's intention to use technology were personal attributes, such as experience with the system [33]. In this study, we adhered to the core UTAUT predictors to ensure comparability with previous research, as emphasized in recent meta-analyses [38,39]. Furthermore, in accordance with the principle of parsimony, any extension of the theoretical model should be justified empirically by a meaningful increase in the variance it accounts for in the outcome variable [40].

A crucial consideration in our choice of model is the target group's stage of interaction with the technology [39]. Because of the relevance of predictors that vary across the technology life cycle [41], we focused on the preadoption phase [42]. At this stage, individuals express preuse perceptions of a scenario-based prototype without prior hands-on experience [42]. By targeting this specific phase, we aim to understand the formation of initial intentions, which is critical for successful long-term technology integration.

Methods and Results

Overview

The present study aimed to develop a scenario-based prototype of a DCTS in geriatric care facilities, using a sequential multimethod study design: an exploratory literature review (Study 1) informed a structured, participatory development of the scenario-based prototype via focus group interviews (Study 2), and a quantitative evaluation of its acceptance (Study 3).

In Study 1, an exploratory literature review was performed to summarize what was already known about the acceptance of DCTS in indoor environments, particularly among nursing staff. The main aim was to answer the question: what predicts nursing staff's intention to use a DCTS in geriatric care facilities? The review also focused on the theoretical bases that were used in prior research.

In Study 2, based on the findings of the exploratory literature review and using the UTAUT as the theoretical framework, a preliminary scenario-based prototype for a DCTS in geriatric care facilities was constructed. This preliminary version was then described and discussed in focus groups with potential users to clarify nursing staff's preferences for a DCTS and identify relevant predictors of successful implementation in geriatric care facilities. From this, a refined and detailed scenario-based prototype was developed.

In Study 3, the final scenario-based prototype was evaluated in a quantitative survey investigating nursing staff's acceptance of a DCTS in geriatric care facilities.

Ethical Considerations

Formal ethics board approval was not sought, as it was not considered necessary under the institutional research ethics guidelines of Leuphana University Lueneburg (Section 2(3)) [43], which identify formal ethical review as particularly relevant for research involving risks to participants or deception. The present study involved noninvasive qualitative focus groups and a quantitative survey concerning a hypothetical technology deployment scenario and did not involve physical procedures, deception, or the collection of personal health or other sensitive data. The study was therefore considered to involve no more than minimal foreseeable risk. The study protocol was preregistered on the Open Science Framework (OSF).

Participation was voluntary. Participants received comprehensive information about the study and provided informed consent prior to participation, with the right to withdraw at any time without consequences. No direct personal identifiers were collected, and the background variables were limited to basic demographic and professional characteristics (eg, age, gender, facility type, and work experience). For the focus groups, participants were informed about the importance of maintaining the confidentiality of other participants' statements. Focus group participation took place during participants' regular working hours, and participants received the agreed compensation for their participation.

For the survey, all data were anonymized at the point of collection. Survey participants did not receive direct compensation from the research team; any incentives associated with participation in the online panel were provided independently by the respective panel provider.

Study 1 Methods (Exploratory Literature Review)

To obtain information on the acceptance of DCTS in indoor environments, especially by nursing staff working in geriatric care facilities, an exploratory literature review was conducted. While framed as an exploratory synthesis, the review process was informed by the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews) guidelines [44] to ensure transparency. The related PRISMA-ScR checklist is provided in Checklist 1.

The following questions guided the development of the search string and data extraction process:

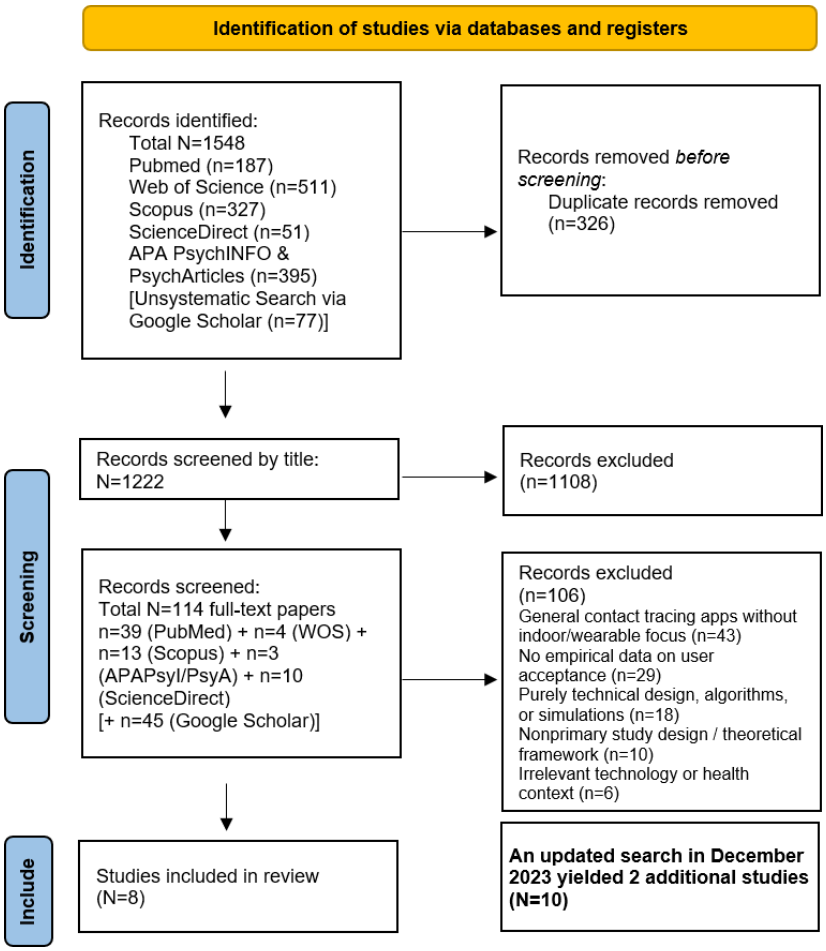
1. To what extent are sensor technologies for the contact tracing of infectious diseases accepted in indoor environments, and how is acceptance measured?
2. What are the main predictors of the acceptance of sensor technologies used for contact tracing infectious diseases in indoor environments, including potential barriers?
3. Which strategies have been developed to improve the acceptance of sensor technologies for the contact tracing of infectious diseases?

The search string (Table S1 in Multimedia Appendix 1) considered four concepts: (1) technology acceptance, (2) contact tracing, (3) health care facilities, and (4) sensor technology. An additional fifth concept referring to communicable diseases was dropped, as it resulted in a low hit rate. The systematic search was conducted in December 2021 using 5 databases, including MEDLINE (PubMed), Web of Science, Scopus, APA PsycINFO, and PsycArticles,

and ScienceDirect. The search was accompanied by a nonsystematic search using Google Scholar. To ensure coding consistency, 2 researchers independently screened all retrieved records against the defined eligibility criteria (Table S2 in Multimedia Appendix 1) and extracted data using a standardized extraction table (S1 in Multimedia Appendix 1). Because the explicit eligibility criteria, interrater discrepancies were minimal and restricted to minor initial ambiguities regarding whether studies reported empirical acceptance data versus purely technical metrics. All discrepancies were resolved through direct joint consensus and full-text reexamination, rendering third-party arbitration unnecessary and yielding an initial sample of 8 eligible studies.

To keep the body of literature updated for discussion, the search was repeated for each database in December 2023 and again for PubMed in September 2024, yielding a final sample of 10 studies. The steps of the systematic searches are summarized as a flowchart in Figure 1.

Figure 1. Flowchart: literature search.



Study 1 Results (Exploratory Literature Review)

Overview

The first exploratory literature search in November 2021 yielded 1548 hits. After narrowing down the record count based on titles, 2 researchers (LK and NU) independently screened the 114 full-text studies, according to the eligibility criteria presented in Table S2 in Multimedia Appendix 1. Eight studies were found to address the research questions [45-52]. Results from these studies were considered when the scenario-based prototype was developed in Study 2 and evaluated in Study 3. The literature search was later updated twice, in 2023 and 2024. The search in 2023 yielded an additional 289 records, of which 2 were relevant to the research context [53,54]. No additional relevant publications were found in September 2024.

Digital contact tracing in the studies referred to the use of sensors integrated into smartphones or wearable devices that were carried indoors, with a special interest in studies examining clinical settings. Most sensors communicated using radio-frequency identification (RFID), Bluetooth, or Wi-Fi technology. All 10 studies were observational in nature.

Overview of Study Content

One study [52] aimed to explain health care staff's willingness to carry wearable devices for digital contact tracing in the hospital. The study examined the 2 UTAUT predictors of performance expectancy and social influence, which were combined into the single predictor of acceptance, as

well as effort expectancy and perceived privacy harm. The other studies did not focus on explaining acceptance in terms of usage intention and/or actual use. Instead, they investigated the feasibility of using various wearable devices that used either RFID or Bluetooth technology for effective contact tracing. For example, Chambers and Anglemyer [53] performed a feasibility study of a Bluetooth-enabled card with hospital staff, whereas Curtis et al [54] examined wearable DCTS to quantify nursing staff's contacts with one another and with patients. Nursing staff members were found to have a high number of contacts with colleagues and patients, making them the linchpin for the spread of infectious diseases [46,47]. In this way, the studies underlined the potential of DCTS in health care settings. Three articles addressed the use of DCTS in other indoor settings: at a high school [49], a scientific conference [51], and a university [50]. Two studies [49,51] compared digital contact tracing with paper-based contact tracing strategies, such as contact diaries. Shelby et al [50] compared wearable versus smartphone app–based contact tracing and found a preference for wearables provided by the organization. Table 1 summarizes the characteristics of each study.

Table 1. Results of the exploratory literature search.

Context and source	Location	Target group	N	Contact tracing technology	Theory/ measures	Technology acceptance
Health care staff's acceptance of a wearable contact tracing unit						
Guo et al (2021) [52]	National Center for Infectious Diseases (Singapore)	• Health care staff	• 260	Wearable tag (RFID[a] and Wi-Fi for triangulation of location)	TAM[b] (Davis et al [55] 1989, theory of planned behavior (Ajzen 1991 [56]), and UTAUT[c] (Venkatesh et al 2003 [30])	High wearable compliance (93.4%) carrying the wearable at all times (use). Willingness to use RTLS[d] in the workplace was high (75%)
Investigation of contact tracing technologies in indoor health care settings						
Isella et al (2011) [46]	Hospital (Italy)	• Health care staff and patients	• 188	Wearable badges (RFID)	—[e]	High study participation rate (wearable use) within the study (96% accepted study invitation)
Lucet et al (2012) [48]	Hospital (France)	• Health care staff • Patients	• 111 • 118	Wearable mobile sensor (staff), fixed sensor (patient rooms; RFID)	—	High study participation rate among health care staff (wearable use) within the study (90% of those who accepted study invitation)
Lowery-North et al (2013) [47]	Hospital (United States)	• Health care staff	• 105	Wearable badges (RFID)	—	Initially a high study participation rate among health care staff (84% accepted study invitation). The tag was perceived as annoying and hindering (interference with stethoscopes or staff ID cards)
Ho et al (2020) [45]	Infectious Disease Center (Singapore)	• Health care staff	• 66	Wearable tag (RFID)	—	Initially a high study participation rate, but technical issues and low wearable compliance led to declining participation (use)
Chambers and Anglemyer (2022) [53]	Hospital (New Zealand)	• Health care staff	• 42	Wearable card (Bluetooth)	—	All participants said they would use the wearable again for contact tracing (continuous intention)
Curtis et al (2022) [54]	Hospital (Australia)	• Health care staff	—	Wearable tagBLE[f]	—	Low uptake of wearable tags (use)
Indoors areas in non–health care settings						

Context and source	Location	Target group	N	Contact tracing technology	Theory/ measures	Technology acceptance
Mastrandrea et al (2015) [49]	High school (France)	• Students	327	Wearable sensors (ultralow power radio packets), contact diaries, friendship surveys (both paper-based) and online social links	—	High study participation rate (wearable use) during study (86%); paper-based surveys had low participation
Smieszek et al (2016) [51]	Scientific conference (Germany)	• Conference participants	76	Wearable sensors (RFID), paper-based contact diaries	—	Study participation rate (wearable use) was moderate (of 300 conference attendees, 76 agreed to participate; 100 contact tracing units available); low rate of negative sentiments for wearable contact tracing at conference
Shelby et al (2021) [50]	University (United States)	• Students	• 47	Smartphone app and wearable tag (both Bluetooth)	mHealth[g] usability questionnaire	Higher use of wearable (91%) than app (81%) for contact tracing; higher perceived usefulness of wearable (92% vs 74%); preference for wearable devices provided by organization instead of personal devices

[a]RFID: radio-frequency identification.
[b]TAM: technology acceptance model.
[c]UTAUT: Unified Theory of Acceptance and Use of Technology.
[d]RTLS: real-time locating system.
[e]Not applicable.
[f]BLE: Bluetooth low energy.
[g]mHealth: mobile health.

Measuring Acceptance

Acceptance of sensor technologies for contact tracing has been measured in various ways. Guo et al [52] asked about health care staff's willingness to use the considered DCTS at their workplace and found an initially high willingness (75%). However, participation rates later declined because of several issues and barriers. In most studies, wearable acceptance was determined by people's willingness to use the wearable device throughout the study [45-51,53]. In addition, Chambers and Anglemyer [53] investigated whether participants were willing to use the wearable again. Most studies identified initially high levels of willingness to participate in the contact tracing study and use the DCTS throughout the study (75%-96%). Study participation rates are reported in Table 1. Only Curtis et al [54] reported low uptake of the wearables throughout the study without providing the actual rate of participation.

Predictors of Digital Contact Tracing

Only one study systematically investigated the predictors of health care staff's willingness to use a DCTS [52]. It had been found that willingness to use the system was favored when participants perceived the wearable as useful and easy to use, which refers to the 2 UTAUT predictors of "performance expectancy" and "effort expectancy." Interestingly, privacy concerns for the wearable were not linked to health care staff's willingness to use the DCTS. As part of the reported personal communication with the researchers, the health care staff expressed their concerns about the inconveniences of the wearable used for contact tracing (usability) and their wish for technical support [52], the latter being encompassed within the UTAUT predictor "facilitating conditions."

Furthermore, Chambers and Anglemyer [53] found that individuals in high-risk roles, such as nursing staff, showed especially high interest in participating in the contact tracing study, which could indicate a greater perceived usefulness of contact tracing technology when a high risk of infection spread is present.

Additionally, based on nonsystematically collected feedback from study participants, more issues pertaining to carrying the wearable were identified [45,47]. Issues included difficulties with sensor association and charging the battery [45], battery failures [47], perceptions that the wearables were annoying or obstructive (eg, falling out of pockets or interfering with the user's stethoscope or lanyards for hospital staff IDs [47]), and privacy concerns [51,54], all of which might explain declining wearable adherence.

Finally, Shelby et al [50] identified a preference for Bluetooth technology over GPS or Wi-Fi technology, as well as for wearables provided by the organization instead

of using smartphone apps on personal devices. In terms of perceived usefulness, ease of use, and satisfaction, wearables were preferred over smartphone apps.

Strategies for Improving Acceptance

Notably, we found no study that tested strategies for DCTS implementation. Still, most investigators underlined the importance of using wearables for contact tracing, especially in health care settings, and the importance of further research on implementation strategies. Ho et al [45], for example, emphasized putting more effort into research on the implementation of contact tracing technology among health care staff. Additionally, research should examine barriers to the use of contact tracing technology. Investigators also underlined the importance of involving DCTS stakeholders during the device's development, using a participatory research approach.

Summary of Findings Informing Study 2

The findings of the exploratory literature review contributed to developing a conceptual prototype and user scenario as a basis for further research. Specific results suggested that willingness to use a DCTS may be enhanced when (1) Bluetooth technology is used instead of GPS or Wi-Fi technology; (2) devices or wearables are provided by the workplace [50]; (3) infrastructure to help the system work reliably is installed; (4) a solid operating plan for battery charging and technical maintenance is available [46,50]; (5) the wearable is user-friendly; and (6) technical support is available [52]. Additionally, it may be more likely for health care staff to view the system as useful when they perceive high risks in their work and see contact tracing's potential to reduce that risk [53]. Since the perceived usefulness of contact tracing technology seems relevant to usage [52], benefits and potential should be made salient among health care staff. To ensure this, health care staff should be integrated into the development and introduction of a DCTS [54].

Study 2 Methods (Focus Group Interviews)

Overview

The aim of the second study was to develop a scenario-based prototype for a DCTS for geriatric care facilities. The focus was on integrating nurses' perspectives on DCTS to achieve a participatory approach. Early engagement of end users is important to identify their needs during the design stage [57].

Conceptual Prototype and Usage Scenario

To guide the focus group interviews and facilitate discussion, we developed a preliminary scenario-based prototype for a DCTS, called "ProTrace (preliminary)," and described it at the beginning of each focus group session. To this end, various sources were considered. First, the theoretical framework of the UTAUT guided the tracer's development and proposed implementation in geriatric care facilities. Second, findings from the exploratory literature review led to a preference for Bluetooth technology, and ideas for user-friendly wearables were integrated by taking the needs of nursing staff, residents, and visitors into account. Third, market research aimed to identify existing solutions for digital contact tracing used in (geriatric) care facilities. As a result, a promising DCTS was identified that had been successfully introduced at a Swiss health care facility and served as an additional blueprint for "ProTrace (preliminary)."

Briefly, we designed the conceptual prototype based on the following: informed by the results of the exploratory literature review, the DCTS was meant to run on smartwatches worn by the nursing staff, residents, and visitors, which would be able to track recent encounters with infected individuals. Additionally, nursing staff and visitors could send infection warnings and receive alerts about the potential exposure to an infected person via an accompanying smartphone application. The data would be stored centrally via a computer program in the geriatric care facility. The computer program had to be accessible in every ward and by every nurse. Whenever residents, nursing staff members, or visitors report an infection, each event would need to be indicated within the computer program. The program would then identify the contact chains. Accordingly, actions (eg, isolation) could be initiated.

To introduce this scenario-based prototype to focus group participants, a PowerPoint (Microsoft) presentation and printed handouts were used (see Figure S1 in Multimedia Appendix 1). Following a user-centered approach [57], participants were encouraged to make suggestions to enhance the preliminary scenario-based prototype.

Participants and Setting

For the focus group interviews, nurses working in health care and health care management at 3 (geriatric) care facilities were recruited during the summer of 2022. One of the participating facilities had extensive prior experience using the DCTS that served as the blueprint. In total, 17 nurses from geriatric care facilities participated.

Materials

The interview guide and a short accompanying questionnaire were designed according to the UTAUT model. A similar approach was used in comparable studies [31,32,52]. The questionnaire (see Appendix S2 in Multimedia Appendix 1) addressed each UTAUT predictor in a single question, with each question having a 4-point response scale ranging from "do not agree at all" to "fully agree." Additionally, participants were asked to indicate whether they thought using a DCTS in geriatric care facilities should be voluntary or mandatory. Finally, participants were asked about their experiences using contact tracing technology, such as the national application for contact tracing used during the COVID-19 pandemic, and whether they would feel comfortable using a DCTS.

The interview guide addressed the UTAUT predictors as well but asked more precisely about what would make the system useful. It also asked about the perceived usefulness of the DCTS during a pandemic and any perceived risks

associated with its use. Furthermore, the guide asked for reasons for high effort expectancies, features to increase the perceived ease of use, and why the system seemed easy or difficult to use. Finally, the nurses were asked whether and from whom they perceived social influence concerning the decision to use or not to use the system and which facilitating conditions must be met for them to be able to use it. The interview guide was extended by additional questions asking about nurses' needs for contact tracing technology for themselves, residents, and visitors (eg, wearable preferences).

Procedures

The semistructured focus group interviews were audio-recorded and transcribed using MAXQDA (VERBI Software GmbH) for structured content analysis [58,59]. We used a hybrid deductive-inductive coding strategy: initial main categories were derived from the UTAUT-based interview guide, whereas further categories and subcategories were developed inductively from the material. Two researchers independently coded the transcripts. Discrepancies were resolved through consensus discussions, resulting in a finalized category system and coding matrix (Figure S2 in Multimedia Appendix 1). The category system facilitated a systematic comparison of thematic prevalence across the different focus groups, effectively highlighting shifts in emphasis—such as differing thematic priorities between participants with and without prior contact tracing experience—by contrasting both proportional distributions and absolute segment frequencies. Exemplary quotations are provided in Table S3 in Multimedia Appendix 1. The sample size (n=17) was justified by the high information power [60], as the narrow research aim, the expertise of the nurses, the theoretical focus of the UTAUT framework, and the high dialogue quality collectively ensured sufficient data depth for prototype optimization.

Study 2 Results (Focus Group Interviews)

Group Description

According to their differing levels of experience using contact tracing technologies in health care, the focus group discussions contributed different perspectives on nurses' wearable preferences and acceptance.

Group 1 (n=5, 4 female and 1 male) had no prior experience with digital contact tracing and, compared to the other groups, made the most skeptical assumptions about using a DCTS, such as "ProTrace (preliminary)." Nevertheless, they provided several suggestions for improvement and successful implementation to achieve increased acceptance. Group 2 (n=6, all female) consisted of experienced nurses who had already used a DCTS during the COVID-19 pandemic; this system served as a blueprint for "ProTrace (preliminary)." Based on their experiences, they were able to provide valuable information regarding the unforeseen challenges of using a DCTS. Focus group participants from the third geriatric care facility (Group 3, n=6, all female) had no previous experience with contact tracing at work. This group was curious about the system and saw the potential of using a system like "ProTrace (preliminary)." They also offered suggestions for adapting the system and altering the wearable devices to achieve increased usability and acceptance.

Results of the Accompanying Questionnaire

Across the 3 groups (17 participants), most (n=14) found "ProTrace (preliminary)" to be (somewhat) useful and (somewhat) easy to use, and almost all (n=16) stated they would somewhat agree to use the system if it were introduced at their workplace. Most participants somewhat agreed that they felt confident using a DCTS, although almost 60% did not have the COVID-19 contact tracing app installed on their phones. Concerning "ProTrace (preliminary)," almost all participants (n=16) indicated that they had the resources and knowledge to use it. Thirteen felt that their workplace would appreciate the use of "ProTrace (preliminary)."

Results of Focus Group Discussions

Applying qualitative analysis to the transcribed focus group interviews yielded 6 main categories and several subcategories to structure the results (see Figure S2 and Table S3 in Multimedia Appendix 1). All groups provided suggestions to improve and develop the DCTS during the interviews and across all categories.

Findings per category are detailed below. Because the groups had differing levels of experience and overall attitudes toward the presented usage scenario of the system "ProTrace (preliminary)," the results are summarized by group.

Main Category 1: Performance Expectancy and Conditional Usefulness

For the first main category, "Performance expectancy," the themes "Meaningfulness," "Influence on work processes," "Usefulness for each stakeholder," and "Anxiety and data safety" were detected during coding and transferred into subcategories to structure the results. Because all participants discussed performance expectancy in a pandemic scenario, an additional category addressed "Conditional usefulness," which pertained to the perceived usefulness in instances when protective resources, such as vaccines and rapid tests, were sufficiently available, or in cases of a severe threat from an infectious disease when no other protective resources were yet available.

Participants in focus group 1 viewed the system as useful but raised concerns about implementation effort, costs, and the suitability of smartwatches for health care staff. Some considered testing sufficient under moderate conditions but saw greater potential for contact tracing during a severe pandemic.

Experienced participants (focus group 2) emphasized the value of the system for informed action under uncertainty and reported greater willingness to use it when testing capacity was low and vaccines were unavailable. Additional information reduced initial concerns about data protection and monitoring. One participant preferred not to use an accompanying app on a private device.

Participants in focus group 3 similarly saw potential, particularly when other protective measures were scarce and health authorities were overburdened. They noted potential time savings and improved documentation.

Main Category 2: Effort Expectancy

For "Effort expectancy," the subcategories of "Introduction of the system" and "Handling the system" were perceived as effortful by the groups.

Introducing the system to residents and informing relatives and visitors were considered particularly effortful during the initial implementation phase. Participants suggested providing information to all relevant visitor groups from the outset to reduce repeated explanations, misunderstandings, and frustration. They also noted that the perceived benefit of being better prepared for a pandemic could offset this effort.

Participants identified potential effort in managing the computer program, reconstructing contact chains, and charging wrist-worn devices. They emphasized user-friendly software and opposed requiring a smartphone app on private devices.

Main Category 3: Social Influence

For social influence, "Management," "Colleagues," and people from the "Private sector" were identified as subcategories. Additionally, the preference for voluntary or mandatory usage was subcategorized under "Voluntariness."

Management was perceived as the strongest influence. Participants expected greater acceptance when management supported and explained the system and involved staff in implementation, but some feared being forced to use it.

The influence of colleagues was addressed by only a few nurses in the inexperienced groups. They stated that colleagues needed to work together and adopt the system as a group for it to have an impact.

Participants generally expected limited influence from private contacts, although concerns about data security and monitoring were mentioned. Most inexperienced participants doubted that the system would work effectively if its use were voluntary, whereas others expressed concerns about mandatory use. The experienced group reported that contact tracing had been mandatory during the pandemic and that visitors had generally accepted the requirement.

Main Category 4: Facilitating Conditions

For facilitating conditions, the subcategories formed were "Technical infrastructure," "Organizational prerequisites," and "Necessary resources and knowledge."

The inexperienced groups emphasized the need for sufficient Wi-Fi connectivity and compatibility between the computer program and the existing digital infrastructure. Some participants added the need for clear information from the organization about the system and data protection, while one highlighted the need for (technical) support.

Group 2 emphasized the need to receive a thorough briefing from the organization. In terms of organizational prerequisites, the experienced group explained that it was helpful to clearly assign responsibilities (eg, designating who informs relatives about the residence's policies in cases of an infection).

Main Category 5: Choice of Wearable

Among the most discussed topics across all focus groups were the types and characteristics of the wearables for the nurses, residents, and visitors, as well as the ability to choose among different types of wearables to match diverse needs and preferences. This topic was summarized under the category "Choice of wearable."

Although Group 2 reported good acceptance of smartwatches among nurses, both inexperienced groups agreed that smartwatches were unsuitable as contact tracing devices for nurses for safety and hygiene reasons. Instead, they suggested a clip for a breast or trouser pocket. For residents, both the experienced and inexperienced groups agreed that wearables needed to accommodate health conditions such as dementia or parchment skin, which require different types of wearables. They suggested sensors in slippers, (pain) patches with a sensor to adhere to the resident's back, or tags to wear on clothing. For wrist-worn wearables, it could be beneficial to let residents choose from different colors for fashion and aesthetic reasons.

For visitors, all groups agreed that smartwatches or wrist-worn sensors were appropriate and only need to be robust and easy to disinfect.

Summary of Findings Informing Study 3

From a theoretical perspective, Study 2 identified 3 context-specific constructs that appeared relevant to technology acceptance in geriatric care facilities. Therefore, we propose "Usefulness under threatening conditions" and "Usefulness for additional protection" (representing conditional usefulness) as meaningful theoretical extensions that integrate elements of protection motivation theory (PMT) [61] and the health belief model (HBM) [62]. This extension argues that in health care, the intention to use contact tracing technology is related to "threat appraisal," which encompasses the perceived severity of a pandemic and the perceived vulnerability of residents. This advances acceptance theory by explaining why the same technology may be rejected during routine operations but highly accepted during periods of acute threat.

Additionally, we extend the model by introducing "Choice of wearable." Unlike "Facilitating conditions" [30], which typically describe external resources such as infrastructure, "Choice of wearable" can address the internal psychological need for autonomy, as proposed by self-determination theory [63], for nursing staff and residents.

Two main hypotheses focus on the predictive power of the standard UTAUT model to explain the intention to use "ProTrace" for digital contact tracing and the conditions for

extending the standard UTAUT model with context-specific predictors:

Hypothesis 1: the variables included in the UTAUT are practically meaningful and significant predictors of nursing staff's intention to use a wearable system for digital contact tracing in geriatric care facilities. We hypothesized that the standard model would explain at least 20% of the variance.

Hypothesis 2: extending the UTAUT through additional context-specific predictors would explain significantly more of the variance (≥5%) in the intention to use a wearable system for digital contact tracing in geriatric care facilities than either the original UTAUT or the additional context-specific predictors by themselves.

Further specific hypotheses 3-9 focus on the contributions of individual predictors to the intention to use and are listed in Table S4 in Multimedia Appendix 1.

Regarding the scenario-based prototype, the following changes were made to obtain the final "ProTrace" prototype: the offering of a broader variety of wearable devices while excluding smartwatches or any other wrist-worn sensors for nursing staff; the integration of a computer program to provide easy access to encounter data for authorized nursing staff; and the clarification of the alert concept in the event of an encounter with an infectious person.

Study 3 Methods (Survey Study)

Overview

The aim of the third study was to gain knowledge about predictors associated with nursing staff's acceptance of wearable DCTS in geriatric care facilities by using the refined scenario-based prototype "ProTrace."

To empirically validate the qualitative findings from Study 2, the third study presented a quantitative questionnaire-based study that incorporated the newly identified constructs as variables in an expanded UTAUT model.

Materials

The revised usage scenario, "ProTrace," served as the basis for producing an explanatory video that represented a "best-case scenario" for identifying contact persons in geriatric care facilities. Screenshots of the video, as well as the translated English script, are included in Figure S3 and Appendix S3 in Multimedia Appendix 1.

The usage scenario functioned as a "best-case scenario" to illustrate what a wearable DCTS could look like and how it would function in geriatric care facilities. Briefly, "ProTrace" was characterized by the following features and background variables:

- It considered all stakeholders at a geriatric care facility and could trace contacts among individuals wearing the DCTS using Bluetooth technology.
- To accommodate individual needs and preferences, the nursing staff, residents, and visitors received different wearable DCTS devices. Nursing staff could use a clip-on wearable, whereas visitors would be loaned a smartwatch for the time they spend at the geriatric care facility, and residents could wear either a smartwatch, a sensor within their shoes, or a wristband.
- All encounters are saved in a computer program. When an infection was detected, the program sent an alert identifying the infection chain to quickly inform everyone involved in it.

Characteristics of the updated "ProTrace" system are summarized in Table 2.

Table 2. Features and design of ProTrace.

Opportunity to choose a wearable	Nursing staff	Residents	Visitors
Choice of wearable	• Yes	• Yes	• No
Technology contact identification	• Bluetooth	• Bluetooth	• Bluetooth
Technology data synthesis	• Wi-Fi	• Wi-Fi	• Wi-Fi
Wearable options	• Clip attached to clothing	• Smartwatch • Necklace • Clip attached to clothing • Sensor built-in slippers	• Smartwatch/wrist-worn sensor
Reporting activity in case of infection	• Required	• Not required, nurse can substitute	• Required
System options to report infection	• Telephone call (if not present in care home) • Text message	• Communication by nursing staff	• Telephone call • Text message
Choice of alert in case of exposure	• Yes	• No	• Yes
Alert options	• Telephone call (if not present in care home) • Text message • App notification	• Verbal communication and further actions by nursing staff	• Telephone call • Text message • App notification
Access to contact chains via the administration program	• Yes	• No	• No

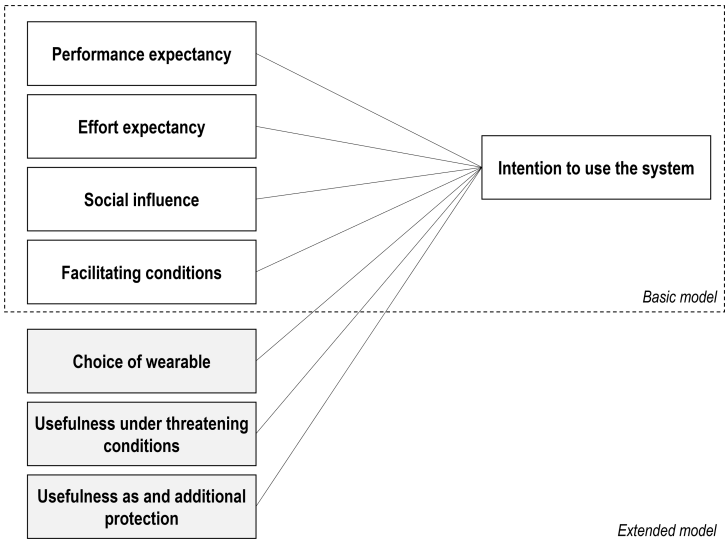
All the above-listed information was presented to survey participants prior to the survey in a 9-minute explanatory video to ensure that all participants had a shared understanding.

Regarding the background variables, the scenario presented in the video assumed the sudden appearance of a new airborne virus, with no vaccine available and limited or no capacity for rapid testing. As in the early stages of the COVID-19 pandemic, laboratory testing taking hours or days was assumed to be necessary. Finally, to ensure participants watched the explanatory video carefully and with the supporting audio, the survey started with a short video for a visual and audio check. After watching it, participants were asked what type of landscape they saw and which name of an animal they heard and were asked to select the correct answer from 2 multiple-choice questions. Only when both questions had been answered correctly could participants proceed to the explanatory video. The video needed to be watched completely to be able to proceed with the survey questions.

Since wearable DCTS are not yet used routinely in German geriatric care facilities, participants in this survey were considered to be in a preadoption stage. Therefore, they evaluated "ProTrace" based on their expectations and impressions rather than on actual experience. The survey aimed to assess technology acceptance by examining nursing staff's intention to use the proposed DCTS if it were introduced at their workplace.

The items published by Venkatesh et al [30] were adapted to the present context and served as a measurement for the standard UTAUT model. For the extended model, new items were developed to measure "Choice of wearable," "Usefulness under threatening conditions," and "Usefulness for additional protection" (Figure 2). All predictors were measured on a 4-point scale with the following response options: do not agree at all (1), partially disagree (2), partially agree (3), and fully agree (4). For the predictor "Effort expectancy," higher scores indicated increased perceived ease of use. The survey was delivered via the survey platform LimeSurvey (LimeSurvey GmbH). Table S4 in Multimedia Appendix 1 lists all the variables considered and provides an example of each item.

Figure 2. Standard and extended Unified Theory of Acceptance and Use of Technology (UTAUT) model.



Sample Size Calculation

An a priori sample size calculation using the software G*Power (Heinrich Heine University Düsseldorf) resulted in a required sample size of 292 participants to permit multiple regression analyses (see OSF registration). The calculation was based on the following assumptions:

- The standard UTAUT model should explain at least 20% of the variance in nursing staff's usage intention, while the extended model should incrementally explain at least 5% of the variance to demonstrate a meaningful effect.
- At the level of single predictors, the family-wise error rate should be kept at the P=.05 level using the Bonferroni method to adjust for multiple comparisons.
- Four specific predictors for the standard model and 2 additional predictors for the extended model were considered. Eleven moderating effects were included in the model at an exploratory level. If the additional model failed to show a meaningful incremental effect, the additional single predictors would be interpreted for exploratory level only.
- Statistical power was set at 80%, and overrecruiting was allowed to increase power.

Deviation From Registration

Reliability analyses indicated that the items for conditional usefulness did not measure a homogeneous factor, but rather 2 background conditions that affect the perception of usefulness. Therefore, 2 predictors were considered. First, "usefulness under threatening conditions" refers to perceived usefulness in the context of a highly contagious and life-threatening infectious disease for which no other protective

options are available. Second, "usefulness for additional protection" measures perceived usefulness even in situations where rapid test capacities are high and vaccines are available.

Participant Recruitment and Inclusion Criteria

Participants were recruited via 3 online panels and were included if they had worked in geriatric or other care facilities, such as hospitals or medical day care centers, over the last 12 months and were aged between 18 and 67 years.

Statistical Analysis

First, reliability analyses were conducted for all scales measuring the predictors. Second, the respective means were calculated. Third, univariate Pearson correlation coefficients between predictors were determined. Fourth, for the main analyses, multiple linear regression analyses were performed to investigate the explanatory power of the standard UTAUT model relative to the extended model. The Bonferroni-Holm (BH) method [64] was used to control for the family-wise error rate.

Study 3 Results (Survey Study)

Participants

In total, 8176 people were informed about the survey by the panel providers, and 1697 started the survey. The majority had to be excluded because they did not work or had no practical experience in the health care sector, were already retired, showed implausible response times, did not complete the survey, or were unable to correctly answer the audio and visual check questions to demonstrate that they had adequately watched the video material.

Most of the final sample (n=329) were female and worked either in older adult care or hospitals. Almost half reported prior use of the national tracing app, but most indicated that they were familiar with digital tracing via mobile apps (Table 3).

Table 3. Sample characteristics.

Characteristics	Variables, n (%)
Sex	
Female	221 (67)
Male	108 (33)
Age (years), mean (SD)	44 (12.50)
Area of work	
Older adult care	150 (46)
Hospital	110 (33)
Care facility for impaired people	22 (7)
Rehabilitation center	8 (2.5)
Hospice	8 (2.5)
Assisted living	8 (2)
Doctor's office	2 (1)
Others	21 (6)
Digital tracing experience	
Feeling (rather) familiar with app-based contact tracing	237 (72)
Experience with "Corona Warn App" (German national app for COVID-19 contact tracing)	158 (48)
Downloaded the "Corona Warn App," but did not use it	61 (19)
No "Corona Warn App" installation	110 (33)
(Rather) agree that everyone should use the DCTS[a] "ProTrace" when implemented	277 (84)
(Rather) agree with voluntary usage of the DCTS "ProTace"	197 (60)

[a]DCTS: digital contact tracing system.

Descriptives, Reliability, and Correlation Analysis

Cronbach α ranged from 0.71 for facilitating conditions to 0.93 for performance expectancy (Table S5 in Multimedia Appendix 1), indicating sufficient reliability for the subsequent analyses [65].

Regarding the predictors in the basic model, the sample demonstrated, on average, a somewhat high level of intention to use the presented wearable DCTS "ProTrace," as indicated by a mean of 3.00 (SD 0.78) on a scale ranging from 1 to 4 (Table S5 in Multimedia Appendix 1). Likewise, performance expectancy was relatively high (mean 3.17, SD 0.70). For example, 87% of the participants partially or fully agreed that using a DCTS would help to speed up the process of taking protective actions against a highly contagious virus. The system was perceived as rather easy to use (mean 3.37, SD 0.53). In terms of social influence, most survey participants felt that co-workers, leaders, and important others would (rather) support them in using the system (mean 3.12, SD 0.74). Concerning facilitating conditions for system usage,

most were (rather) confident that the necessary infrastructure, knowledge, and support to use the DCTS would be available (mean 3.28, SD 0.58).

For the extended UTAUT model, usefulness under threatening conditions was rated high on average (mean 3.36, SD 0.73), indicating that, especially in times when no other protective options, such as vaccines or tests, were available, the presented DCTS was perceived as advantageous. Nevertheless, a somewhat high rating for additional protection (mean 3.03, SD 0.86) indicates that the proposed digital tracing system might enhance overall protection. For example, 74% found using the system (rather) meaningful, even if there were a sufficient number of rapid tests and vaccinations.

Participants had mixed opinions regarding the choice of wearable (mean 2.42, SD 0.86), indicating diverse preferences both for and against offering various wearables from which to choose. Nevertheless, 88% of the participants partially or fully agreed that all users should decide which kind of wearable (eg, clip-on and smartwatch) they wear.

All predictors were significantly correlated with nursing staff members' intention to use a wearable DCTS, with correlation coefficients ranging from r=0.13 for having the freedom of choice for wearables to r=0.64 for performance expectancy. Notably, apart from the predictor on choice of wearable, all the predictors correlated with intention (r>0.40). Of these, performance expectancy, usefulness under threatening conditions, and social influence were the most strongly correlated. Factor-analytical findings provide preliminary evidence that usefulness under threatening conditions and choice of wearable represented empirically distinguishable constructs within the extended UTAUT framework.

First Hypothesis: The Standard UTAUT Model

Results from the multiple linear regression analysis indicate that the standard UTAUT model significantly explained 44.6% of the variance in nursing staff's intention to use a wearable DCTS (R^2=0.446; $F_{4,324}$=66.954; P<.001; BH-corrected P=<.001), thus confirming hypothesis 1.

Second Hypothesis: The Extended UTAUT Model

Regression analysis demonstrated that the extended model explained 51.6% of the variance in the intention to use (R^2=0.516; $F_{7,321}$=50.973; P<.001; BH-corrected P=.001×6=.006). This marked a significant increase in explained variance of 7% (ΔR^2=0.074; $\Delta F_{3,321}$=16.699; P<.001). The results confirmed hypothesis 2.

Specific Hypotheses: The Impact of Single Predictors

The impact of all single predictors, while simultaneously considering all others, was tested by analyzing their Bonferroni-corrected P values within the extended UTAUT model.

Regarding the single predictors specified by the standard UTAUT, performance expectancy (β=0.291; P<.001; BH-corrected P=.001×5=.005) was the only significant predictor, according to the BH method. Among the additional context-specific predictors, choice of wearable (β=0.174; P<.001; BH-corrected P<.001×8<.001) and usefulness under threatening conditions (β=0.251; P<.001; BH-corrected P=.000×7<.001) were significantly associated with the intention to use the system.

No other predictor was significantly associated with the intention to use the DCTS after applying the BH method. The results of the multiple regression analysis are summarized in Table 4.

Table 4. Results of multiple linear regression analysis.

Predictor	Standardized coefficient β	Unstandardized coefficient B	F test	t test	Determination coefficient R^2	Change in R^2 ΔR^2	P value	Bonferroni-Holm correction[a] P=.05
Step 1: standard UTAUT[b] model			66.954 (4, 324)		0.446	0.446	<.001	×5<.001[c]
Performance expectancy	0.370	0.415		4.838 (324)			<.001	
Effort expectancy	0.032	0.048		0.576 (324)			.57	
Social influence	0.230	0.244		2.805 (324)			.005	
Facilitating conditions	0.117	0.158		1.958 (324)			.05	
Step 2: extended UTAUT model			50.973 (7, 321)		0.516	0.070	<.001	×8<.001[c]
Performance expectancy	0.291	0.259		3.439 (321)			.001	×5=.005[d]

Predictor	Standardized coefficient β	Unstandardized coefficient B	*F* test	*t* test	Determination coefficient R^2	Change in R^2 ΔR^2	*P* value	Bonferroni-Holm correction[a] *P*=.05
Effort expectancy	0.051	0.034		0.651 (321)			.52	×1=.52
Social influence	0.100	0.094		1.152 (321)			.25	×2=.50
Facilitating conditions	0.114	0.084		1.497 (321)			.14	×3=.42
Choice of wearable	0.174	0.191		4.944 (321)			<.001	×7<.001[c]
Usefulness threatening conditions	0.251	0.235		3.586 (321)			<.001	×6<.001[c]
Usefulness additional protection	0.117	0.129		2.269 (321)			.02	×4=.08

[a]Bonferroni-Holm correction ("×" indicating multiplication of *P* value).
[b]UTAUT: Unified Theory of Acceptance and Use of Technology.
[c]*P*<.001.
[d]*P*<.01.

Discussion

Overview

The present research aimed to develop and evaluate a conceptual DCTS for use in geriatric care facilities and to investigate nursing staff's acceptance of such a system. Nursing staff are key stakeholders in the successful implementation of new technologies in care settings. Although previous studies have identified initial challenges and user preferences related to DCTS, knowledge about nursing staff's acceptance remains limited.

To address this gap, the scenario-based prototype "ProTrace" for digital contact tracing in geriatric care facilities was developed and refined through focus group interviews with nursing staff. Based on the results, a survey study was conducted to examine nursing staff's intention to use a DCTS in their workplace.

Principal Findings

Our exploratory literature review revealed a substantial lack of research on nursing staff's acceptance of DCTS. Only one study was identified that focused on medical staff's willingness to use wearables for contact tracing.

Our findings demonstrate that the scenario-based prototype "ProTrace," developed and refined in the focus group interviews performed in Study 2, was generally favorably evaluated—specifically under high-threat pandemic preparedness conditions—by the nursing staff participating in the survey performed in Study 3.

A key theoretical contribution is the extension of the UTAUT model, which was significantly superior (ΔR^2=0.074) to the standard model in explaining usage intention. This extension was directly informed by the qualitative insights from Study 2, which identified context-specific predictors—choice of wearable and usefulness under threatening conditions—that were subsequently tested and empirically evaluated in Study 3.

Comparison With Prior Work

Our findings concerning relevant predictors of nursing staff's technology acceptance are in line with, as well as further inform, previous research findings. Similar to the results of Guo et al [52], participants were more willing to use a DCTS when they perceived it as beneficial. This aligns with broader meta-analytic evidence showing that performance expectancy is a dominant factor for technology acceptance in general [39] and health care technology specifically [26]. The perceived benefits for residents' safety and work efficiency found in our studies echo research on electronic patient records and patient portals [31,34]. In contrast, effort expectancy had a comparatively smaller impact on usage intention. This is consistent with the findings of Chong et al [26], who reported that ease of use is often less important for health care professionals than for patients.

However, the sequential mixed methods design provides a more nuanced picture. Although participants in the focus groups emphasized the need for a user-friendly system, the quantitative results indicate that in the preadoption phase, perceived usefulness has a stronger influence on acceptance than ease of use. This is in line with the findings of Blut et al [39], who showed that the influence of UTAUT predictors varies across stages of technology adoption.

The significance of usefulness under threatening conditions highlights the importance of context-specific variables, as advocated by Venkatesh et al [38]. The issue of threatening conditions seems to capture similar aspects as research on the effects of risk perception and health behavior [66]. The next step toward a deeper understanding of threatening conditions could be to consider the perceived severity of the infection, the nurses' individual risks, their patients' risks, and their respective likelihoods of becoming infected [67].

In terms of the sample's wearable preferences in Study 2, their rejection of personal smartphones for use in contact tracing and their preference for specific wearable devices are consistent with the findings of Shelby et al [50]. Furthermore, Guo et al [52] previously reported that nursing staff found certain wearables, such as tags attached to ID cards, inconvenient or distracting. Our research took this a step further: by identifying choice of wearable as a qualitative theme in Study 2 and validating it as a quantitative predictor in Study 3, we empirically confirmed that individual autonomy in device selection (the need for autonomy, as described by self-determination theory [63]) is a vital, yet often overlooked, factor in DCTS acceptance.

Furthermore, our study's perspective on the preadoption phase of a scenario-based prototype aligns with and extends recent research on technology-enabled contact tracing in long-term care settings. Within the National Institute for Health and Care Research (NIHR) CONTACT study, Thompson et al [68] were the first to use a theory-informed, mixed methods feasibility design to evaluate a DCTS for use within care homes. While their study focused on real-world feasibility and operational challenges during a live trial, the present study captures the psychological and structural antecedents to adoption before system introduction and in consideration of a high-threat framing. Interestingly, both lines of research converge on the insight that individual acceptance cannot be isolated from organizational realities: The NIHR CONTACT study highlighted that operational success is highly contingent on workflow integration and staff engagement [68]—a finding that mirrors our qualitative insights regarding management influence and the necessity of giving staff an autonomous choice of wearable to benefit technology acceptance.

Importantly, the empirical results of the present study address the core limitations identified by Thompson et al [68]. In their trial, the authors concluded that a definitive DCTS trial was not feasible, largely due to high participation burden, device loss, and technical wearability issues (eg, battery failures). They explicitly called for future research to co-design interventions with homes and focus heavily on wearability. The present study partly addresses this call, focusing on conceptual co-design alongside geriatric care facility nurses and investigating wearability options prior to implementation. Still, as the present study does not extend beyond the phase of preadoption, it does not evaluate real-world deployment, staff adherence, data completeness, or long-term technical reliability. Operational challenges, such as device loss or workflow burden, as observed in the NIHR CONTACT study, may therefore still emerge when transitioning from this conceptual stage to actual deployment.

Strengths and Limitations

Regarding the overall strengths of the present study, the sequential mixed method design of the research ensured practical relevance in conceptualizing the prototype and usage scenario of "ProTrace" (for a joint display of all studies, see Table S6 in Multimedia Appendix 1). From an exploratory literature review, a research-informed prototype of a wearable DCTS was developed. It was then refined using feedback and suggestions from nursing staff who participated in semi-structured focus group interviews. Study 2 served as more than just a preliminary exploration—it acted as the theoretical foundation for the quantitative extension of the UTAUT model. For instance, the surprising preference for mandatory use expressed in the focus groups—despite the human need for autonomy [63]—informed our understanding of why collective effectiveness and threat appraisal might override individual preference during a pandemic. This qualitative-to-quantitative transition ensured that the survey in Study 3 was not just a generic application of technology models but was tailored to the lived reality of nursing staff.

Blut et al [39] emphasized the importance of considering the standard set of predictors provided by the UTAUT model [30] when research on extending the UTAUT is performed. Therefore, to ensure a solid methodological approach and comparability to future research on nursing staff technology acceptance, the survey investigating the predictors associated with nursing staff's intention to use a wearable DCTS was developed accordingly. In keeping with the principle of parsimony [40], the context-specific predictors retrieved from the focus group interviews were part of an extended UTAUT model that was tested against the standard UTAUT model to identify any practically relevant increase in explained variance.

A limitation of this study is the hypothetical nature of the evaluation. Participants assessed the DCTS based on an illustrative video of a scenario-based prototype, assuming the hypothetical conditions of a virus outbreak characterized by high health risks, the absence of vaccines, and limited rapid-testing options. While this high-threat framing was chosen to assess acceptability under acute crisis conditions, the observed acceptance levels and predictor relationships reflect a pandemic preparedness scenario rather than a neutral, day-to-day routine deployment. Consequently, caution is warranted when generalizing these findings to nonemergency health care settings or routine digital workplace tools.

While focusing on the preadoption phase allowed us to gather early insights into design requirements to foster usage intention, it is critical to acknowledge the "intention-behavior gap." As outlined in various theories of behavioral change, such as the theory of planned behavior [56], intention is a vital antecedent but does not equate to actual adoption. Without longitudinal and experimental evidence, our findings regarding intention should not be interpreted as a definitive prediction of future behavior or system implementation success.

Furthermore, the design of our DCTS scenario requires careful ethical contextualization. In this research, the scenario evaluated in Study 3 was directly shaped by the qualitative focus groups in Study 2, where the majority of nurses explicitly advocated for facility-wide, mandatory deployment to ensure the system's technical effectiveness. Because of this user-informed choice, the survey in Study 3 framed the usage scenario as mandatory by default. Consequently,

we did not explicitly investigate how individual privacy concerns or voluntary choices might lead to the nonacceptance or rejection of the DCTS. While our study shows that a mandatory setup is accepted when designed alongside staff, it does not erase the ethical tensions surrounding autonomy, privacy, and employment relations. We cannot deeply analyze these underlying psychological boundaries based on our data, because they were outside the scope of our scenario. Future research may explicitly investigate the complex cost-benefit trade-offs of mandatory contact tracing.

Another limitation of our work is the exclusive focus on nurses and nursing staff: residents of geriatric care facilities and their relatives were not included in this study. As emphasized by Veras et al [69], ethics and equity challenges—such as dignity, inclusion, and unequal burden—are frequently overlooked in research regarding technology implementation for older adults. To ensure truly equitable care, future studies should survey and interview residents and relatives equally to understand their acceptance of digital contact tracing.

A further limitation concerns the measurement validity of the newly constructed scales and the respective items for the additional UTAUT predictors (choice of wearable and usefulness under threatening conditions). As these items were specifically developed for the context of DCTS in geriatric care, they have not yet undergone full psychometric validation in independent samples. This may limit the robustness of the construct interpretation. However, as noted in recent literature within implementation science [70], considering new items is a necessary step to advance theory beyond standard models. Future research should focus on the formal validation of these scales to ensure their reliability across different health care settings.

Additionally, even though we targeted nursing staff in geriatric care to participate in the study, the sample ended up being somewhat heterogeneous. In Germany, nursing staff work in hospitals, (geriatric) care facilities, day care centers, doctors' offices, and elsewhere. We, therefore, gathered several perspectives on the topic from nursing staff who were not working within geriatric care facilities. It is possible that nursing staff with no experience working within geriatric care facilities might differ in how they perceive the setting: for example, in terms of the residents' needs. Therefore, as less than half of the surveyed nursing staff were actively working in geriatric care facilities, the findings must be interpreted with caution regarding their generalizability to the broader geriatric care sector. Finally, because we used an online panel for recruitment, the sample may be biased toward individuals with higher digital literacy than the broader long-term care workforce. Consequently, the absolute levels of technology acceptance observed in our study should be interpreted with caution, as these findings may not directly generalize to all nursing staff.

Implications

First, longitudinal studies in geriatric care facilities launching a wearable DCTS could examine whether potential predictors of intention translate into sustained usage acceptance [42].

Second, interventional studies should investigate acceptance-facilitating interventions for initial and continued use [71-73].

Third, as the relative importance of predictors explaining technology acceptance may change in concert with additional variables, we encourage further studies based on existing theoretical models and measures to facilitate robust cross-study comparisons. Therefore, future studies should combine technology acceptance models with implementation science frameworks such as the Consolidated Framework for Implementation Research (CFIR) [74] or the Nonadoption, Abandonment, Scale-up, Spread, and Sustainability (NASSS) [75] to capture organizational and sociotechnical factors such as management influence and workflow integration.

Fourth, the new short scales should be refined and formally validated, including assessment of factorial, concurrent, and discriminant validity [76]. In particular, usefulness under threatening conditions should be compared with established constructs such as risk perception [61], altruistic motivation to protect vulnerable groups [77], affective responses such as threat appraisal and perceived severity [78], and professional responsibility [79].

Fifth, the prominent role of management in the focus groups suggests that implementation research should also examine management acceptance and communication. Practical implementation should emphasize the benefits of DCTS, accommodate individual wearable preferences, and communicate the increased risk posed by highly contagious diseases in geriatric care facilities. For example, the acceptance of a wearable DCTS may be greater when nursing staff:

- Are convinced of the benefits of the wearable contact tracing device;
- Recognize the potential for residents and themselves to use wearables tailored to their individual needs; and
- Anticipate an increased health risk posed by a highly contagious disease, especially for residents within a geriatric care facility.

Emphasizing benefits may foster usage intention, especially when disease threat is high and alternative protective measures are limited.

Facilities could also allow staff, residents, and visitors to trial different wearable devices and practice using the system during periods of low threat. "ProTrace" may serve as a guide for developers, intervention, and implementation studies [72,80-82].

Finally, to transition from theoretical acceptance to successful real-world deployment, any future implementation of a DCTS in any long-term care setting should account for the concrete operational barriers identified by Thompson et al [68]. Their live deployment study serves as a critical

blueprint, demonstrating that technical effectiveness alone does not guarantee sustainable usage.

Conclusions

To prepare for future infectious disease outbreaks, effective preventive strategies are needed. In this sequential mixed methods study, a scenario-based prototype DCTS, "ProTrace," was developed from the literature, refined through focus groups, and evaluated in a survey. Nursing staff generally approved the prototype, and intention to use it was associated with performance expectancy, usefulness under threatening conditions, and choice of wearable. These findings extend knowledge on DCTS acceptance and provide design and implementation considerations for future systems. However, because the evaluation was hypothetical and preadoption, future research has to determine whether these acceptance patterns translate into routine use and successful implementation.

Generative AI Use

We used generative artificial intelligence tools (ChatGPT [OpenAI] and Gemini Pro [Google]) in a limited capacity to assist with grammar, stylistic refinement, and clarity of manuscript text. We did not use artificial intelligence tools to design this study, collect data, analyze data, interpret findings, or create original research content. All substantive content was drafted, critically reviewed, and verified by the authors, who take full responsibility for the integrity and accuracy of this paper.

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Data Availability

The datasets generated or analyzed during this study are available from the corresponding author upon reasonable request.

Authors' Contributions

LK, NU, BF, PD, and DL conceptualized the study, LK and NU established the methodology and performed the data curation; LK conducted the formal analysis and interpretation of the data, wrote the first draft of the manuscript, and critically reviewed and edited the manuscript. DL supervised the entire process of intervention development and evaluation and critically reviewed and edited the manuscript. BF, PD, and DL engaged in the funding acquisition.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Additional background information and complete results for all 3 studies reported in this paper.
[DOCX File (Microsoft Word File), 1068 KB-Multimedia Appendix 1]

Checklist 1

PRISMA-ScR checklist.
[DOCX File (Microsoft Word File), 87 KB-Checklist 1]

References

1. Van Hout MC, Wells JSG. The right to health, public health and COVID-19: a discourse on the importance of the enforcement of humanitarian and human rights law in conflict settings for the future management of zoonotic pandemic diseases. Public Health. Mar 2021;192:3-7. [doi: 10.1016/j.puhe.2021.01.001] [Medline: 33601306]
2. Carlson CJ, Farrell MJ, Grange Z, et al. The future of zoonotic risk prediction. Philos Trans R Soc Lond B Biol Sci. Nov 8, 2021;376(1837):20200358. [doi: 10.1098/rstb.2020.0358] [Medline: 34538140]
3. Jaquis WP, Schneider SM, Panelists from Preparing for the Next Pandemic Summits. Preparing for the next pandemic. Ann Emerg Med. Aug 2021;78(2):212-219. [doi: 10.1016/j.annemergmed.2021.03.010] [Medline: 33933301]
4. The continuum of pandemic phases – 508. Centers for disease control and prevention. 2016. URL: https://archive.cdc.gov/www_cdc_gov/flu/pandemic-resources/planning-preparedness/global-planning-508.html [Accessed 2026-11-01]
5. Williamson EJ, Walker AJ, Bhaskaran K, et al. Factors associated with COVID-19-related death using OpenSAFELY. Nature. Aug 2020;584(7821):430-436. [doi: 10.1038/s41586-020-2521-4] [Medline: 32640463]
6. Aalto UL, Pitkälä KH, Andersen-Ranberg K, et al. COVID-19 pandemic and mortality in nursing homes across USA and Europe up to October 2021. Eur Geriatr Med. Jun 2022;13(3):705-709. [doi: 10.1007/s41999-022-00637-1] [Medline: 35299261]
7. Yonas M, Tabbach A, Gandal N, Pauzner A, Feldman M. Long-term care facilities as a risk factor in death from COVID-19. VoxEU. 2020. URL: https://cepr.org/voxeu/columns/long-term-care-facilities-risk-factor-death-covid-19 [Accessed 2026-11-02]

8. Rothgang H, Müller R, BARMER Pflegereport 2022: stationäre Versorgung und COVID-19. Schriftenreihe zur gesundheitsanalyse. Vol 38. BARMER; 2022. URL: https://www.barmer.de/resource/blob/1142760/9ec71d5ae2f750239f74532a33d14490/barmer-pflegereport-2022-bifg-data.pdf [Accessed 2026-11-12]
9. Henssler J, Stock F, van Bohemen J, Walter H, Heinz A, Brandt L. Mental health effects of infection containment strategies: quarantine and isolation-a systematic review and meta-analysis. Eur Arch Psychiatry Clin Neurosci. Mar 2021;271(2):223-234. [doi: 10.1007/s00406-020-01196-x] [Medline: 33025099]
10. Ferretti L, Wymant C, Kendall M, et al. Quantifying SARS-CoV-2 transmission suggests epidemic control with digital contact tracing. Science. May 8, 2020;368(6491):eabb6936. [doi: 10.1126/science.abb6936] [Medline: 32234805]
11. Biala TA, Afolabi YO, Khaliq AQM. How efficient is contact tracing in mitigating the spread of COVID-19? A mathematical modeling approach. Appl Math Model. Mar 2022;103:714-730. [doi: 10.1016/j.apm.2021.11.011] [Medline: 34815616]
12. Golinelli D, Boetto E, Carullo G, Nuzzolese AG, Landini MP, Fantini MP. Adoption of digital technologies in health care during the COVID-19 pandemic: systematic review of early scientific literature. J Med Internet Res. Nov 6, 2020;22(11):e22280. [doi: 10.2196/22280] [Medline: 33079693]
13. MIT technology review. covid tracing tracker. Google Sheets. 2021. URL: https://docs.google.com/spreadsheets/d/1ATalASO8KtZMx__zJREoOvFh0nmB-sAqJ1-CjVRSCOw/edit#gid=0 [Accessed 2026-11-06]
14. Prodan A, Birov S, Wyl V, Ebbers W, Schulz C, Hentges M, et al. Digital contact tracing study: study on lessons learned, best practices and epidemiological impact of the common european approach on digital contact tracing to combat and exit the COVID-19 pandemic. Publications Office of the European Union; 2022. [doi: 10.2759/146050]
15. Kamel Boulos MN, Berry G. Real-time locating systems (RTLS) in healthcare: a condensed primer. Int J Health Geogr. Jun 28, 2012;11:25. [doi: 10.1186/1476-072X-11-25] [Medline: 22741760]
16. Yao W, Chu CH, Li Z. The adoption and implementation of RFID technologies in healthcare: a literature review. J Med Syst. Dec 2012;36(6):3507-3525. [doi: 10.1007/s10916-011-9789-8] [Medline: 22009254]
17. Druschel P, Federrath H, Hansen M, Lehr T, Lengauer T, Meyer-Hermann M, et al. Ansatzpunkte für eine stärkung digitaler pandemiebekämpfung. diskussion. Vol 25. Nationale Akademie der Wissenschaften Leopoldina; 2021. [doi: 10.26164/leopoldina_03_00354]
18. Wilmink G, Summer I, Marsyla D, et al. Real-time digital contact tracing: development of a system to control COVID-19 outbreaks in nursing homes and long-term care facilities. JMIR Public Health Surveill. Aug 25, 2020;6(3):e20828. [doi: 10.2196/20828] [Medline: 32745013]
19. Meng J, Liu JYW, Yang L, et al. An AI-empowered indoor digital contact tracing system for COVID-19 outbreaks in residential care homes. Infect Dis Model. Jun 2024;9(2):474-482. [doi: 10.1016/j.idm.2024.02.002] [Medline: 38404914]
20. Chopdar PK. Adoption of Covid-19 contact tracing app by extending UTAUT theory: perceived disease threat as moderator. Health Policy Technol. Sep 2022;11(3):100651. [doi: 10.1016/j.hlpt.2022.100651] [Medline: 35855013]
21. Kahnbach L, Lehr D, Brandenburger J, et al. Quality and adoption of COVID-19 tracing apps and recommendations for development: systematic interdisciplinary review of European apps. J Med Internet Res. Jun 2, 2021;23(6):e27989. [doi: 10.2196/27989] [Medline: 33890867]
22. Tomczyk S, Barth S, Schmidt S, Muehlan H. Utilizing health behavior change and technology acceptance models to predict the adoption of COVID-19 contact tracing apps: cross-sectional survey study. J Med Internet Res. May 19, 2021;23(5):e25447. [doi: 10.2196/25447] [Medline: 33882016]
23. van der Waal NE, de Wit J, Bol N, et al. Predictors of contact tracing app adoption: integrating the UTAUT, HBM and contextual factors. Technol Soc. Nov 2022;71:102101. [doi: 10.1016/j.techsoc.2022.102101]
24. Walrave M, Waeterloos C, Ponnet K. Ready or not for contact tracing? Investigating the adoption intention of COVID-19 contact-tracing technology using an extended unified theory of acceptance and use of technology model. Cyberpsychol Behav Soc Netw. Jun 2021;24(6):377-383. [doi: 10.1089/cyber.2020.0483] [Medline: 33017171]
25. Chauhan S, Jaiswal M. A meta-analysis of e-health applications acceptance: moderating impact of user types and e-health application types. J Enterp Inf Manag. 2017;30(2):295-319. [doi: 10.1108/JEIM-08-2015-0078]
26. Chong AYL, Blut M, Zheng S. Factors influencing the acceptance of healthcare information technologies: a meta-analysis. Inf Manag. Apr 2022;59(3):103604. [doi: 10.1016/j.im.2022.103604]
27. Wong BLH, Khurana MP, Smith RD, et al. Harnessing the digital potential of the next generation of health professionals. Hum Resour Health. Apr 14, 2021;19(1):50. [doi: 10.1186/s12960-021-00591-2] [Medline: 33853625]
28. Inskip JA, Lauscher HN, Li LC, et al. Patient and health care professional perspectives on using telehealth to deliver pulmonary rehabilitation. Chron Respir Dis. Feb 2018;15(1):71-80. [doi: 10.1177/1479972317709643] [Medline: 28569116]

29. Alwashmi MF, Fitzpatrick B, Davis E, Gamble JM, Farrell J, Hawboldt J. Perceptions of health care providers regarding a mobile health intervention to manage chronic obstructive pulmonary disease: qualitative study. JMIR Mhealth Uhealth. Jun 10, 2019;7(6):e13950. [doi: 10.2196/13950] [Medline: 31199330]
30. Venkatesh V, Morris MG, Davis GB, Davis FD. User acceptance of information technology: toward a unified view1. MIS Q. Sep 1, 2003;27(3):425-478. [doi: 10.2307/30036540]
31. Janssen A, Keep M, Selvadurai H, et al. Factors that influence use of a patient portal by health professionals. Int J Environ Res Public Health. Feb 15, 2021;18(4):1877. [doi: 10.3390/ijerph18041877] [Medline: 33671953]
32. Kim S, Lee KH, Hwang H, Yoo S. Analysis of the factors influencing healthcare professionals' adoption of mobile electronic medical record (EMR) using the unified theory of acceptance and use of technology (UTAUT) in a tertiary hospital. BMC Med Inform Decis Mak. Jan 30, 2016;16:12. [doi: 10.1186/s12911-016-0249-8] [Medline: 26831123]
33. Kooij L, Peters GM, Doggen CJM, van Harten WH. Remote continuous monitoring with wireless wearable sensors in clinical practice, nurses perspectives on factors affecting implementation: a qualitative study. BMC Nurs. Mar 7, 2022;21(1):53. [doi: 10.1186/s12912-022-00832-2] [Medline: 35255894]
34. Maillet É, Mathieu L, Sicotte C. Modeling factors explaining the acceptance, actual use and satisfaction of nurses using an electronic patient record in acute care settings: an extension of the UTAUT. Int J Med Inform. Jan 2015;84(1):36-47. [doi: 10.1016/j.ijmedinf.2014.09.004] [Medline: 25288192]
35. Venkatesh V, Thong JYL, Xu X. Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology1. MIS Q. Mar 1, 2012;36(1):157-178. [doi: 10.2307/41410412]
36. Pynoo B, Devolder P, Duyck W, van Braak J, Sijnave B, Duyck P. Do hospital physicians' attitudes change during PACS implementation? A cross-sectional acceptance study. Int J Med Inform. Feb 2012;81(2):88-97. [doi: 10.1016/j.ijmedinf.2011.10.007] [Medline: 22071012]
37. Venkatesh V, Thong JYL, Chan FKY, Hu PJH, Brown SA. Extending the two-stage information systems continuance model: incorporating UTAUT predictors and the role of context. Inf Syst J. Nov 2011;21(6):527-555. [doi: 10.1111/j.1365-2575.2011.00373.x]
38. Venkatesh V, Thong J, Xu X, University of Arkansas, Hong Kong University of Science and Technology, The Hong Kong Polytechnic University. Unified theory of acceptance and use of technology: a synthesis and the road ahead. J Assoc Inf Syst. 2016;17(5):328-376. [doi: 10.17705/1jais.00428]
39. Blut M, Chong AYL, Tsigna Z, et al. Meta-analysis of the unified theory of acceptance and use of technology (UTAUT): challenging its validity and charting a research agenda in the red ocean. J Assoc Inf Syst. 2022;23(1):13-95. [doi: 10.17705/1jais.00719]
40. Borsboom D, van der Maas HLJ, Dalege J, Kievit RA, Haig BD. Theory construction methodology: a practical framework for building theories in psychology. Perspect Psychol Sci. Jul 2021;16(4):756-766. [doi: 10.1177/1745691620969647] [Medline: 33593167]
41. Batt-Rawden KB, Björk E, Waaler D. Human factors in the implementation and adoption of innovations in health care services: a longitudinal case study on the introduction of new technology. Innovation J Public Sect Innov J. 2017;22(3):2-25. URL: https://innovation.cc/wp-content/uploads/2017_22_3_3_kari-batt-rawden_human-factor.pdf [Accessed 2026-11-13]
42. Nadal C, Sas C, Doherty G. Technology acceptance in mobile health: scoping review of definitions, models, and measurement. J Med Internet Res. Jul 6, 2020;22(7):e17256. [doi: 10.2196/17256] [Medline: 32628122]
43. Einrichtung eines beirats für ethikfragen in der forschung (ethikbeirat) an der leuphana universität (establishment of an ethics advisory board for research at leuphana university lüneburg). Leuphana university lueneburg; 2012. URL: https://www.leuphana.de/fileadmin/user_upload/Aktuell/files/Gazetten/Gazette_19_12.pdf [Accessed 2026-11-02]
44. Tricco AC, Lillie E, Zarin W, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): checklist and explanation. Ann Intern Med. Oct 2, 2018;169(7):467-473. [doi: 10.7326/M18-0850] [Medline: 30178033]
45. Ho HJ, Zhang ZX, Huang Z, Aung AH, Lim WY, Chow A. Use of a real-time locating system for contact tracing of health care workers during the COVID-19 pandemic at an infectious disease center in Singapore: validation study. J Med Internet Res. May 26, 2020;22(5):e19437. [doi: 10.2196/19437] [Medline: 32412416]
46. Isella L, Romano M, Barrat A, et al. Close encounters in a pediatric ward: measuring face-to-face proximity and mixing patterns with wearable sensors. PLoS One. Feb 28, 2011;6(2):e17144. [doi: 10.1371/journal.pone.0017144] [Medline: 21386902]
47. Lowery-North DW, Hertzberg VS, Elon L, et al. Measuring social contacts in the emergency department. PLoS One. 2013;8(8):e70854. [doi: 10.1371/journal.pone.0070854] [Medline: 23990915]
48. Lucet JC, Laouenan C, Chelius G, et al. Electronic sensors for assessing interactions between healthcare workers and patients under airborne precautions. PLoS One. 2012;7(5):e37893. [doi: 10.1371/journal.pone.0037893] [Medline: 22662245]

49. Mastrandrea R, Fournet J, Barrat A. Contact patterns in a high school: a comparison between data collected using wearable sensors, contact diaries and friendship surveys. PLoS One. 2015;10(9):e0136497. [doi: 10.1371/journal.pone.0136497] [Medline: 26325289]
50. Shelby T, Caruthers T, Kanner OY, et al. Pilot evaluations of two bluetooth contact tracing approaches on a university campus: mixed methods study. JMIR Form Res. Oct 28, 2021;5(10):e31086. [doi: 10.2196/31086] [Medline: 34586078]
51. Smieszek T, Castell S, Barrat A, Cattuto C, White PJ, Krause G. Contact diaries versus wearable proximity sensors in measuring contact patterns at a conference: method comparison and participants' attitudes. BMC Infect Dis. Jul 22, 2016;16(1):341. [doi: 10.1186/s12879-016-1676-y] [Medline: 27449511]
52. Guo H, Huang Z, Yeo JYP, Wang Y, Chow A. Psychosocial determinants of healthcare personnel's willingness to carry real-time locating system tags during daily inpatient care in hospital managing COVID-19 patients: insights from a mixed-methods analysis. JAMIA Open. Jul 2021;4(3):ooaa072. [doi: 10.1093/jamiaopen/ooaa072] [Medline: 34505000]
53. Chambers T, Anglemyer A. Pilot of a digital contact tracing card in a hospital setting in New Zealand, 2020. J Public Health (Oxf). Jun 14, 2023;45(2):e171-e174. [doi: 10.1093/pubmed/fdac045] [Medline: 35380703]
54. Curtis SJ, Rathnayaka A, Wu F, et al. Feasibility of bluetooth low energy wearable tags to quantify healthcare worker proximity networks and patient close contact: a pilot study. Infect Dis Health. May 2022;27(2):66-70. [doi: 10.1016/j.idh.2021.10.004]
55. Davis FD, Bagozzi RP, Warshaw PR. User acceptance of computer technology: a comparison of two theoretical models. Manage Sci. Aug 1989;35(8):982-1003. [doi: 10.1287/mnsc.35.8.982]
56. Ajzen I. The theory of planned behavior. Organ Behav Hum Decis Process. Dec 1991;50(2):179-211. [doi: 10.1016/0749-5978(91)90020-T]
57. Lyon AR, Koerner K. User-centered design for psychosocial intervention development and implementation. Clin Psychol (New York). Jun 2016;23(2):180-200. [doi: 10.1111/cpsp.12154] [Medline: 29456295]
58. Kuckartz U, Rädiker S. Fokussierte Interviewanalyse Mit MAXQDA: Schritt Für Schritt. Springer VS; 2020. [doi: 10.1007/978-3-658-31468-2]
59. Schulz M, Mack B, Renn O, editors. Fokusgruppen in Der Empirischen Sozialwissenschaft: Von Der Konzeption Bis Zur Auswertung. VS Verlag für Sozialwissenschaften; 2012. [doi: 10.1007/978-3-531-19397-7]
60. Malterud K, Siersma VD, Guassora AD. Sample size in qualitative interview studies: guided by information power. Qual Health Res. Nov 2016;26(13):1753-1760. [doi: 10.1177/1049732315617444] [Medline: 26613970]
61. Rogers RW. A protection motivation theory of fear appeals and attitude change1. J Psychol. Sep 1975;91(1):93-114. [doi: 10.1080/00223980.1975.9915803] [Medline: 28136248]
62. Rosenstock IM. Why people use health services. Milbank Mem Fund Q. Jul 1966;44(3):Suppl. [doi: 10.2307/3348967] [Medline: 5967464]
63. Deci EL, Ryan RM. The "What" and "Why" of goal pursuits: human needs and the self-determination of behavior. Psychol Inq. Oct 2000;11(4):227-268. [doi: 10.1207/S15327965PLI1104_01]
64. Holm S. A simple sequentially rejective multiple test procedure. Scand J Stat. 1979;6(2):65-70. [doi: 10.2307/4615733]
65. Hulin C, Netemeyer R, Cudeck R. Can a reliability coefficient be too high? J Consum Psychol. 2001;10(1-2):55-58. [doi: 10.1207/S15327663JCP1001&2_05]
66. Schwarzer R, Lippke S, Luszczynska A. Mechanisms of health behavior change in persons with chronic illness or disability: the Health Action Process Approach (HAPA). Rehabil Psychol. Aug 2011;56(3):161-170. [doi: 10.1037/a0024509] [Medline: 21767036]
67. Terry E, Cartledge S, Damery S, Greenfield S. Factors associated with COVID-19 vaccine intentions during the COVID-19 pandemic; a systematic review and meta-analysis of cross-sectional studies. BMC Public Health. Sep 2, 2022;22(1):1667. [doi: 10.1186/s12889-022-14029-4] [Medline: 36056325]
68. Thompson CA, Willis TA, Farrin A, et al. Technology-enabled CONTACT tracing in care homes in the COVID-19 pandemic: the CONTACT non-randomised mixed-methods feasibility study. Health Technol Assess. May 2025;29(24):1-24. [doi: 10.3310/UHDN6497] [Medline: 40350743]
69. Veras M, Auger LP, Sigouin J, et al. Ethics and equity challenges in telerehabilitation for older adults: rapid review. JMIR Aging. Aug 13, 2025;8:e69660. [doi: 10.2196/69660] [Medline: 40802966]
70. Beidas RS, Dorsey S, Lewis CC, et al. Promises and pitfalls in implementation science from the perspective of US-based researchers: learning from a pre-mortem. Implement Sci. Aug 13, 2022;17(1):55. [doi: 10.1186/s13012-022-01226-3] [Medline: 35964095]
71. Baumeister H, Nowoczin L, Lin J, et al. Impact of an acceptance facilitating intervention on diabetes patients' acceptance of Internet-based interventions for depression: a randomized controlled trial. Diabetes Res Clin Pract. Jul 2014;105(1):30-39. [doi: 10.1016/j.diabres.2014.04.031] [Medline: 24862240]

72. Baumeister H, Seifferth H, Lin J, Nowoczin L, Lüking M, Ebert D. Impact of an acceptance facilitating intervention on patients' acceptance of internet-based pain interventions: a randomized controlled trial. Clin J Pain. Jun 2015;31(6):528-535. [doi: 10.1097/AJP.0000000000000118] [Medline: 24866854]
73. Lin J, Faust B, Ebert DD, Krämer L, Baumeister H. A web-based acceptance-facilitating intervention for identifying patients' acceptance, uptake, and adherence of internet- and mobile-based pain interventions: randomized controlled trial. J Med Internet Res. Aug 21, 2018;20(8):e244. [doi: 10.2196/jmir.9925] [Medline: 30131313]
74. Damschroder LJ, Reardon CM, Widerquist MAO, Lowery JC. The updated consolidated framework for implementation research based on user feedback. Implement Sci. Oct 29, 2022;17(1):75. [doi: 10.1186/s13012-022-01245-0] [Medline: 36309746]
75. Greenhalgh T, Wherton J, Papoutsi C, et al. Beyond adoption: a new framework for theorizing and evaluating nonadoption, abandonment, and challenges to the scale-up, spread, and sustainability of health and care technologies. J Med Internet Res. Nov 1, 2017;19(11):e367. [doi: 10.2196/jmir.8775] [Medline: 29092808]
76. Stefana A, Damiani S, Granziol U, et al. Psychological, psychiatric, and behavioral sciences measurement scales: best practice guidelines for their development and validation. Front Psychol. 2024;15:1494261. [doi: 10.3389/fpsyg.2024.1494261] [Medline: 39916786]
77. Trang STN, Trenz M, Weiger WH, Tarafdar M, Cheung CMK. One app to trace them all? Examining app specifications for mass acceptance of contact-tracing apps. Eur J Inf Syst. Jul 3, 2020;29(4):415-428. [doi: 10.1080/0960085X.2020.1784046]
78. Kaspar K. Motivations for social distancing and app use as complementary measures to combat the COVID-19 pandemic: quantitative survey study. J Med Internet Res. Aug 27, 2020;22(8):e21613. [doi: 10.2196/21613] [Medline: 32759100]
79. Varsi C, Ekstedt M, Gammon D, Ruland CM. Using the consolidated framework for implementation research to identify barriers and facilitators for the implementation of an internet-based patient-provider communication service in five settings: a qualitative study. J Med Internet Res. Nov 18, 2015;17(11):e262. [doi: 10.2196/jmir.5091] [Medline: 26582138]
80. Apolinário-Hagen J, Fritsche L, Bierhals C, Salewski C. Improving attitudes toward e-mental health services in the general population via psychoeducational information material: a randomized controlled trial. Internet Interv. Jun 2018;12:141-149. [doi: 10.1016/j.invent.2017.12.002] [Medline: 30135778]
81. Apolinário-Hagen J, Fritsche L, Wopperer J, et al. Investigating the persuasive effects of testimonials on the acceptance of digital stress management trainings among university students and underlying mechanisms: a randomized controlled trial. Front Psychol. 2021;12:738950. [doi: 10.3389/fpsyg.2021.738950] [Medline: 34721212]
82. Ebert DD, Berking M, Cuijpers P, Lehr D, Pörtner M, Baumeister H. Increasing the acceptance of internet-based mental health interventions in primary care patients with depressive symptoms. A randomized controlled trial. J Affect Disord. May 1, 2015;176:9-17. [doi: 10.1016/j.jad.2015.01.056] [Medline: 25682378]

Abbreviations

BH: Bonferroni-Holm
CFIR: consolidated framework for implementation research
DCTS: digital contact tracing system
HBM: health belief model
NASSS: nonadoption, abandonment, scale-up, spread, and sustainability
NIHR: National Institute for Health and Care Research
OSF: Open Science Framework
PMT: protection motivation theory
PRISMA-ScR: Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews
RFID: radio-frequency identification
UTAUT: Unified Theory of Acceptance and Use of Technology

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