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Determinants of Contact Tracing Apps: An Adoption Study Using UTAUT Model

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ABSTRACT

In the aftermath of the coronavirus (COVID-19) outbreak that impacted human lives globally, a contact tracing app was introduced to control and ease tracking processes via smartphone-based to track positive cases and potential contacts. Major concerns about trust, personal information leakage, and data privacy stored in the system would reserve citizens' willingness to adopt and use the technology. This study focuses on the adoption of contact tracing mobile apps in looking at the key determinants influencing user's acceptance. An extended Unified Theory of Acceptance and Use of Technology (UTAUT) model was used in this study. A cross-sectional online survey was conducted between September and October2021 and Partially Least Squares (SmartPLS) was used to evaluate about 400 users in Malaysia. The findings revealed that 50.9 % in behavioural intention to adopt a contact tracing app. The highest acceptance rate was among users aged 26 to 35. Effort expectancy was the most important predictor, followed by performance expectancy, perceived risk (of COVID-19), social influence and perceived credibility. Sustainable usage among the users were also being discussed to avoid abundant or inexhaustible use of mobile apps especially relates to health concerns and to prepare for potential new pandemics, such as "Disease X", which were characterised by more infectious and dangerous diseases outbreaks.

Keywords: *Contact tracing apps (CTAs), Corona virus (COVID-19), Intention to adopt, use of technology, UTAUT.*

INTRODUCTION

In January 2020, Malaysia reported its first COVID-19 case, initially linked to three Chinese nationals with a history of contact in Singapore (Elengoe, 2020). Subsequently, the country faced multiple clusters of cases due to gatherings and international travel. Ever since the outbreak, various CTAs were introduced in Malaysia (Table 1), such as SELangkah in Selangor, COVIDTrace in Sarawak, PgCare in Penang, Sabah Trace in Sabah, MySejahtera, and others, along with the challenges associated with their adoption, including low uptake and privacy concerns.

Table 1: List of contact tracing apps and its primary functions in Malaysia

Timeline	Application	Developer	Function
April – June 2020	Gerak Malaysia	Federal government (MCMC and the Royal Malaysia Police, RMP)	GPS-enabled and QR code to inform authorities of permissions granted to travel
April 2020 – present	MySejahtera	Federal government agencies (National Security Council, NSC) the Health Ministry (MoH), the Malaysian Administrative Modernisation and Management Planning Unit (MAMPU), the Malaysian Communications and Multimedia Commission (MCMC)	Multi-purpose application intended for individuals to assess health levels, discover hotspots, seek health facilities, receive latest updates materials from the MoH and adopts web based QR scanning functions

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May 2020 (linked with MySejahtera)	MyTrace	Federal government agencies led by the Ministry of Science, Technology and Innovation (MOSTI)	Uses Bluetooth low energy (BLE) and anonymises data while retaining information of encounters in the device
May 2020 – present	SELangkah	Selangor government	Location-based and QR code enabled contact tracing
May 2020 – present	Sabah Trace	Sabah government	Location-based and QR code enabled contact tracing
May 2020 – December 2021	COVIDTrace	Sarawak government	Location-based and QR code enabled contact tracing
May – August 2020	PgCare	Penang government	Location-based and QR code enabled contract tracing

Despite extensive vaccination campaigns and contact tracing efforts, Malaysia faced a significant surge in COVID-19 cases, reporting a high of 17,405 new confirmed cases on July 28, 2021.The country struggled to control the pandemic, even with various restrictions and a state of emergency declaration. Additionally, the review of literature sheds light on the existing research gap concerning the adoption of contact tracing apps (CTAs) in developing nations like Malaysia, as pointed out by Nur Khairlida, Lee, and Mazlin (2021). Previous studies primarily concentrated on app features and privacy concerns but often overlooked a comprehensive exploration of the factors associated with technology use, societal influence, and environmental conditions that impact user acceptance, as highlighted by Oldeweme, Märtins, Westmattelmann and Schewe (2021). Not to mention the absence of geofencing enforcement and surveillance systems, like AI-powered surveillance cameras equipped with facial recognition capabilities, as well as cross-verification of individual input data with other sources such as the COVID-19 database (which ceased updates on October 6, 2020), transportation records, and financial transactions, can be attributed to the current absence of well-defined legislation, regulatory frameworks, policies, or guidelines in Malaysia (Azmi et al., 2022).

Significantly, Malaysia's primary contact tracing app, MySejahtera, is on track to maintain its importance in the daily lives of Malaysians. The government is proactively reshaping it, shifting from its exclusive role as a COVID-19 app to a versatile public health tool. This transformation underscores the potential for Malaysia to harness the power of big data analytics and artificial intelligence (AI) from contact tracing apps, thereby strengthening its capacity to combat various diseases.

Therefore, the continued study of contact tracing apps post-COVID-19 in Malaysia is vital for several reasons. Firstly, it enables the nation to bolster its readiness for future pandemics or disease outbreaks by drawing lessons from past experiences and refining both the technology and strategies employed. Secondly, the data collected by these apps remains a valuable resource for public health research, offering insights into disease transmission patterns, aiding in identifying and understanding high-risk regions or demographics. Thirdly, ongoing research can help address persistent concerns surrounding data privacy and security, facilitating the development of stronger safeguards for user information. This is particularly highlighted by the recent study conducted by Nguyen (2023a), which underscores the importance of technical transparency. Furthermore, assessing the real-world effectiveness of contact tracing apps can lead to refinements and innovations in technology. Additionally, maintaining public awareness, as demonstrated by the promotion of social norms in the study conducted by Geber and Friemel (2022a) and fostering international collaboration can jointly

bolster the resilience and preparedness of the healthcare system, equipping it more effectively to address future health crises.

LITERATURE REVIEW

Unified Theory of Acceptance and Use of Technology (UTAUT)

This research study is centred on examining the acceptance and utilisation of contact tracing apps, employing the Unified Theory of Acceptance and Use of Technology (UTAUT) as its foundational theoretical framework. The selection of UTAUT is based on its comprehensive capacity to elucidate user intention and technology adoption, encompassing diverse human and social variables, as advocated by Venkatesh, Morris, & Davis (2003). To be specific, the UTAUT model explains 70% of the variance in user intention and 50% of the variance in technology-based applications and systems (Vankatesh, Thong & Xu, 2012). As UTAUT amalgamates components from various antecedent theories, including the Technology Acceptance Model (TAM) and the Theory of Reasoned Action (TRA), where the models include the concepts about the perception of influence of others, usefulness, feelings about behaviour and control. Thereby forming a robust model for comprehending technology adoption and usage behaviour by adding the following constructs that are relevant to the particular context of the COVID-19 pandemic.

The main constructs in this study focuses on facilitating conditions, performance expectancy, effort expectancy, and social influence with other two (2) additional constructs: perceived risk of COVID-19, adopted from the study of (Velicia, Cabrera, Gil & Palos, 2021) to fit into the special circumstances. Similar to the studies concept of the UTAUT combined with HBM used by Lu and Lin (2022) highlighted that the value of staying healthy or the expectancy that measures against the illness succeed whereas Walrave, Waeterloos and Ponnet (2020b) also use the same extended UTAUT perspective to investigate the factors that would influence citizens' willingness to use an app that traces nearness with COVID-19 diagnosed individuals and notifies app users of this contact. Furthermore, perceived credibility covered trust, privacy and security dimensions which had been supported from previous studies as like Duan and Deng (2021), stating that individuals are more concerned about their privacy as more personal data is collected. Hence, these interrelated themes within the literature and the chosen theoretical framework underscore the foundation of this research's focus on the acceptance and utilisation of CTAs in Malaysia.

CTAs Usage in Malaysia (Technology Adoption and Innovation)

In the Malaysian context, the utilisation of contact tracing apps (CTAs) has played a pivotal role in managing the COVID-19 pandemic. Conventional contact tracing methods proved to be sluggish and heavily reliant on human resources, rendering them inadequate in keeping pace with the rapid spread of infections. In spite of that, many studies only focused on perceived risk in other dimensions such as performance risks, financial risks, time/convenience risks, technology risks, and psychological risks related to internet banking (Aji, Berakon & Md Husin, 2020). Yet, there are also ongoing privacy concerns about the adoption of contact tracing apps for COVID-19 control especially on health-related information.

For this reason, the researcher examines available CTAs for cues about their risk perspectives, privacy and security quality through several lenses as in detail as the results for this study context may differ. For instances, current study introduces the concept of perceived

risk of contracting COVID-19 as a critical factor influencing app acceptance and usage, underscoring the necessity to scrutinize actual app usage behaviour rather than solely focusing on intentions, as emphasized by Li, Cobb, Yang, Baviskar, Agarwal, Li, Bauer and Hong (2021) where proved that US people are more amenable to use contact-tracing apps and contribute their data when they test positive for COVID-19 which might be reflected same to the Malaysians who are more concerned with cognitive and disease risk. A clear understanding of the benefit structure of COVID-19 apps is required, and the associated concerns should be further explored (Trang, Trenz, Weiger, Tarafdar & Cheung, 2020). Understanding whether individuals are willing to share their data, and under which circumstances, is vital for improving the app uptake within general populations. Thus, the construct of Perceived Risk of COVID-19 (PRCOV) and Perceived credibility (PC) are therefore integrated into the research framework in Figure 1.

Meanwhile, Kukuk (2020) and Velicia, Cabrera, Gil and Palos (2021) did not investigate use behaviour because they could not predict the effectiveness of the apps at this preliminary phase of the COVID-19 outbreak. Prior research Rehse and Tremöhlen (2021) also explained the difference between a positive attitude and high intention to adopt and low actual uptake. Hence, to close the intention-behaviour gap, current research provides a comprehensive evaluation of the impact and effectiveness of contact tracing apps on actual COVID-19 pandemic responses. Besides, for a deeper understanding of the other factors at play, the following hypotheses were examined:

Facilitating conditions (FC) refer to an individual's perception of an organization's capability to provide technical support for system usage (Venkatesh, Morris & Davis, 2003). This hypothesis is rooted in the concept that when users perceive that adequate technical support and resources are available for using contact tracing apps, they are more inclined to express the intention to adopt and use of CTAs in Malaysia.

> **H1a:** There is a positive relationship between Facilitating Conditions and Behavioural Intention to adopt contact tracing apps.
> **H1b:** There is a positive relationship between Facilitating Conditions and the Use of contact tracing apps.

Performance expectancy (PE) is a concept that reflects the extent to which users believe that using information technologies will lead to improved performance (Venkatesh, Morris, & Davis, 2003). This hypothesis posits that when users perceive contact tracing apps as valuable and believe that using them will lead to performance gains, they are more likely to express the intention to adopt these apps during the COVID-19 pandemic in Malaysia.

> **H2:** There is a positive relationship between Performance Expectancy and Behavioural Intention to adopt contact tracing apps.

Effort expectancy (EE) defined as the ease of use of systems or technologies (Venkatesh, Morris, & Davis, 2003). This hypothesis suggests that users are more likely to intend to adopt contact tracing apps when they perceive these apps as easy to use and user-friendly.

> **H3:** There is a positive relationship between Effort Expectancy and Behavioural Intention to adopt contact tracing apps.

Social influence (SI) defined by Venkatesh, Morris and Davis (2003), refers to the extent to which individuals are swayed by significant figures in their lives, such as friends, family, colleagues, and supervisors, when making decisions about adopting a new system. This hypothesis suggests that individuals, influenced by their social networks and the prevailing societal context shaped by the pandemic, are more likely to express the intention to adopt contact tracing apps as they recognise the importance of collective efforts in limiting the disease's transmission.

> **H4:** There is a positive relationship between Social Influence and Behavioural Intention to adopt contact tracing apps.

Perceived credibility (PC) that encompasses aspects of security, risk, trust, and credibility, has been examined from various angles in the literature related to internet banking and the food and beverage industry (Palau-Saumell, Forgas-Coll, Sánchez-García & Robres, 2019), but also in research involving healthcare professionals adopting social media apps (Khan, Saleh & Quazi, 2021). This hypothesis suggests that individuals are more likely to adopt contact tracing apps when they perceive these apps as credible, secure, and trustworthy, with minimal associated risks and privacy concerns, especially in the Malaysian context.

> **H5:** There is a positive relationship between Perceived Credibility and Behavioural Intention to adopt contact tracing apps.

Perceived risk of COVID-19 (PRCOV), the subjective belief in potential negative outcomes due to the virus, plays a pivotal role in driving public engagement in preventive measures (Geber & Friemel, 2022; Van Der Weerd et al., 2011). This hypothesis suggests that individuals who perceive a higher risk of COVID-19 infection and related health complications are more likely to use contact tracing apps to assess their risk of infection.

> **H6:** There is a positive relationship between Perceived Risk of COVID-19 and Behavioural Intention to adopt contact tracing apps.

Behavioural intention (BI) directly influences an individual's actual technology use (Venkatesh, Morris, & Davis, 2003). Meanwhile, use behaviour (UB) pertains to the consistent commitment to a service, considering both how often and how effectively technology is utilised. Given the rising COVID-19 cases in Malaysia and the increasing behavioural intention to adopt contact tracing apps, it is expected that individuals will make greater efforts to engage in specific use behaviours, including app adoption.

> **H7:** There is a positive relationship between Behavioural Intention and Use of contact tracing apps.

Research Framework

The proposed research framework (Figure 1) is based on adaptations of the Unified Theory of Acceptance and Use of Technology (UTAUT) and the Technology Acceptance Model (TAM), as well as previous research by Kukuk (2020), and Velicia, Cabrera, Gil and Palos (2021). The

framework integrates these hypotheses to explore the factors influencing the acceptance and use of contact tracing apps during the COVID-19 pandemic in Malaysia.

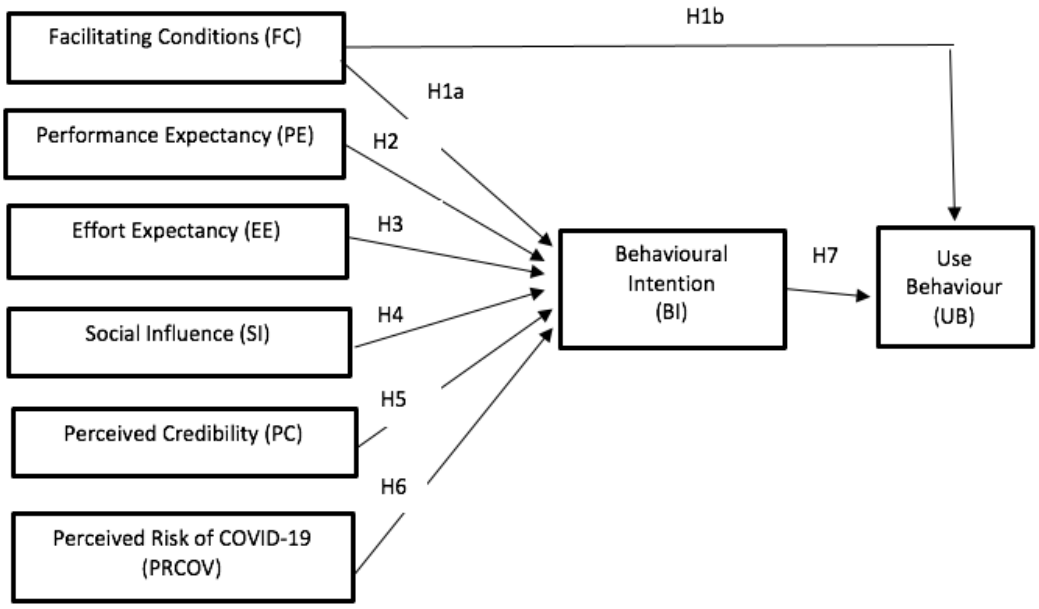

Figure 1: Research framework

METHODOLOGY

The present study outlines the research methodology for investigating contact tracing app acceptance in Malaysia covering data collection, sampling, and analysis techniques. The study employed a quantitative approach to validate relationships identified in the literature (Creswell & Creswell 2017). Self-administered English questionnaires were used, comprising screening questions, demographic information collection, and assessment of behavioural factors (Kukuk, 2020; Napper et al., 2012; Velicia-Martin et al., 2021; Venkatesh, Thong, & Xu, 2012). Eight variables (Table 2) were examined and encompass facilitating conditions, performance expectancy, effort expectancy, social influence, perceived credibility, perceived COVID-19 risk, behavioural intention, and actual usage behaviour, each assessed with reliable instruments.

Sampling for this study combined purposive and snowball techniques and targeted smartphone-owning Malaysians in Klang Valley, an area with a population exceeding one million and experiencing elevated COVID-19 rates (Salim, 2021). To achieve a 95% confidence level and an accuracy within ±5%, the research required a maximum of 384 respondents (Hardwick Research, n.d.) where the sample size is determined using guidelines from Krejcie and Morgan (1970).

Data collection was conducted through a Google Forms survey distributed via various communication apps over one month. A pilot test involving a sample of 30 participants was also conducted to enhance questionnaire quality (Creswell & Creswell, 2017). Further to this, the analysis was carried out using SPSS and SmartPLS, including validity checks, measurement model testing, internal consistency assessment, and multiple regression analysis.

Table 2: Measurements of the variables

Constructs	Items	Descriptions	Sources
Facilitating Conditions (FC)	FC1	I have the resources (e.g., smartphone) to use contact tracing apps.	(Kukuk, 2020; Venkatesh, Thong, & Xu, 2012)
	FC2	I have the knowledge to use contact tracing apps.	
	FC3	The contact tracing apps are compatible with other apps.	
	FC4	I have somebody to assist me whenever I have difficulties in using the contact tracing apps.	
Performance Expectancy (PE)	PE1	I find contact tracing apps useful in my daily life.	(Kukuk, 2020)
	PE2	I receive information about possible infections more quickly by using the contact tracing apps.	
	PE3	Contact tracing apps protect my health from COVID-19.	
	PE4	Contact tracing apps help to reduce the spread of COVID-19.	
Effort Expectancy (EE)	EE1	My interaction with contact tracing apps is clear and understandable.	(Kukuk, 2020; Venkatesh, Morris, Davis, 2003)
	EE2	I rapidly become skilful in using contact tracing apps.	
	EE3	Learning to operate contact tracing apps is very easy for me.	
	EE4	I find contact tracing apps easy to use.	
Social Influence (SI)	SI1	People who are important to me think that I should use the contact tracing apps.	(Venkatesh, Thong, & Xu, 2012)
	SI2	People who influence my behaviour think that I should use the contact tracing apps.	
	SI3	People whose opinions that I value prefer that I use the contact tracing apps.	
Perceived Credibility (PC)	PC1	When I use the contact tracing apps, I am sure of my information is kept confidential.	(Kukuk, 2020)
	PC2	When I use the contact tracing apps, my personal information is secure.	
	PC3	When I use the contact tracing apps, my privacy is not breached.	
	PC4	When I use the contact tracing apps, this app is safe to use.	
Perceived Risk of COVID-19 (PRCOV)	PRCOV1	I am at risk of getting infected by COVID-19.	(Napper, Fisher & Reynolds, 2012)
	PRCOV2	My family members are at risk of getting COVID-19.	
	PRCOV3	My community is at risk of getting COVID-19.	
	PRCOV4	COVID-19 is contagious and widely spread.	
	PRCOV5	COVID-19 causes deaths more than other respiratory disease.	
Behavioural Intention (BI)	BI1	I intend to continue the use of contact tracing apps in the future.	(Venkatesh, Thong, & Xu, 2012)
	BI2	I will always try to use contact tracing apps in my daily life.	
	BI3	I plan to use this contact tracing apps frequently.	

Use Behaviour (UB)	UB1	How often do you use contact tracing apps per day? (0, 1-2 times, 3-4 times, 5-6 times, more than 6 times)	(Semiz & Semiz, 2021; Venkatesh, Thong, & Xu, 2012)
	UB2	How many hours do you use contact tracing apps per day? (<1 hours, 1-2 hrs, 3-4hrs, 5-6 hrs, more than 6hrs)	
	UB3	I need to use contact tracing apps to keep my health safe.	
	UB4	Overall, contact tracing apps are pleasant to use.	

RESULTS AND DISCUSSION

A total of 400 participants took place in this study. The study illuminated a discernible trend toward greater acceptance of technological factors, particularly within the domain of mobile contact tracing applications. Notably, the demographic insights gleaned from this research underscore several key findings. A significant majority of respondents were females, comprising 62.4% of the sample, with the primary age group falling between 26 and 35, representing 52.2% of participants. Ethnicity-wise, Chinese respondents held the majority share at 73.6%, followed by Malays at 19.4%, Indians at 5%, and individuals from other ethnic backgrounds at 2%.

A substantial portion of the participants held Bachelor's Degrees (70.6%), while 52.2% were employed in the private sector, and 24.6% were unemployed. The majority were classified as singles, accounting for 80.3%, with 33.1% falling within the B40 income tier (RM2,000-RM3,999). Geographically, the study was predominantly concentrated in the Federal Territory of Kuala Lumpur at 31.6% and Selangor's Petaling district at 31.1%. Impressively, an overwhelming 98.8% of respondents reported using the MySejahtera contact tracing app. The primary incentive for app usage was government recommendations, cited by 47% of participants. The app's features witnessed extensive utilization, including QR Check-In at 94.8%, COVID-19 Vaccination at 71.1%, and access to COVID-19 Update Statistics, Status, and News at 45.5%.

On top of that, the data showed that the respondents' characteristics aligned with a normal distribution. However, multivariate analysis revealed deviations from multivariate normality, which is common in real-world data. A Kaiser-Meyer-Olkin (KMO) test confirmed data adequacy for factor analysis, and Bartlett's Test indicated significant results, allowing for factor analysis.

The measurement model exhibited reliability, with composite reliability exceeding 0.7, indicating high internal consistency. Convergent validity was established with average variance extracted (AVE) values above 0.5 for all constructs. Discriminant validity was confirmed through the Fornell-Larcker Criterion and Heterotrait-Monotrait Ratio. Pearson correlation analysis revealed positive relationships among constructs, with all values statistically significant at the 0.01 level. The strength of relationships ranged from low to moderate.

Similarly, the structural model analysis demonstrated that constructs such as effort expectancy, performance expectancy, and social influence significantly influenced behavioural intention to adopt contact tracing apps. These findings indicate the importance of these factors in promoting app adoption. Additionally, behavioural intention had a moderate effect on use behaviour, while facilitating conditions had a minor effect. Besides, the VIF values consistently remained below the critical threshold of 3.3, conclusively eliminating any concerns related to collinearity in the study.

Researchers also focused on the R^2 values for behavioural intention (BI) and use behaviours (UB). Notably, BI showed a moderate level of predictability, with an R^2 of 0.509. This means that the combined influence of latent variables (FC, PE, EE, SI, PC, and PRCOV)

explained 50.9% of the variability in BI. In contrast, the predictability of UB was somewhat weaker, with an R^2 of 0.297. This indicates that FC and BI together clarified 29.7% of the variability in UB. Nonetheless, all $R^2$and Q^2 values for the endogenous constructs were above 0, confirming the model's strong predictive validity.

Not to mention the analysis of path coefficients and significance levels, as illustrated in Table 3 revealed significant relationships between various factors and the adoption of contact tracing apps, as the p-values were greater than the significance level of 0.05, indicating inconclusive evidence. While the positive link between facilitating conditions and behavioural intention was inconclusive, a positive relationship between facilitating conditions and use behaviour was confirmed. Factors such as effort expectancy, performance expectancy, perceived risk of COVID-19, social influence, and perceived credibility all showed significant correlations with behavioural intention and use behaviour.

Table 3: Structural model test (Path coefficients)

Hypothetical Path	Path (β)	Std Deviation	T-value	Inference	P-value	Decision
FC→ BI	0.092	0.056	1.640	Insignificant	0.101	Rejected
FC→ UB	0.133	0.059	2.275	Significant	0.023	Supported
PE→ BI	0.200	0.052	3.862	Significant	0.000	Supported
EE→ BI	0.254	0.060	4.254	Significant	0.000	Supported
SI→ BI	0.132	0.058	2.331	Significant	0.020	Supported
PC→ BI	0.110	0.052	2.109	Significant	0.035	Supported
PRCOV→ BI	0.156	0.039	3.953	Significant	0.000	Supported
BI→ UB	0.460	0.060	7.640	Significant	0.000	Supported

Table 4: Ranking of hypotheses (Model I & II)

Hypotheses	Hypothetical Path (Model I)	Path Coefficient	Rank
H3	EE→ BI	0.254	1
H2	PE→ BI	0.200	2
H6	PRCOV→ BI	0.156	3
H4	SI→ BI	0.132	4
H5	PC→ BI	0.110	5
H1a	FC→ BI	0.092	6
Hypotheses	**Hypothetical Path (Model II)**	**Path Coefficient**	**Rank**
H7	BI→ UB	0.460	1
H1b	FC→ UB	0.133	2

As seen in the statistical tests detailed in Table 4, these findings establish a hierarchy of factor influence on CTA adoption, commencing with effort expectancy, followed by performance expectancy, perceived COVID-19 risk, social influence, and perceived credibility. Behavioural intention emerges as the most influential factor, with facilitating conditions and other elements exerting diminishing levels of influence in descending order of impact. Incorporating the insights garnered from the data analysis presented in Table 5, these findings confirm the validity of hypotheses H2, H3, H4, H5, H6, and H7, underscoring the substantial roles played by various factors in shaping individuals' behavioural intentions to adopt contact tracing apps (CTAs). However, it is noteworthy that hypothesis H1a is contradicted, indicating that the relationship between facilitating conditions and behavioural intention lacks significant strength.

Effort Expectancy (EE)
One key finding is the strong positive relationship between effort expectancy and the intention to adopt CTAs. Users found these apps to be remarkably effortless, simplifying their daily routines and providing swift assistance when exposed to potential COVID-19 risks.

Performance Expectancy (PE)
Performance expectancy was another significant determinant, with users more inclined to adopt CTAs when they believed in the app's efficacy in enhancing their understanding of virus exposure and control. Providing valuable information on symptoms and testing locations further bolstered the value proposition of the app.

Perceived Risk of COVID-19 (PRCOV)
The perceived risk of contracting COVID-19 had a substantial impact on user intentions towards adopting CTAs. Users who were concerned about infection, both personally and within their communities, displayed a strong inclination to use the app. This finding underscores the app's role in proactive monitoring and prevention.

Social Influence (SI)
Social influence emerged as a potent factor, with users heavily influenced by family, friends, and colleagues to adopt CTAs. Peer-to-peer promotion and endorsements proved effective in driving app adoption.

Perceived Credibility (PC)
User confidence in the app's credibility and security significantly influenced intentions to adopt it. Assurance of privacy protection and trustworthiness played a pivotal role in user decision-making, emphasizing the importance of data security.

Facilitating Conditions (FC)
Facilitating conditions showed no direct effect on behavioural intention. This suggests that the familiarity of users with technology and smartphones negated the need for external support. However, facilitating conditions did positively impact actual usage behaviours.

Behavioural Intention (BI) and Use Behaviour (UB)
Strong behavioural intention was found to directly influence use behaviour. Users with a strong desire to embrace CTAs were more likely to actively use the technology, contributing to the app's efficacy.

Table 5: Summary of research question, research objectives, hypotheses and findings

Research Questions	Research Objectives	Hypotheses	Findings
RQ1: What are the determinants influencing the behavioural intention to adopt contact tracing apps?	**RO1:** To identify the determinants have a positive influence on the behavioural intention to adopt contact tracing apps.	**H1a:** There is a positive relationship between Facilitating Conditions and Behavioural Intention to adopt contact tracing apps.	Rejected
		H2: There is a positive relationship between Performance Expectancy and Behavioural Intention to adopt contact tracing apps.	Supported

		H3: There is a positive relationship between Effort Expectancy and Behavioural Intention to adopt contact tracing apps.	Supported
		H4: There is a positive relationship between Social Influence and Behavioural Intention to adopt contact tracing apps.	Supported
		H5: There is a positive relationship between Perceived Credibility and Behavioural Intention to adopt contact tracing apps.	Supported
		H6: There is a positive relationship between Perceived Risk of COVID-19 and Behavioural Intention to adopt contact tracing apps.	Supported
RQ2: Do the facilitating conditions influence the use of contact tracing apps?	**RO2:** To examine the facilitating conditions that positively influence the use of contact tracing apps.	**H1b:** There is a positive relationship between Facilitating Conditions and the Use of contact tracing apps.	Supported
RQ3: What is the relationship between behavioural intention and use of contact tracing apps?	**RO3:** To determine the relationship between behavioural intention and use of contact tracing apps.	**H7:** There is a positive relationship between Behavioural Intention and Use of contact tracing apps.	Supported

In the discussion, the findings showed that ease of using the app (effort expectancy) had the strongest impact on behavioural intention, while behavioural intention had the most robust influence on user behaviour. In simpler terms, when people have a strong intention to use a contact tracing app, they are more likely to actually use it. This intention has a moderate impact on their actual behaviour. However, other factors like how useful it is (performance expectancy), concerns about COVID-19 (perceived risk), influence from others (social influence), and how trustworthy the app is (perceived credibility) have smaller effects on people's intention to use the app. Interestingly, the conditions that make using the app easier (facilitating conditions) have only a minor impact on people's intention to use it. So, overall, having the intention to use the app is a stronger predictor of actual usage.

Thereby, findings of this study offer valuable insights, covering various aspects like the demographic profiles of app users, trends in adoption, and the core factors driving widespread acceptance among the surveyed population. It enhances preparedness for future pandemics, refines technology and strategies, provides valuable data for public health research, addresses data privacy and security concerns, and promotes technical transparency, as highlighted by Nguyen's 2023b study. This research also evaluates the real-world effectiveness of contact tracing apps, fosters social norms, and encourages international collaboration, collectively strengthening the healthcare system's resilience and readiness to tackle future health crises. Crucially, these insights provide compelling evidence that underscores the continuous relevance and validity of contact tracing apps (CTAs) for use in 2023 and beyond. The data highlights the pivotal role played by government directives in

spurring app adoption and also identifies specific app features that enjoy substantial usage. These insights transcend mere informativeness; they are essential tools for crafting precise and effective strategies aimed at promoting the adoption of public health apps.

In summary, these findings strongly affirm that CTAs remain pertinent and indispensable tools for addressing contemporary health challenges. As we move into the near future, their continued utilization should be guided by these insights to fully harness their potential in effectively safeguarding public health.

CONCLUSION

Implications

This study contributes significantly to the UTAUT theory by introducing novel factors such as perceived credibility and perceived risk of COVID-19, enriching our understanding of CTA adoption during the pandemic. Furthermore, it compliments prior research on CTAs in the Malaysian market (Chan et al., 2021), offering distinct insights and revealing differences in adoption patterns. The research addresses a gap in the literature by focusing on the Asian context, shedding light on critical factors influencing behavioural intentions to adopt CTAs, notably during the COVID-19 pandemic (Garrett et al., 2021; Zhou et al., 2021). Additionally, this study holds substantial relevance for Malaysian policymakers, app developers, and marketers, offering valuable insights into the adoption of contact tracing apps (CTAs). It emphasises the importance of user-friendly CTAs that complement the efforts of public health authorities. Key takeaways from this research include the need for user-centric app development, with a focus on performance and functionality to drive user intentions. Moreover, the government should improvise current CTAs to be able to use for future use and prepare for any new pandemic (especially on “Disease X”) which is a more serious or dangerous disease.

Leveraging social influence, through sharing campaigns and integration with popular platforms, can further promote CTA adoption. This study also underscores the critical role of trust, security, and privacy, calling for transparent policy frameworks where also reflecting on the works of (Kwarteng, Ntsiful, Osakwe, & Ofori, 2023) confirmed that the positive influence of information privacy on the resistance to use mobile contract tracing app (MCTA). Thereby, education initiatives targeting various communities, particularly vulnerable groups, are essential for increasing adoption rates. Likewise, the level of campaign transparency, regarding the information offered in a campaign, holds significance in shaping user beliefs concerning future tracking app technology, consistent with findings from a previous study (Matt, Teebken & Özcan, 2022). In addition, the design and marketing of CTAs should highlight their societal benefits and incorporate accessibility features. Business managers and marketers must align their strategies with user expectations and emphasize the personal and community advantages of using CTAs to enhance adoption rates. In summary, this study advocates for user-centric, trustworthy, and inclusive CTAs, backed by effective marketing efforts, to facilitate widespread adoption and support COVID-19 preparedness.

Limitations

The limitations of the study encompass several key areas. Due to the reliance on an online survey methodology, the findings primarily reflect the perspectives of the internet-connected population within the Klang Valley, potentially side-lining disadvantaged groups and overlooking their experiences. Additionally, the adoption of a cross-sectional survey design, which measured behavioural intentions and usage behaviour exclusively during the COVID-

19 pandemic, presented a limitation as it may not capture the evolving emotions and behaviours of users over time. Furthermore, the non-probabilistic sampling method employed in the study raises concerns about the generalisability of the findings to the wider Malaysian population, potentially introducing sampling bias into the analysis. Variations in technologies and approaches to COVID-19-related apps across different countries may influence perceptions and behaviours of participants, limiting the broader applicability of the study's results beyond its specific context. Lastly, age-related disparities in perspectives on contact tracing apps, especially concerning younger and older participants, introduce complexities into the analysis, particularly given the uncertainty surrounding the duration of the pandemic and its impact on technology adoption patterns. These limitations underscore the need for a nuanced interpretation of findings in the study, considering the outlined constraints.

Future Research

This study suggests a few future directions, including longitudinal studies, cross-country comparisons, and investigations into the impact of age, knowledge, and experience on CTA adoption. In future research, the inclusion of paper questionnaires would enhance survey validity and allow for a broader examination of contact tracing app (CTA) adoption, encompassing both urban and rural users. Qualitative interviews should supplement current findings, employing a mixed-method approach to gain deeper insights into user challenges. By measuring actual user behaviour over time can provide valuable before-and-after pandemic comparisons. The evolving stability and credibility of CTAs, even with vaccine usage, necessitate continued assessment of public reliance on these apps, considering potential post-pandemic roles such as vaccination passports. Moreover, this study should expand the UTAUT framework by addressing individual factors like personal innovativeness, digital efficacy and habit in understanding CTA user behaviour. Further, given that only a few studies used an integrative approach that combined different CTA perceptions (Geber & Ho, 2022), future research should delve into cross-cultural disparities between Asian and Western countries regarding app-related perceptions when it comes to perceptions of prevention measures and crises. It should also investigate how age, knowledge, and experience levels moderate the adoption of technology-driven (CTA) strategies, particularly in light of the hurdles older individuals encounter when embracing new technologies. Lastly, the study should take into account the impact of digital detoxing norms within the domain of digital media, as exemplified by Nguyen (2023b). It paves the way for further research in this critical area of technology adoption.

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