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The design of the Deaf in Touch Everywhere (DITE)™ mobile application with Deaf and interpreter communities in Malaysia

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Abstract

Background: Ineffective communication with Deaf individuals in healthcare settings has led to poor outcomes including miscommunication, waste, and errors. To help address these challenges, we developed a mobile app, Deaf in Touch Everywhere (DITE™) which aims to connect the Deaf community in Malaysia with a pool of off-site interpreters through secure video conferencing.

Objectives: The aims of this study were to (a) assess the feasibility and acceptability of measuring unified theory of acceptance and use of technology (UTAUT) constructs for DITE™ with the Deaf community and Malaysian sign language (BIM) interpreters and (b) seek input from Deaf people and BIM interpreters on DITE™ to improve its design.

Methods: Two versions of the UTAUT questionnaire were adapted for BIM interpreters and the Deaf community. Participants were recruited from both groups and asked to test the DITE app features over a 2-week period. They then completed the questionnaire and participated in focus group discussions to share their feedback on the app.

Results: A total of 18 participants completed the questionnaire and participated in the focus group discussions. Ratings of *performance expectancy, effort expectancy, facilitating conditions* and *behavioural intention* were high across both groups, and suggestions were provided to improve the app. High levels of engagement suggest that measurement of UTAUT constructs with these groups (through a modified questionnaire) is feasible and acceptable.

Conclusions: The process of engaging end users in the design process provided valuable insights and will help to ensure that the DITE™ app continues to address the needs of both the Deaf community and BIM interpreters in Malaysia.

Keywords

UTAUT, Deaf, participatory design, mHealth, sign-language interpreters

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Introduction

The Deaf community, written with a capital D, is a cultural and linguistic minority. The group is defined by identification and active engagement with their community and communicating in their national sign language as a primary mode of communication. Members of the Deaf community do not view hearing impairment as a medical condition or disability, but rather as an intrinsic part of their identity.

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The World Federation of the Deaf reports that there are approximately 70 million Deaf people, using more than 300 sign languages around the world.[1] According to the 2022 statistics report by the Department of Social Welfare Malaysia,[2] they have accepted 42,349 registrations from Malaysian citizens with hearing loss, though it is not clear whether all of these registrants are fluent in Malaysian Sign Language (BIM).

In 2021, the World Health Organization (WHO) estimated that 5% of the world's population, or 430 million people, have hearing loss.[3] While controversial in the Deaf community, due to the implication that deafness should be 'cured' and the potential impact on Deaf culture and sign languages,[4] some Deaf people (or their carers, in the case of children) have chosen to receive a cochlear implant or a 'small, complex electronic device that can help to provide a sense of sound to a person who is profoundly deaf or severely hard-of-hearing'.[5] An estimated 736,900 registered devices had been implanted worldwide as of 2019. However, this paper will focus on the needs of the Deaf community in Malaysia who use BIM as their primary mode of communication.

Despite the significant size of the Deaf community, they face disproportionate difficulty when accessing healthcare. With the deeply personal and individual nature of healthcare, communication is of vital importance to the patient–provider relationship to ensure optimal treatment for each patient. Ineffective communication with the Deaf has led to outcomes such as miscommunication leading to errors in diagnosis and management,[6] increased levels of anxiety and embarrassment due to 'mishearing' instructions,[7] delayed treatment, unnecessary testing, privacy breaches, or insufficient patient education resulting in poor home care or incorrect drug usage.[8,9]

Given these obstacles, Deaf people often avoid seeking healthcare services.[10] This has prompted countries such as the United States and the United Kingdom to stipulate that all healthcare providers are required by law to provide American Sign Language and British Sign Language interpreting services respectively for Deaf patients. In Malaysia, however, there is no such specific legislation in place that protects the needs of the Deaf to access BIM interpreting services for healthcare. Having an interpreter present is deemed the best communication mode in a healthcare setting.[11,12] However, Deaf patients in Malaysia use a range of written text, hand gestures, and having family/friends or an interpreter present (at their own expense) during healthcare consultations.[6]

Local news reports and academic research both highlight these healthcare access issues of people who are Deaf and highlight the desperate need for BIM interpreting services in Malaysia.[13–15] It is clear that a lack of access to healthcare for the Deaf community, due to language and other barriers, is an important public health issue. Thus, as long as these communication barriers are not addressed, scholars have warned that health inequalities faced by Deaf patients will continue to worsen.

To address the healthcare interpretation needs of the Deaf community, our team has developed a cross-platform mobile app, Deaf in Touch Everywhere (DITE^{TM}) which aims to connect the Deaf with a pool of off-site interpreters through secure video conferencing. The main functionality of DITE^{TM} is to help Deaf individuals book a BIM interpreter in advance or on-demand at their convenience. The concept is similar to on-demand service providers such as Uber or Grab but caters to the need of the Deaf community to book BIM interpreters. The app was built using Flutter which can be deployed on both iOS and Android ecosystems. The video call features are built on top of the Agora platform, which provides native support for telehealth. This ensures that the communication between the users and health practitioners is encrypted and kept confidential. DITE^{TM} also addresses a more general need for the Deaf, which is having an interpreter present to assist in a variety of situations, and therefore might gain acceptance of a larger user base. As such BIM interpreters would no longer be limited by geographical and time constraints as they can conduct their interpretations remotely without the hassle of commuting between different locations. All users of the app (both BIM interpreters and the Deaf community) use their own devices (usually smartphones) and the BIM interpreters can be located anywhere (i.e. not in a call centre or clinic). Furthermore, in the current COVID-19 pandemic, the communication needs of Deaf patients are often forgotten. DITE^{TM} also houses short, looped videos — or graphics interchange formats (GIFs) — for COVID-19 screening and its management, and a repository of health promotion videos in BIM.

DITE^{TM} was developed in a community-based participatory manner working with key stakeholders including the Deaf, BIM interpreters, and medical practitioners. Using participatory design methods can help to improve health communication tools and ensure they fit the needs of specific audiences.[16] Earlier research with Deaf communities has highlighted the need to include the Deaf in the app design process to identify and address their needs and requirements.[17] This study will contribute to the iterative improvement of the DITE^{TM} app's design by seeking input from the Deaf community and BIM interpreters.

The first overall aim of this study was to assess the feasibility and acceptability of measuring unified theory of acceptance and use of technology (UTAUT) constructs for DITE^{TM} with the Deaf community and BIM interpreters in Malaysia. As described more in the Methods section below, the UTAUT theoretical framework is used to identify factors related to behavioural intention to use a technology and can help to ensure we are addressing these factors in the design of the DITE app. The second aim of this study

is to seek qualitative input from Deaf people and BIM interpreters on DITE™ to iteratively improve its design.

Methods

Ethics for this mixed methods study, including a cross-sectional quantitative survey and qualitative focus groups, was obtained from Monash University Human Research Ethics Committee (Project ID: 20452).

Participants

Participants, aged 25–50, were purposively sampled from the research team's networks in the BIM interpreter and Deaf communities. Participants were selected to ensure broad representation across races and places of residence. The main inclusion criterion for both groups was that participants had access to an Android smartphone to install the DITE™ app. In addition, BIM interpreters had to have prior experience in interpretation to participate in this study. It's important to note that while the significance of using trained interpreters is recognised, there is currently no officially accredited sign language interpretation course available in Malaysia. Instead, several organisations offer sign language interpretation courses, either through collaborations or by developing in-house programmes, but these courses lack approval from the national accreditation body. All participants were sent an explanatory statement and consent form. These documents were provided in English and accompanied by a BIM video.

Questionnaire development

The study was designed using the extended UTAUT.[18] UTAUT identifies factors related to the prediction of behavioural intention to use a technology. The factors identified in the original UTAUT model were (a) *performance expectancy*, or the degree to which using a technology will provide benefits to those users, (b) *effort expectancy*, or the degree of ease associated with the use of the technology, (c) *social influence*, or the extent to which users think that important others (e.g. friends and family) believe they should use the technology, and (d) *facilitating conditions*, or the users' perceptions of resources and support available to them. The UTAUT2 model added three additional factors (*hedonic motivation*, *price value*, and *habit*); however, these constructs were not relevant to the DITE™ app.[19] By drawing on UTAUT, we can ensure we are addressing key factors influencing the adoption of the DITE™ app in its design.

In this study, two versions of the questionnaire (one for BIM interpreters and one for Deaf people) were developed starting from the validated UTAUT2 questionnaire[19] and adapting the questions to fit the context of DITE™. The UTAUT2 questionnaire was published in MIS Quarterly. Permission to make digital or hard copies of part or all of the work in MIS Quarterly is granted, as long as full citations are provided, which we have done. The UTAUT2 questionnaire consists of 32 items under nine constructs (*Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, Hedonic Motivation, Price Value, Habit, Behavioural Intention,* and *Use*), and uses a seven-point Likert scale, with the anchors being 'strongly disagree' and 'strongly agree' to measure responses.

The research team adapted the questionnaires for this study by first replacing the technology in the original questionnaire (mobile internet) with the DITE™ in all questions. Next, the research team reviewed the questions and removed some measures and items that were not relevant to the DITE™, such as the *Price Value* measure (as the app is currently free and the developers do not intend to charge the Deaf community or interpreters to use it, as this would limit its accessibility). The items measuring the use of technology were also updated from outdated technologies to newer ones (e.g. from 'Java games' to 'app games'). Third, two separate versions of the questionnaire were developed for the Deaf and Interpreter communities. For example, the questions on *Performance Expectancy* were slightly different for an interpreter (using the app as part of their work) and a Deaf person (using the app to access interpretation services for healthcare). Fourth, additional questions were added to seek feedback on specific app features or aspects to help inform improvements to the design. For example, 'I can understand the language in the DITE™' was added to both questionnaires. Questions related to assistive features and societal integration were also adapted and added to the questionnaire for the Deaf community from Romero et al.'s study examining the quality of Deaf and Hard-of-hearing apps.[20] Finally, all items in the questionnaire for the Deaf community were reviewed by a Deaf member of our research team (AC) and edited to ensure they would be understandable to a Deaf person. The final questionnaires are provided in Appendix B.

Participant introduction to the DITE™ app

After obtaining written informed consent, each participant was given access to their own WhatsApp group with one of the app developers and two research assistants to avoid influence on other participants. The WhatsApp groups were only accessible to these research team members and individual participants who consented to participate. WhatsApp is a secure, end-to-end encrypted messaging platform frequently used in research studies. Participants were asked to download the app. They were also given step-by-step instructions to set up an account and trial the various features of the app. These instructions/checklists

are provided in Appendix A. Participants were given 2 weeks to test the app and could use their WhatsApp group to communicate any issues and feedback encountered while using the app.

Data collection

Qualitative. At the end of the 2 weeks, participants joined one of two virtual focus group discussions on Zoom with the other Deaf or BIM interpreter participants (combined groups). The sessions were facilitated by VYC (a Deaf male post-doctoral researcher) with support from JN (a profoundly Deaf female research assistant, living in both the Deaf and hearing world with the assistance of a cochlear implant). Both researchers have strong connections to the Deaf community as advocates and were already acquainted with the participants as the Deaf community is relatively small. Both researchers have training and experience in conducting group discussions using BIM. During these sessions, the participants were encouraged to share their experiences using DITE™. The objective was to discover issues encountered with DITE™. The focus groups were semi-structured and a formal discussion guide was not used to allow the participants to share what they felt was most pressing or important. Participants shared what they liked; what didn't work; what was not necessary; what could be improved; and what they would like to see in the future. Each focus group lasted for approximately 2 h.

Quantitative. Participants completed the online questionnaire after the focus group discussion. The questionnaires were administered in English and BIM (video form). They were distributed by sending a link to the WhatsApp groups and were completed using Google Forms. The full questionnaires can be viewed in Appendix B.

Data analysis

Qualitative. The research team took notes during the Zoom focus group discussions (without audio or video recording or associating comments to specific participants), and these were later analysed using Microsoft Excel. The data was not shown to participants for verification. Data saturation was determined to have been achieved during the focus groups when participants had no new comments or ideas to contribute. The analysis followed Braun and Clarke's[21] steps for thematic analysis. To facilitate the interpretation of the qualitative findings together with the quantitative findings, the UTUAT factors were used as an initial guide to assign codes and identify themes, and new themes also emerged. VYC performed the initial assignment of codes and grouped them into themes. The initial codes and themes were then discussed and modified with input from UDP, JN, DT, and JLW, and JLW helped to modify them based on the discussion. Participants were not asked to provide feedback on the findings.

Quantitative. Quantitative survey data were analysed by calculating basic descriptive statistics using Microsoft Excel. For continuous measures, mean values and standard deviations were calculated. For categorical variables, proportions were calculated. While the UTAUT questionnaire is most commonly used to test associations between various factors and behavioural intention to use a technology, we did not test any associations due to our small sample size and the focus of the study on feasibility, acceptability, and seeking feedback for app development.

Results

Summary of participant details

A total of 18 participants were recruited, nine Deaf persons and nine BIM interpreters, with 20% of the invited participants either not responding or declining to participate. The demographic details of the 18 participants are outlined in Table 1. They indicate that most of the Deaf (66.67%) and BIM interpreters (55.56%) participants are male. While all Deaf participants are Android users, only 55.6% of BIM interpreters are Android users. Deaf participants were spread across age categories from 31 to 60, whereas most interpreters were under 40 years old (77.8%). The majority of Deaf participants have obtained an SPM (similar to International General Certificate of Secondary Education) or diploma (77.8%), whereas most interpreters have earned an undergraduate or postgraduate degree (77.8%). More than half of the BIM interpreters have 1–5 years of interpreting experience (66.67%).

Participants' perceptions of and feedback on DITE™

Table 2 outlines the results of the quantitative questionnaire asking about participants' perceptions of the DITE™ app. These results are also described in more detail in each section below relating to the relevant UTAUT2 construct, along with the corresponding qualitative results.

Performance Expectancy. Interpreters and Deaf respondents rated the app highly for the statements relating to *Performance Expectancy* (mean ± SD: 6.08 ± 1.82). They felt that it is useful (6.22 ± 0.88), helps accomplish their aims more quickly (6.11 ± 0.83), increases their productivity (interpreters) or ability to book an interpreter (Deaf respondents) (6.11 ± 0.83), and reduces miscommunication with healthcare workers (5.89 ± 1.08).

Table 1. Participant demographics.

	Deaf (n = 9)		BIM interpreters (n = 9)		Total (n = 18)	
Characteristics	n	(%)	N	(%)	n	(%)
Gender						
Male	6	(66.67)	5	(55.56)	11	(61.11)
Female	3	(33.33)	4	(44.44)	7	(38.89)
Other	N/A		N/A		N/A	
Age						
18–30	N/A		3	(33.33)	3	(16.67)
31–40	3	(33.33)	4	(44.44)	7	(38.89)
41–50	4	(44.44)	1	(11.11)	5	(27.78)
51–60	2	(22.22)	1	(11.11)	3	(16.67)
Education level						
SPM	2	(22.22)	1	(11.11)	3	(16.67)
Diploma	5	(55.56)	1	(11.11)	6	(33.33)
Undergraduate	1	(11.11)	6	(66.67)	7	(38.89)
Postgraduate	1	(11.11)	1	(11.11)	2	(11.11)
Mobile phone type						
Android	9	(100.00)	5	(55.56)	14	(77.78)
Apple/iOS	N/A		4	(44.44)	4	(22.22)
Years of experience as a BIM interpreter						
1–5 years	N/A		6	(66.67)	N/A	
6–10 years	N/A		2	(22.22)	N/A	
10+ years	N/A		1	(11.11)	N/A	

Five themes were identified in the focus group discussion with both the Deaf and interpreter respondents and are outlined below.

The first theme related to sharing users' information that would benefit both interpreters and Deaf clients. For example, one of the interpreters commented that they would like to have information on a client's appointment in advance, such as the hospital and department name and the purpose of the appointment to allow them to prepare for their interpreting assignment and minimise miscommunication (this feature does not currently exist). Another interpreter commented that they would like to keep all appointment records, such as the actual duration and frequency of the appointment for tracking purposes (which would also be a new feature). On the other hand, a Deaf participant mentioned that they liked having the interpreter's information as provided in the app, such as their gender, profile picture, interpreting experience and background,

Table 2. Participants' perceptions of the DITE™ app (adapted UTUAT2 questionnaire).

Items			BIM interpreter (n = 9)	Deaf (n = 9)	Total (n = 18)
BIM interpreters	Deaf	Code	Mean ± St Dev.	Mean ± St Dev.	Mean ± St Dev.
A. Performance Expectancy[a]			6.11 ± 1.80	6.06 ± 1.91	6.08 ± 1.82
1. I think the DITE™ app will be useful in my daily life. For example, it may help me get interpretation jobs/work.	1. The DITE™ app will help me to FIND an interpreter easily.	A1	6.22 ± 0.83	6.22 ± 0.97	6.22 ± 0.88
2. I think using the DITE™ app will help me to accomplish things/aims more quickly. For example, it will help me to reach out to more Deaf clients/BNU.	2. The DITE™ app will save my time.	A2	6.11 ± 1.05	6.11 ± 0.60	6.11 ± 0.83
3. I think using the DITE™ app will increase my work productivity. For example, it will help me to respond to the Deaf clients/BNU more quickly and not requiring travelling to the clients' location.	3. The DITE™ app will help me to BOOK an interpreter easily.	A3	6.33 ± 0.71	5.89 ± 0.93	6.11 ± 0.83
4. I think using the DITE™ app will reduce miscommunication between the healthcare workers (e.g. doctors, pharmacists, nurses etc.) and patients.	4. The DITE™ app will help me to communicate better with the healthcare workers (e.g. doctors, pharmacists, nurses etc.).	A4	5.78 ± 0.97	6.00 ± 1.22	5.89 ± 1.08
B. Effort Expectancy[a]			5.57 ± 3.53	5.93 ± 2.55	5.75 ± 3.08
1. Registration for a DITE™ app account is a simple process for me.	1. Registration for a DITE™ app account is easy.	B1	6.11 ± 0.60	5.78 ± 0.83	5.94 ± 0.73
2. Learning how to use the DITE™ app is easy for me.	2. It is easy to learn to use the DITE™ app.	B2	5.78 ± 0.67	6.00 ± 0.87	5.89 ± 0.76
3. My interaction with the DITE™ app is clear and understandable.	3. I know how to use the DITE™ app.	B3	5.11 ± 1.27	6.00 ± 0.87	5.56 ± 1.15
4. I find the DITE™ app easy to use.	4. I agree that the DITE™ app is easy to use.	B4	5.22 ± 1.30	6.11 ± 0.78	5.67 ± 1.14
5. It is easy for me to become skilful at using the DITE™ app.	5. I can teach my friends to use the DITE™ app.	B5	5.56 ± 1.24	5.89 ± 0.93	5.72 ± 1.07
6. It is easy for me to navigate within the DITE™ app.	6. It is easy to find information in the DITE™ app.	B6	5.44 ± 1.33	5.78 ± 0.67	5.61 ± 1.04
7. When the DITE™ app is clicked, I can access the app immediately. (The app opens/loads immediately when clicked)	7. The DITE™ app opens/loads immediately when clicked.	B7	5.56 ± 1.13	5.67 ± 1.22	5.61 ± 1.14

(continued)

Table 2. Continued.

Items			BIM interpreter (n = 9)	Deaf (n = 9)	Total (n = 18)
BIM interpreters	Deaf	Code	Mean ± St Dev.	Mean ± St Dev.	Mean ± St Dev.
8. I find the video call function in the DITE™ app easy to use.	8. It is easy to use the video call in the DITE™ app.	B8	5.67 ± 1.22	6.11 ± 0.60	5.89 ± 0.96
9. I find the messaging function in the DITE™ app easy to use.	9. It is easy to use the messaging in the DITE™ app.	B9	5.67 ± 1.50	6.00 ± 0.71	5.83 ± 1.15
C. Facilitating Condition[a]			5.98 ± 2.49	5.68 ± 2.08	5.83 ± 2.32
1. I have the necessary resources to use the DITE™ app. For example: Enough mobile data, phone storage space etc.	1. I have enough mobile data, phone storage space etc. to use the DITE™ app.	C1	6.00 ± 1.22	5.33 ± 1.22	5.67 ± 1.24
2. I have the necessary knowledge to use the DITE™ app. For example, I have the skills using other apps on the mobile phone.	2. I use many different apps, so I know how to use the DITE™ app.	C2	6.22 ± 0.67	5.78 ± 0.83	6.00 ± 0.77
3. The DITE™ app is compatible with other technologies I use on my phone.	3. I can use/run the DITE™ app on my phone.	C3	5.89 ± 0.93	6.00 ± 0.50	5.94 ± 0.73
4. I can get technical help from the app developer team when I have difficulties using the DITE™ app.	4. I can get technical help from the app developer team if I do not know how to use the DITE™ app	C4	5.89 ± 1.17	5.44 ± 0.88	5.67 ± 1.03
5. My Internet speed is sufficient to use the DITE™ app. For example, it is sufficient for the video call function in the DITE™ app.	5. I have fast internet connection, therefore I do not have problem using the DITE™ app e.g. the video call in the DITE™ app.	C5	5.78 ± 1.20	6.11 ± 0.60	5.94 ± 0.94
6. I can understand the language used in the DITE™ app.	6. I can read and understand the language used in the DITE™ app.	C6	6.11 ± 0.78	5.44 ± 0.88	5.78 ± 0.88
D. Motivation[a]			5.36 ± 2.33	5.31 ± 2.63	5.33 ± 2.21
1. Using the DITE™ app is enjoyable/ pleasant.	1. I enjoy using the DITE™ app.	D1	5.22 ± 1.48	6.22 ± 0.67	5.72 ± 1.23
2. The appearance of the DITE™ app is appealing.	2. The DITE™ app has a beautiful design.	D2	5.00 ± 1.12	4.22 ± 1.20	4.61 ± 1.20
3. The colours used in the DITE™ app are comfortable to my eyes.	3. My eyes are comfortable with the colours used in the DITE™ app.	D3	5.44 ± 1.24	5.33 ± 1.22	5.39 ± 1.20
4. The size of the text in the DITE™ app is suitable for viewing.	4. The text size is normal/big enough, I can read easily.	D4	5.78 ± 0.67	5.44 ± 0.73	5.61 ± 0.70

(continued)

Table 2. Continued.

Items			BIM interpreter (n = 9)	Deaf (n = 9)	Total (n = 18)
BIM interpreters	Deaf	Code	Mean ± St Dev.	Mean ± St Dev.	Mean ± St Dev.
N/A	5. I would likely use the DITE™ app because of my past experiences with the healthcare workers (e.g. doctors, pharmacists, nurses etc.).	D5	N/A	6.00 ± 0.50	N/A
N/A	6. I would likely use the DITE™ app because I do not know many BIM interpreters.	D6	N/A	4.67 ± 1.66	N/A
E. Behavioural Intention[a]			5.78 ± 1.76	6.11 ± 1.26	6.03 ± 1.37
1. I will use the DITE™ app when it is available.	1. I want to use the DITE™ app in the future.	E1	5.89 ± 1.17	6.44 ± 0.53	6.17 ± 0.92
2. I will use the DITE™ app frequently for my medical interpretation services.	2. I will always use the DITE™ app when I see a healthcare worker (e.g. doctor, pharmacist, nurse etc.).	E2	5.67 ± 1.32	6.11 ± 0.60	5.89 ± 1.02
N/A	3. I won't hesitate to see a healthcare worker (e.g. doctor, pharmacist, nurse etc.) now that I have the DITE™ app.	E3	N/A	5.78 ± 0.97	N/A
F. DITE™ App Features / Functions (Interpreters Only)[a]			5.65 ± 3.15		
1. The chat/messaging function in the DITE™ app is useful.		F1	6.11 ± 0.78	N/A	N/A
2. The attachment function (to send GIF/ photo) in the DITE™ app is useful.		F2	5.33 ± 1.58	N/A	N/A
3. The video call function in the DITE™ app is useful.		F3	6.00 ± 1.00	N/A	N/A
4. The transaction status function in the DITE™ app is useful.	N/A	F4	5.44 ± 1.33	N/A	N/A
5. The function of ending the session for your interpreting service in the DITE™ app is useful.	N/A	F5	6.00 ± 1.00	N/A	N/A
6. The app notifications (booking & cancellation request, message, incoming video call and the completion of session) from your client are useful.	N/A	F6	5.89 ± 0.78	N/A	N/A

(continued)

Table 2. Continued.

Items			BIM interpreter (n = 9)	Deaf (n = 9)	Total (n = 18)
BIM interpreters	Deaf	Code	Mean ± St Dev.	Mean ± St Dev.	Mean ± St Dev.
7. The user guide (assess at the settings) in the DITE™ app is useful.	N/A	F7	4.78 ± 1.56	N/A	N/A
F. DITE™ App Features / Functions (Deaf Only)[a]				6.21 ± 3.57	
N/A	1. The chat function is important.	F1	N/A	6.44 ± 0.53	N/A
N/A	2. It is important to read your interpreter's profile before you book him/her.	F2	N/A	5.56 ± 1.42	N/A
N/A	3. Before you book an interpreter, it is important to choose the spoken language (English/ Bahasa Malaysia) to be used by your interpreter when communicating with the healthcare workers (e.g. doctors, pharmacists, nurses etc.).	F3	N/A	6.00 ± 1.22	N/A
N/A	4. It is important that you can book an interpreter on an urgent basis.	F4	N/A	6.22 ± 0.97	N/A
N/A	5. It is important that you can make a scheduled booking for an interpreter.	F5	N/A	6.44 ± 0.53	N/A
N/A	6. The attachment function (to send GIF/photo) is important.	F6	N/A	6.33 ± 0.71	N/A
N/A	7. The video call is important.	F7	N/A	6.78 ± 0.44	N/A
N/A	8. It is important that you can cancel/ end a booking.	F8	N/A	6.33 ± 0.71	N/A
N/A	9. The transaction status is important.	F9	N/A	6.56 ± 0.53	N/A
N/A	10. The app notifications (that your interpreter accepts/ declines/ ends your booking, sends message and makes a video call to you) are important.	F10	N/A	6.22 ± 0.83	N/A
N/A	11. The Covid-19 screening survey is important.	F11	N/A	6.00 ± 1.00	N/A

(continued)

Table 2. Continued.

Items			BIM interpreter (n = 9)	Deaf (n = 9)	Total (n = 18)
BIM interpreters	Deaf	Code	Mean ± St Dev.	Mean ± St Dev.	Mean ± St Dev.
N/A	12. It is good to see a list of registered interpreters.	F12	N/A	5.78 ± 1.92	N/A
N/A	13. The user guide (at the settings) is important.	F13	N/A	6.11 ± 0.93	N/A
G. Social Integration (Deaf Only)[a]					
N/A	1. Do you think the DITE™ app will give you good accessibility in society?	G1	N/A	6.67 ± 0.50	N/A
G. Use [b]			3.82 ± 3.06	4.35 ± 2.62	4.08 ± 2.93
1. SMS		G1	2.56 ± 1.24	3.33 ± 1.66	2.94 ± 1.47
2. Browse website (For example: Google search)		G2	4.67 ± 0.50	4.78 ± 0.44	4.72 ± 0.46
3. Email		G3	4.11 ± 0.93	4.22 ± 0.97	4.17 ± 0.92
4. Video calls (Facebook, WhatsApp, Telegram etc.)		G4	4.00 ± 1.00	4.89 ± 0.33	4.44 ± 0.86
5. Social media (Facebook, Instagram, Twitter etc.)		G5	4.33 ± 1.12	4.78 ± 0.44	4.56 ± 0.86
6. Messaging (WhatsApp, Telegram, Signal etc.)		G6	5.00 ± 0.00	5.00 ± 0.00	5.00 ± 0.00
7. Banking apps		G7	2.67 ± 1.50	4.00 ± 1.32	3.33 ± 1.53
8. Online services (Grab, Foodpanda, Shopee/Lazada etc.)		G8	3.22 ± 1.48	3.78 ± 0.97	3.50 ± 1.25

[a]Likert scale 1 to 7 (1 = Strongly Disagree, 7 = Strongly Agree).
[b]Likert scale 1 to 5 (1 = Never, 5 = Always).
DITE™: Deaf in Touch Everywhere.

fluency in BIM and spoken languages, and current area of residence. These requirements give comfort and assurance to the Deaf in deciding on the interpreter they engage for their consultation appointment. One of the female Deaf respondents commented that she would need a female interpreter if she was doing a Pap smear examination.

The second theme was related to the presentation of visual information in non-written forms. The Deaf respondents were happy with the idea of the inclusion of GIFs showing BIM interpretations of medical terms. One of the Deaf respondents agreed that the BIM demonstrations help enable the Deaf to communicate with their interpreter through the DITE™ app if they do not know any Malay or English words. The interpreter respondents also gave similar responses and added that these GIFS help them in their interpretation of medical terms, helping them to maintain their signing fluency.

The third theme was focused on extending the use of the DITE™ app beyond medical appointments. For example, one of the Deaf respondents indicated that they may need interpreter services when they collect medicine from a pharmacy. Unlike the United States and Canada, there is no video relay service available in Malaysia, so Deaf respondents also suggested a feature where they could call 999 for emergency/ambulance service through the DITE™ app.

The fourth theme was related to the matching of appointments with interpreters' availability. One of the greatest concerns for the Deaf respondents was the availability of BIM interpreters for their medical consultation. One

commented that they were unsure if the BIM interpreter they chose would be available for their medical consultation, especially if they requested an on-demand (i.e. immediate) interpreting service. For this reason, they proposed establishing a system where interpreters could indicate their availability. Interpreter respondents also suggested creating an auto-switch feature, where if they were unable to carry out an assignment due to unforeseen circumstances, the DITE™ would automatically route the assignment to another interpreter with similar criteria (as selected by the Deaf patient).

The last theme related to *Performance Expectancy* was feedback on the layout of DITE™. Deaf respondents commented that they would need to see their interpreter's signing space clearly. They explained that when they are on a video call, they do not need to see themselves, therefore, they suggested that their video frame should be appropriately smaller than the interpreter, prioritising the interpreter's signing space in their view. One respondent also commented that if there were three parties in a video call, they would have trouble seeing each other as all three video frames are the same size. Finally, both Deaf and interpreter respondents felt that the font size used in the DITE™ is too small.

Effort Expectancy. Participants' ratings of statements related to *Effort Expectancy* were somewhat high (5.75 ± 3.08), regarding the general ease of use (5.67 ± 1.14), learning to use the app (5.89 ± 0.76), video call function usability (5.89 ± 0.96), ease to navigate in the app (5.61 ± 1.04), messaging function usability (5.83 ± 1.15), ease to be skilful in using the app (5.72 ± 1.07), the clearness and understandability (5.56 ± 1.15), simple registration process for the app (5.94 ± 0.73), and immediate accessibility of the app after clicking (5.61 ± 1.14).

Four themes were identified in the focus group discussion in relation to the ease of use of the DITE™ app. The first theme was navigation within the app. Both groups identified an issue where their booking details disappeared, which would result in wasted time and potentially a missed medical consultation. The respondents also suggested creating a shortcut for them to make video calls instead of navigating through multiple pages to click the video call function. The third point of this theme was the respondents commented that they may not be able to remember where they stored particular information in the DITE™ app, hence it was suggested to create an effective information search to save time.

The next theme was around engagement and interaction between Deaf and interpreter users of the app. The Deaf respondents expressed their pleasure when they discovered that they could send BIM GIFs in a chat room with their interpreter(s). They felt that this will come in very handy when they do not know or cannot remember the correct word. A suggestion raised under this theme was to create a function in the chatroom where they could send video messages, similar to the Telegram app. One of the Deaf respondents explained that in Telegram chat rooms, people can send video recordings directly to the recipient without having to save the recorded video on their phone. Another suggestion was to allow the DITE™ app to block other Deaf people from booking the 'on-duty' interpreter until they manually touch a button to complete his/her assignment. Finally, both Deaf and interpreter respondents suggested using simple Malay or English words in the DITE™ app to account for low literacy in the Deaf community.

The third theme was related to the usability of the booking system. While testing the prototype, Deaf participants noted that they were not sure if their booking request had been accepted or not. They suggested that after requesting a specific interpreter for an appointment, there should be a time frame for the Deaf patient to know if the request was accepted or not, and the status needs to be updated immediately and correctly. In addition, when the Deaf respondents sent messages to the interpreters, there was no indication if the messages were successfully delivered or read, so they suggested implementing delivery status notifications with time stamps.

The last theme was around customisation, with different needs arising for different users. For example, respondents spoke about their individual preferences around reminders and notification settings for their medical appointments or interpreting assignments. Some respondents wanted to block other apps' notifications from appearing on the top of the mobile phone screen during an appointment to avoid distraction.

Facilitating Conditions. Participants agreed that *Facilitating Conditions* are present for them to use the DITE™ app (5.83 ± 2.32). They have the necessary resources (5.67 ± 1.24), the knowledge (6.00 ± 0.77), sufficient internet speed (5.94 ± 0.94), the ability to understand the language (5.78 ± 0.88), and an app that is compatible with other technologies (5.94 ± 0.73), the ability to get technical help from the app developer team when needed (5.67 ± 1.03).

Four themes relating to *Facilitating Conditions* arose from the focus group discussions with both Deaf and interpreter respondents. The first theme related to the need for more interpreting options, either in-person or virtual. The COVID-19 pandemic has enabled more online medical consultancy, however, the DITE™ app did not yet have the capability for three-way calling (i.e. for an interpreter, doctor, and Deaf patient to be on one call). This feature was suggested to enable Deaf patients to not have to go to a medical institution physically. Conversely, one Deaf participant commented that there are elderly Deaf people who might face challenges adapting to a virtual interpreting service, so they suggested providing an option for them to book the BIM interpreter using the DITE™ app, but to request to have the interpreter on-site during their medical appointment.

The second theme was around technical support for the DITE™ app. It was suggested that it is important to include a means for the users to provide feedback on the app. They also added that it would be convenient for them if they had access to an FAQ for reference and if they could have someone respond to requests for help (as they did for this testing period). Both groups of respondents agreed that it would be very useful if they could have a tutorial in the form of a video on how to use the DITE™ app. They felt that instructions given through video, similar to the Grab app, were engaging and encouraged them to watch until the end.

The third theme was focused on access to internet data and phone memory. Participants felt that the app ran slowly, and the Deaf respondents shared that they sometimes struggle to access internet data. Some of the respondents admitted that they tended to rely on available wifi which is often intermittent. They also revealed that they sometimes have difficulty obtaining phone data, especially in rural areas where there is limited connectivity. One suggestion to address the cost of data was to provide 1 hour of free data/credit for emergency use with the DITE™ app.

The fourth theme focused on privacy and security. The Deaf respondents suggested not revealing interpreters' personal contact information. It was also suggested that the Deaf patient should consent to share their health information with the BIM interpreter and the interpreter should agree to maintain the confidentiality of that health information. Finally, concerning a recording feature, some Deaf respondents were uncomfortable with having their personal information recorded by their interpreters. Solutions were proposed such as temporary storage, and having the choice to accept or decline video call recording.

Motivation. Deaf participants rated that they are neutral on whether they would use the DITE™ app as they do not know many BIM interpreters (4.67 ± 1.66), however, with high variability. They rated that they would be very likely to use the DITE™ app because of their past experiences with healthcare workers (6.00 ± 0.50) with less variability.

Both participant groups have an overall high mean score for the app being enjoyable (5.72 ± 1.23). The average scores for the visual design of the app were reasonably high, including the appearance of the DITE™ app is appealing (4.61 ± 1.20), the colours used in the app are comfortable to their eyes (5.39 ± 1.20), and the size of the text in the app is suitable for viewing (5.61 ± 0.70). In the focus group discussions, there was a suggestion to redesign the DITE™ logo to be more attractive.

Behavioural Intention. Both the interpreters and Deaf respondents reported that they will use the app when it's available (6.17 ± 0.92) and will use it frequently for their medical interpretation services (5.89 ± 1.02). The Deaf respondents on average agreed that they will not hesitate to see a healthcare worker now that they have the DITE™ app (5.78 ± 0.97).

In the focus group discussion, both Deaf and interpreter respondents were eager for the DITE™ app to be made widely available. For example, they suggested that the DITE™ app should be installed on every doctor's computer or laptop so that Deaf patients can see their interpreter better, rather than on their phones where the screen is smaller. The respondents also asked for the DITE™ app to be made available on all types of communication devices, such as tablets and iPads, and systems, such as iOS and Android.

Respondents felt that the DITE™ app is excellent to help them find BIM interpreting services for their medical appointments. The Deaf respondents shared their experience that currently, to get BIM interpreting services, they need to already know BIM interpreters and their reliability. This app will instead bring an available pool of interpreters to help the Deaf engage their services. Though there were many suggestions to improve the app, they also commented that the DITE™ app's current features are sufficient for this early stage.

Assistive Features. Overall, the app features were rated highly by respondents. The specific ratings for each feature are listed in Table 2.

Social Integration (Deaf respondents). Deaf respondents felt that the app would allow them good accessibility in society (6.67 ± 0.50).

Use. Compared to interpreters, Deaf respondents are more frequent users of many features on their mobile phones. On average, participants frequently use (in descending order) online messaging (5.00 ± 0.00), browning websites (4.72 ± 0.46), social media (4.56 ± 0.86), video calls (4.44 ± 0.86), email (4.17 ± 0.92), online services (3.50 ± 1.25), banking apps (3.33 ± 1.53), and SMS (2.94 ± 1.47). These responses suggest that participants are already reasonably familiar with the basic features of mobile apps like DITE™ that facilitate video calls, messages, and creating/viewing profiles.

Discussion

This study aimed to assess the feasibility and acceptability of measuring UTAUT constructs for the DITE app and to seek qualitative input from Deaf people and BIM interpreters on DITE to iteratively improve its design. The results of this study demonstrate that the use of the UTAUT questionnaire among Deaf people and BIM interpreters is feasible and acceptable. Further, coupled with the use of focus groups, we were able to determine that both the Deaf and BIM interpreters have high behavioural intention to use the DITE™ app, and they identified areas for further improvements and new features to be incorporated.

This study shares some similarities and differences with previous research on similar topics. Many studies have focused on the development or evaluation of apps to

facilitate Deaf communication more broadly (i.e. outside of healthcare settings specifically) around the world. For example, one study evaluated the quality of apps for the Deaf available for download and found that the quality of the apps varied and had high turnover.[20] Further, many of these apps use pre-recorded videos, artificial intelligence, automated avatars, or text and finger spelling to facilitate communication, rather than live interpreters.[22–25] However, critics point out that these types of apps can lose important communication nuances, such as facial expressions or 'flair' in gestures, or they require the Deaf to be able to read and write.[22]

In the healthcare domain specifically, some apps have been developed to facilitate communication among the Deaf and emergency workers, pharmacists, and dentists.[26–30] Some of these studies also employed co-design or participatory design methods to include the Deaf community in the design process.[26,30] However, one of these apps that used stored videos to facilitate communication found that Deaf participants were disappointed at the lack of video calling features,[30] suggesting that a solution like DITE™ might better address this need. An app with similar functionality to DITE™ was developed by Henney and Tucker; however, the prototype had not yet been tested with any Deaf users when the researchers published it.[31]

Support for some of the same themes that we identified was found in other literature as well. For example, Deaf participants also requested a video tutorial on the app and offline capabilities in an app developed for communication with emergency workers in South Africa.[30] More broadly, the important role of technology has been acknowledged in extending access to interpreters and combating health illiteracy among the Deaf, using tools like sign language web dictionaries (like those in the DITE™ app).[32]

This is the first study to our knowledge that has employed UTAUT2 (or UTAUT) in the development or evaluation of a mobile app for the Deaf. However, the framework has been applied to research on apps across many other areas of health, such as managing post-traumatic stress disorder, adoption of mHealth apps by people with visual impairment, and development of an app to support informal caregivers for people with cancer.[33–35]

This study had some important strengths and limitations. It was limited by a small sample size of 18 participants, which meant we were unable to test associations between UTAUT constructs and behavioural intention to adopt the app. Further, these participants were purposively selected and therefore may not be representative of all Deaf people and BIM interpreters in Malaysia. However, the methods used were in line with the aims of this study and the results still provide useful information for the development of an app to support communication for the Deaf community in Malaysia. In addition, adaptations were made to the validated UTAUT2 questionnaires to fit the DITE™ app and to be more understandable to the Deaf community. However, pilot testing and validation of the adapted questionnaire were outside the scope of this study, which is another limitation. A strength of this study was the use of human-centred design methods to ensure input from the target populations was included in the design of the app. While healthcare workers were not included in this study (another limitation), testing of the app in a simulated interaction with healthcare professionals is planned for the future and feedback from all three groups will be sought (Deaf community, BIM interpreters, and healthcare professionals).

In the future, we are also planning to conduct a comprehensive study to assess the feasibility of using DITE in medical settings. It's worth noting that having a trained interpreter present is widely recognised as the best communication approach for Deaf individuals in healthcare settings. While many countries have regulations in place that mandate the provision of sign language interpreters during healthcare consultations, Malaysia currently lacks such legislation. Therefore, it is also imperative to develop a policy paper that we can present to the Malaysian government, advocating for the provision of interpreters in hospital settings. This initiative seeks to ensure that Deaf individuals in Malaysia have access to effective communication in healthcare facilities. Furthermore, we have plans to secure funding to support the sustainability of the DITE app and its integration into healthcare facilities. Beyond healthcare, we envision that the app could be valuable in other service-oriented contexts, such as legal, banking, and more, where interpreter services are also needed.

Conclusions

The adapted UTAUT2 questionnaire is a useful and feasible tool for measuring factors related to the adoption of an app among the Deaf community and sign language interpreters. The process of engaging targeted end users in the design process provided extremely valuable insights and will help to ensure that the DITE™ app continues to address the true needs of both the Deaf community and BIM interpreters in Malaysia.

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