Barriers to the Adoption of Digital Health Solutions Among Type 2 Diabetic Patients During the COVID-19 Pandemic

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The world faces unexpected disruptions, such as the COVID-19 pandemic. These situations expose gaps, specifically in healthcare, and highlight the need for digital health solutions (DHSs). However, managing chronic conditions like Type 2 Diabetes Mellitus (T2DM) becomes challenging during such crises, especially in the U.S. where T2DM is highly prevalent. These challenges offer lessons for better preparedness. Prior studies have overlooked the specific barriers to DHS adoption among T2DM patients. This study addresses this gap by investigating adoption barriers for U.S. T2DM patients. Using the Unified Theory of Acceptance and Use of Technology (UTAUT) and a PRISMA-guided systematic review, we identified key barriers such as infrastructure limitations, usability issues, socio-economic disparities, privacy concerns, and perceived usefulness limitations. Findings recommend enhancing digital infrastructure, simplifying interfaces, and strengthening security measures to improve adoption and long-term use. These insights guide DHS implementation for T2DM, with broader implications for chronic disease management globally, addressing healthcare disruptions beyond COVID-19.

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1 Introduction

The COVID-19 pandemic disrupted global healthcare systems, especially revealing weaknesses in chronic disease management, particularly for Type 2 Diabetes Mellitus (T2DM). In the United States (U.S.), T2DM affects 38.4 million people (11.6% of the population) as of 2023, with an additional 97.6 million showing prediabetic symptoms (CDC, 2024). T2DM's high prevalence also led to high cost and demand for continuous monitoring. It places a significant burden on healthcare systems and the situation further worsened due to restricted access during the pandemic (Filip et al., 2022). Digital health solutions (DHSs), such as telemedicine and mobile apps, were needed to ensure continuity care, especially for T2DM, enabling remote consultations and glucose monitoring (Cimini et al., 2022). However, several unique adoption challenges emerged, particularly in the U.S. context, due to healthcare policy gaps, racial disparities, and infrastructure constraints (Tewari et al., 2023; Waizinger et al., 2022).

On the other hand, T2DM patients faced heightened risks during the pandemic, with increased complications due to disrupted care (Upsher et al., 2022). DHSs mitigated these issues by facilitating remote monitoring, but adoption varied across U.S. populations due to digital literacy, socio-economic status, and trust in technology. Given the U.S.'s uniquely fragmented healthcare system and the disparities it creates this study explores how T2DM impacts diverse communities' access to DHSs (Stange, 2009; Steinhardt et al., 2021). Examining these barriers during COVID-19 provides insights into future disruptions, ensuring DHSs remain relevant for chronic disease management post-pandemic.

Prior research on DHS adoption for T2DM in the U.S. often examines barriers in isolation (Petersen et al., 2020), such as technological constraints, without a unified framework. U.S. specific factors, like insurance barriers, racial inequities and policy fragmentation, also important and remain underexplored (Stange, 2009; Villagra et al., 2019). This study addresses these gaps by systematically analyzing barriers using the Unified Theory of Acceptance and Use of Technology (UTAUT) framework (Venkatesh et al., 2003) (Refer appendix A). UTAUT's application in this context is novel, as its use in digital health for T2DM during crises is limited in the U.S. context (Petersen et al., 2020).

The objective is to identify barriers to DHS adoption among T2DM patients during COVID-19 in the U.S., informing policymakers on equitable solutions. The study was narrowed to pandemic and U.S. context as it accelerated digital health use, highlighting unique challenges like access and usability and U.S. has a high T2DM prevalence. UTAUT's constructs guide the analysis of barriers systematically such as infrastructure and privacy concerns, bridging theoretical and practical insights.

Practically, it provides more important scalable strategies such as enhancing infrastructure and addressing inequities to improve DHS access for T2DM management, benefiting policymakers, providers, and developers, contributing new insights to chronic disease management literature with implications beyond the pandemic.

2 Methodology

2.1 Study Design

This systematic literature review examines barriers to DHSs adoption among U.S. T2DM patients during the COVID-19 pandemic (2020–2023), using the UTAUT framework (Venkatesh et al., 2003). The review adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure transparency and rigor (Page et al., 2021). Refer figure 1.

2.2 Research Question

What are the key barriers to adopting DHSs among T2DM patients in the U.S., and how were these barriers affected by the COVID-19 pandemic?

2.3 Search Strategy

The research question was broken into four concepts focusing on four concepts namely T2DM management, DHSs, COVID-19, and adoption barriers. Keywords included (1) T2DM ("Type 2 diabetes mellitus", "diabetes management"), (2) DHSs ("digital health", "telemedicine", "remote monitoring", "mobile health"), (3) COVID-19 ("COVID-19", "pandemic"), and (4) barriers ("adoption", "barriers", "challenges"). Search strings combined these using Boolean operators (e.g., "Type 2

diabetes AND telemedicine AND COVID-19 AND barriers") across MEDLINE, EMBASE, and Scopus, incorporating MeSH terms and keywords.

2.4 Study Selection

Studies were selected based on predefined criteria (Table 1). Two reviewers independently screened titles and abstracts, resolving discrepancies via discussion or a third reviewer. A full-text review was conducted for the screened articles by assessing in detail by two independent reviewers and the discrepancies between the reviewers were resolved through a third reviewer.

Table 1: Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Studies on T2DM diagnosis/management during COVID-19 using DHSs	Non-T2DM or non-COVID-19 studies
U.S. based community T2DM populations	Non-U.S. populations
Published between 2020 to 2023	Studies published before 2020
Published in English language	Non-English publications

2.5 Data Extraction

A standardized form captured study design, setting, population, interventions, outcomes, and barriers. Two researchers extracted data independently, resolving discrepancies through discussion.

2.6 Data Synthesis

Thematic analysis followed Braun and Clarke's (2006) six-step process (1) data familiarization, (2) coding barriers using UTAUT constructs (3) theme generation, (4) theme review, (5) theme definition, and (6) reporting. UTAUT constructs (Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI), Facilitating Conditions (FC), Behavioral Intention (BI), and Usage Behavior (UB) informed initial coding, with themes refined using NVivo software (Braun & Clarke, 2006).

3 Results

3.1 Study Selection and Characteristics

The review identified 426 publications and 30 duplicates were removed, leaving 396 for screening. After title/abstract screening, 380 were excluded, and 16 articles underwent full-text review resulting in 15 studies for final analysis. Refer figure 1. The small sample reflects the specific U.S. and COVID-19 focus but ensures relevance (Rethlefsen et al., 2021). The analysis shows 50% of the studies were conducted in mixed (both urban and rural) settings, indicating a broad applicability of DHSs across diverse environments. Urban settings accounted for 42% of the studies, highlighting a significant focus on densely populated areas where healthcare infrastructure is generally more accessible.

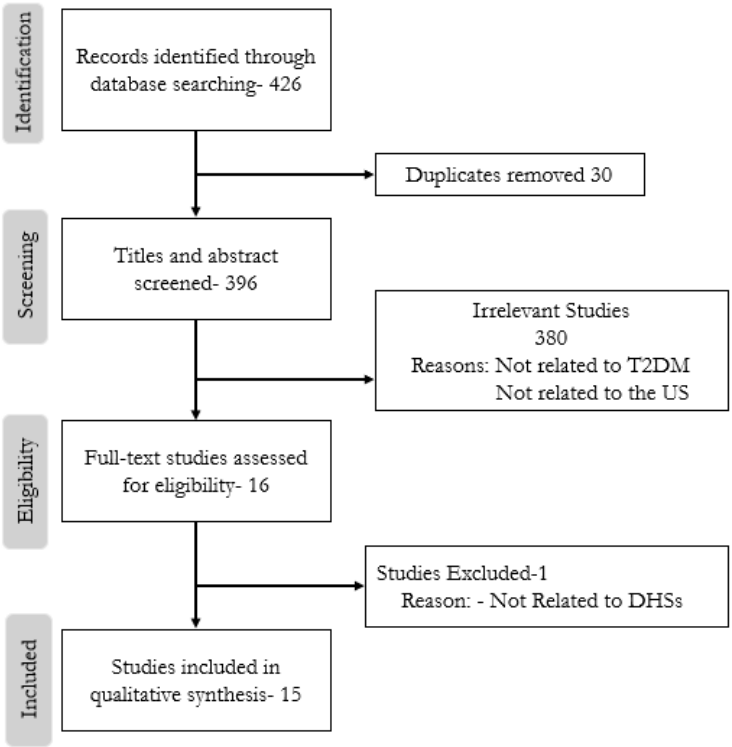

Figure 1: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) diagram of the study selection process

3.2 DHSs for T2DM Management

DHSs such as telemedicine, mobile apps, and remote monitoring, enabled remote consultations, glucose monitoring, and lifestyle interventions have been utilized during COVID-19. These tools ensured care continuity despite restricted in-person access, supporting T2DM management in urban and rural settings. Telemedicine dominated (50%) due to its scalability, while mobile apps facilitated patient engagement.

3.3 Thematic Analysis of Barriers

Five themes emerged namely infrastructure constraints, usability challenges, socio-economic disparities, privacy and trust issues, and perceived usefulness limitations, supported by direct evidence (Table 2). BI and UB were not standalone themes but impacted across barriers, as FC, EE, SI, and PE reduced adoption intentions and usage.

These barriers are visually summarized in a Fishbone Diagram (Figure 2), illustrating their contributions to the limited adoption of DHSs. UTAUT constructs shaped thematic synthesis, mapping barriers to PE, EE, SI, FC, BI, UB (Venkatesh et al., 2003). For example, "limited internet" was coded as an FC barrier which led to reducing BI. Infrastructure constraints (FC) like unstable internet lowered BI and UB, especially for rural patients (He et al., 2023). Usability challenges (EE) increased perceived effort, reducing BI among seniors. Privacy and trust issues reduced engagement in virtual diabetes programs due to 47% of African American participants distrusting health information. Socio-economic disparities, with 60% of low-income patients facing device access issues, and 27.1% reporting financial stress, amplified infrastructure barriers (Chunara et al., 2021; Steinhardt et al., 2021).

Table 2: Detailed Analysis of Barriers

Barrier Theme	UTAUT Construct	Description and Examples	Source(s)
Infrastructure Constraints	FC	Limited internet access and unstable connections restrict video teleconsultations for diabetes management, particularly in rural areas. For example, patients struggle with consistent connectivity for virtual appointments. "Not all families are comfortable using telehealth technology and others lack access to a stable internet connection."	(Monaghan & Marks, 2020; Petersen et al., 2020; Steinhardt et al., 2021; Vaughan et al., 2022)
Infrastructure Constraints	FC	Lack of access to devices (e.g., computers, smartphones) exacerbates the digital divide for diabetes patients. "During the COVID-19 pandemic, populations with health disparities are the same as those that are having difficulty accessing virtual health care. Access barriers include... not having the necessary hardware and software..."	(Kerr & Sabharwal, 2021; Steinhardt et al., 2021)
Infrastructure Constraints	FC	Location-based logistical barriers (e.g., lack of transportation, distance to facilities) hinder telehealth access in rural areas. For example, patients may need in-person visits for device setup.	(Merrill et al., 2022)
Infrastructure Constraints	FC	Lack of interoperability in health devices and data systems complicates virtual diabetes care. "An often-touted reason for reluctance to embrace interoperability is the perception that interoperability will hamper innovation..."	(Kerr & Sabharwal, 2021)
Infrastructure Constraints	FC	Logistical challenges for providers, such as inadequate clinic resources and training, limit telehealth implementation. For example, nurse practitioners face challenges adapting to virtual care.	(Vaughan et al., 2022; Waizinger et al., 2022)
Infrastructure Constraints	FC	Travel requirements and distance to facilities pose barriers, particularly in underserved areas. For example, patients may need in-person visits for initial telehealth setup.	(Casas et al., 2023; Lam et al., 2020; Steinhardt et al., 2021)
Usability Challenges	EE	Older adults with diabetes prefer traditional methods (e.g., landlines) and face physical impairments (e.g., hearing, vision), increasing effort for telehealth use. For example, 36.7% of U.S. seniors used landlines in 2021.	(Casas et al., 2023; He et al., 2023; Lam et al., 2020)

Barrier Theme	UTAUT Construct	Description and Examples	Source(s)
Usability Challenges	EE	Young adults with diabetes faced disruptions (e.g., college closures, unemployment, low digital literacy), increasing effort for virtual diabetes management. "Young adults with diabetes are particularly vulnerable during the COVID-19 pandemic..."	(Monaghan & Marks, 2020; Upsher et al., 2022)
Usability Challenges	EE	Telehealth platforms with technical limitations (e.g., complex interfaces) increase effort, particularly for low-digital-literacy patients. A layered approach is needed for self-efficacy.	(Beks et al., 2022; Petersen et al., 2020; Upsher et al., 2022)
Usability Challenges	EE	Lack of smartphone-focused telehealth platforms increases effort for diverse diabetes populations. "Smartphone-based internet access has substantially reduced the digital divide..."	(Kerr & Sabharwal, 2021)
Usability Challenges	EE	Telehealth's inability to conduct thorough physical examinations (e.g., foot exams) increases effort for accurate diabetes management.	(Casas et al., 2023)
Usability Challenges	EE	Providers require new expertise for virtual diabetes care, increasing effort for tasks like patient education.	(Merrill et al., 2022)
Usability Challenges	EE	Complex telehealth interfaces hinder self-management for type 2 diabetes patients, particularly those with limited digital skills. For example, patients struggle with remote glucose monitoring tools.	(Upsher et al., 2022)
Socio-Economic Disparities	FC	Financial instability and stress (e.g., job loss, insurance concerns) hindered diabetes management and telehealth access. "Financial instability during the pandemic increased worries about contracting COVID-19..."	(Monaghan & Marks, 2020)
Socio-Economic Disparities	FC	Community clinics face resource constraints (e.g., time, participant recruitment) in underserved areas with high diabetes prevalence.	(Beks et al., 2022)
Socio-Economic Disparities	FC	Healthcare disparities limit telehealth access for low-income and minority diabetes patients. For example, underserved areas face economic and systemic inequities.	(Chunara et al., 2021)

Barrier Theme	UTAUT Construct	Description and Examples	Source(s)
Socio-Economic Disparities	FC	Low health insurance literacy among minority and low-income diabetes patients creates barriers to telehealth access. For example, patients may not understand virtual visit coverage.	(Villagra et al., 2019)
Privacy and Trust Issues	SI	Privacy and cybersecurity concerns (e.g., inconsistent privacy notices) undermine trust, particularly among older adults. "A major concern for maintaining and developing trust is the serious issue of privacy..."	(Kerr & Sabharwal, 2021)
Privacy and Trust Issues	SI	Telehealth visits for mental health aspects of diabetes care require private spaces, which many patients lack. For example, crowded households limit privacy.	(He et al., 2023)
Privacy and Trust Issues	SI	Historical healthcare mistreatment contributes to distrust among minority diabetes populations. "Absence of trust in the healthcare system... is based on historical precedents."	(Kerr & Sabharwal, 2021)
Perceived Usefulness Limitations	PE	Telehealth's inability to support physical examinations reduces perceived usefulness. "Telehealth services currently face limitations in conducting thorough physical examinations..."	(Casas et al., 2023; He et al., 2023)
Perceived Usefulness Limitations	PE	Discordant health beliefs, particularly among Black Americans, reduce telehealth's perceived usefulness. "Among Americans with diabetes who are Black, discordant health beliefs are common..."	(Kerr & Sabharwal, 2021; Tewari et al., 2023)

PE was impacted when DHSs couldn't support thorough exams, lowering UB (Casas et al., 2023). UTAUT assumes adequate infrastructure, but U.S.-specific policy gaps (e.g., telehealth reimbursement limits) worsened barriers, requiring framework adaptation (Patel et al., 2021). This U.S.-focused analysis highlights racial disparities (e.g., African Americans facing higher costs), offering new insights into policy-driven barriers (Chunara et al., 2021).

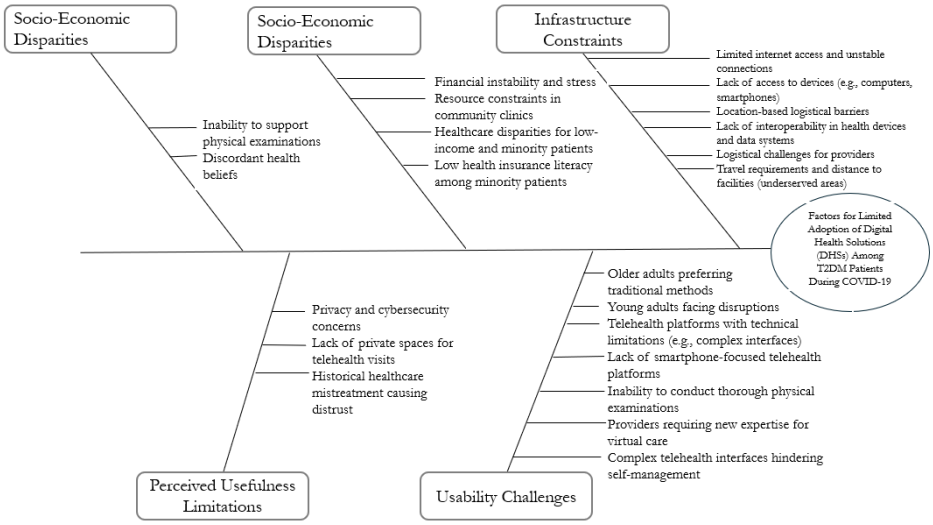

Figure 2: Fishbone Diagram of Barriers to DHS Adoption

4 Discussion

This review identifies infrastructure constraints, usability challenges, socio-economic disparities, privacy concerns, and perceived usefulness limitations as barriers to DHS adoption for T2DM management in the U.S. during COVID-19, analyzed through UTAUT. These U.S.-specific insights highlight policy impacts, addressing stakeholder adoption challenges.

Unreliable rural internet reduced FC, lowering BI (He et al., 2023). UTAUT assumes adequate infrastructure, but U.S. policy gaps, like limited broadband subsidies, exacerbated barriers, necessitating expanded broadband access. Complex interfaces increased EE, reducing BI among seniors, with 36.7% preferring landlines (Casas et al., 2023). Simplified, voice-navigated interfaces can enhance UB. Privacy fears diminished SI, as patients distrusted telehealth platforms. Robust encryption can rebuild trust (Ali et al., 2022). Telehealth's inability to support physical examinations reduced PE, as patients perceived DHSs as less effective, lowering BI (Casas et al., 2023). Demonstrating improved self-management outcomes can address this. Racial disparities, with African Americans facing higher costs due to insurance gaps, further limited FC, affecting 60% of low-income patients (Steinhardt et al., 2021; Tewari et al., 2023). Policies like the Affordable Care Act could ensure equity. Incompatible

systems hindered FC, reducing UB interoperable platforms can streamline care. Recommendations include investing in broadband, simplifying interfaces, enhancing security, promoting interoperability, subsidizing access, and highlighting benefits to boost adoption, aligning with UTAUT to improve BI and UB for T2DM management.

Future studies should test interventions like simplified interfaces or digital literacy programs to validate their impact on adoption. Longitudinal research can assess post-pandemic DHS effectiveness, while cross-regional studies may reveal global disparities in adoption patterns, building on UTAUT's application in diverse contexts.

This study has several limitations. The focus on literature from 2020 to 2023 limits the scope, potentially overlooking relevant studies conducted prior to the COVID-19 pandemic that might provide valuable context. Geographically, the study concentrates on the U.S., which may restrict the applicability of results to countries with different healthcare infrastructures and socio-economic dynamics. The study's reliance on secondary data from published literature, rather than primary data collection, also limits the ability to capture the real-time, nuanced experiences of patients and providers during the pandemic. Inclusion of potential non-empirical studies and lack of formal quality/bias assessment may limit rigor. Future research that incorporates a wider range of datasets, frameworks, and demographic variables could offer a more nuanced, globally relevant understanding of DHS adoption barriers for T2DM care.

5 Conclusion

This systematic review examined the barriers influencing the adoption of digital health interventions among individuals with T2DM during the COVID-19 pandemic, using the Unified Theory of Acceptance and Use of Technology (UTAUT) as a guiding framework. The findings highlight that PE, EE, FC, and SI significantly shaped users' engagement with digital tools, with pandemic-related disruptions amplifying these effects. This study contributes to the digital health literature by synthesizing recent U.S.-based evidence through a theory-driven lens, providing a timely understanding of how contextual and technological factors intersect during public health emergencies. The integration of UTAUT enhances

explanatory power and offers a structured basis for evaluating adoption barriers across different contexts. Moreover, rapid changes in digital health technology may affect the generalizability of these findings over time. Future research should explore the evolving role of digital literacy, personalization, and trust in post-pandemic health technology use, particularly among vulnerable or underserved populations. Expanding the theoretical scope beyond UTAUT may also help uncover deeper sociocultural and behavioral determinants that shape digital health engagement.

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Appendix A

Unified Theory of Acceptance and Use of Technology (UTAUT)

Overview: The Unified Theory of Acceptance and Use of Technology (UTAUT) explains user intentions to use a particular technology and subsequent usage behavior. It integrates elements from multiple technology acceptance models into one unified framework.

Origin: Proposed by Venkatesh et al. (2003).

Key Constructs:

- Performance Expectancy (PE): The degree to which an individual believes using the system will help achieve gains in job performance.
- Effort Expectancy (EE): The degree of ease associated with the use of the system.
- Social Influence (SI): The extent to which an individual perceives that others believe they should use the new system.
- Facilitating Conditions (FC): The degree to which an individual believes that an organizational and technical infrastructure exists to support system use.
- Behavioral Intention (BI): The intention to use the system, which influences actual usage (Use Behavior).
- Moderators: Age, Gender, Experience, and Voluntariness of Use can moderate the relationships between these constructs.

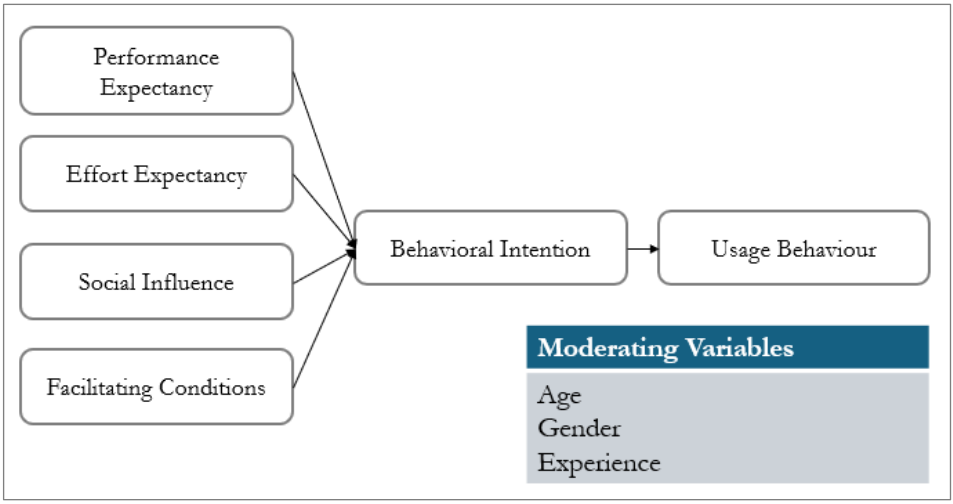

Figure 3: UTAUT Framework