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Review

Digital interventions for antimicrobial prescribing and monitoring: a qualitative meta-synthesis of factors influencing user acceptance

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ABSTRACT

Objective: To understand and synthesize factors influencing user acceptance of digital interventions used for antimicrobial prescribing and monitoring in hospitals.

Materials and Methods: A meta-synthesis was conducted to identify qualitative studies that explored user acceptance of digital interventions for antimicrobial prescribing and/or monitoring in hospitals. Databases were searched and qualitative data were extracted and systematically classified using the unified theory of acceptance and use of technology (UTAUT) model.

Results: Fifteen qualitative studies met the inclusion criteria. Eleven papers used interviews and four used focus groups. Most digital interventions evaluated in studies were decision support for prescribing ($n = 13$). Majority of perceptions were classified in the UTAUT performance expectancy domain in perceived usefulness and relative advantage constructs. Key facilitators in this domain included systems being trusted and credible sources of information, improving performance of tasks and increasing efficiency. Reported barriers were that interventions were not considered useful for all settings or patient conditions. Facilitating conditions was the second largest domain, which highlights the importance of users having infrastructure to support system use. Digital interventions were viewed positively if they were compatible with values, needs, and experiences of users.

Conclusions: User perceptions that drive users to accept and utilize digital interventions for antimicrobial prescribing and monitoring were predominantly related to performance expectations and facilitating conditions. To ensure digital interventions for antimicrobial prescribing are accepted and used, we recommend organizations ensure systems are evaluated and benefits are conveyed to users, that utility meets expectations, and that appropriate infrastructure is in place to support use.

BACKGROUND AND SIGNIFICANCE

Inappropriate antimicrobial drug use, including prescribing the wrong drug, dose or duration of therapy for an infection, is a global public health issue occurring across healthcare settings, including aged care facilities,[1] general practice,[2–4] and hospitals.[5–7] Inappropriate prescribing practices are a key contributor to drug resistance, with research showing a causal link between antimicrobial use and the level of resistance in the community.[8–10] Inappropriate antimicrobial use in hospitals has also been shown to increase 30-day and in-hospital mortality,[11] increase hospital length of stay,[12] and is associated with significantly higher hospital costs.[11]

Digital interventions, such as real-time surveillance, clinical decision support systems (CDSSs), and electronic approval systems, are gaining momentum as strategies to improve antimicrobial use in hospitals. Internationally, clinical guidelines also recommend the use of CDSSs for antimicrobial prescribing.[13–17] A CDSS can take many forms, but a common approach is for systems to guide users in initial drug selection by recommending appropriate antimicrobial treatment, or displaying relevant pathology/microbiology information at the point of care to inform drug selection. Systematic reviews summarizing the evidence on digital interventions supporting the use of antimicrobials have shown that implementation of digital interventions can lead to fewer antimicrobials being prescribed and to more appropriate use of antimicrobials.[18–22]

Despite the potential for digital interventions to improve antimicrobial prescribing, implementation of these systems does not guarantee acceptance and use by clinicians.[23] Antimicrobial prescribing is complex, influenced by clinician attitudes, patient-related factors, and organizational factors.[24] Implementing digital interventions into the antimicrobial prescribing workflow adds to this complexity.[25] There are limited randomized clinical trials available of digital interventions for AMS and they are often implemented in "real-world" settings and studied retrospectively making evaluation challenging.[26] Furthermore, although randomized clinical trials are considered the gold standard, the aim of these digital interventions is often to change the decision-making behavior of prescribers,[26] which is better understood through qualitative evaluation. A systematic review of drivers of antimicrobial prescribing behaviors, found that social norms, attitudes, and beliefs significantly impact prescribing behaviors, and consequently impact acceptance of interventions to improve prescribing.[27] Previous studies of general CDSSs in hospitals have shown that when users view a system negatively, their use of the system decreases.[28,29] These negative attitudes can stem from multiple factors, for example, a mistrust of the evidence supporting recommendations, software or hardware issues, or poor education and training.[28,29]

Qualitative evaluations of digital interventions for antimicrobial prescribing and monitoring are increasingly being used to understand the variability in acceptance and use of these systems. Thus far, no attempt has been made to collate and summarize the literature to understand factors influencing user acceptance of antimicrobial digital interventions in hospitals. A comprehensive understanding of such factors would allow any barriers to acceptance and use of digital interventions to be addressed.

OBJECTIVE

In this review, we aimed to undertake a meta-synthesis of qualitative papers to identify user perceptions of digital interventions used for antimicrobial prescribing and monitoring in hospitals, in order to identify factors influencing acceptance.

MATERIALS AND METHODS

The Enhancing transparency in reporting the synthesis of qualitative research (ENTREQ) guidelines were followed for the methodology and reporting of this review.[30]

Eligibility criteria

Studies were eligible if they explored end-user perceptions of digital interventions used for antimicrobial prescribing and/or monitoring in an inpatient hospital setting using a qualitative method. Studies were excluded if they were not in English, not peer-reviewed, commentaries, reviews, or the digital interventions solely related to identification and surveillance of antimicrobial resistance. Studies were excluded if user perceptions were only explored prior to implementing an intervention.

Search strategy

A literature search was performed using the following databases: MEDLINE, Embase, Web of Science, CINAHL, PsycINFO, and the first 200 references in Google Scholar. These databases were chosen to guarantee adequate coverage of the literature.[31] Keywords combined with database-specific subject headings were used to represent concepts relating to "information technology," "antimicrobials," and "qualitative." The full search strategy can be found in Supplementary File S1. The searches were performed from the inception of the database until December 4, 2020, and then updated on December 1, 2021.

Study selection

Papers were imported into Covidence,[32] duplicates were removed, and all titles and abstracts were screened independently by two researchers (BAVD and JEC). Disagreements during title and abstract screening were resolved by consensus (BAVD and JEC). For full-text review, a sample of 20 full-text papers was screened independently by both researchers (BAVD and JEC) to ensure consistency. The remaining 70 papers were divided into two and screened by one researcher each. The search was updated on December 1, 2021 and identified six papers for full-text screening. Any papers the researchers were unsure of were discussed as a group (BAVD, JEC, and MTB) until a consensus on inclusion was reached.

Data extraction and synthesis

Results from papers were independently extracted by one researcher (BAVD) and then verified by a second researcher (JEC) to ensure accurate data capture. Study characteristics and qualitative results relating to user perceptions of digital interventions were extracted from the Results sections of each paper. We used the unified theory of acceptance and use of technology (UTAUT) to guide our meta-synthesis. UTAUT is a well-known and widely recognized technology acceptance model.[33] The model outlines four core domains, with each domain made up of constructs (Table 1). Three domains, *performance expectancy*, *effort expectancy*, and *social influence*, de-

Table 1. The unified theory of acceptance and use of technology (UTAUT) domains and constructs[33]

Domains	Constructs
Performance expectancy *The degree to which an individual believes that using the system will help him or her to attain gains in job performance*	• Perceived usefulness • Extrinsic motivation • Job-fit • Relative advantage • Outcome expectations
Effort expectancy *The degree of ease associated with the use of the system*	• Perceived ease of use • Complexity • Ease of use
Social influence *The degree to which an individual perceives that it is important others believe that he or she should use the new system*	• Subjective norm • Social factors • Image
Facilitating conditions *The degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system*	• Perceived behavioral control • Facilitating conditions • Compatibility

termine system acceptance, and the fourth domain, *facilitating conditions*, has a direct influence on system use. In this review, qualitative data were independently deductively coded by two researchers (BAVD and JEC) using the UTAUT framework.[33] Any disagreements were discussed with a third researcher (MTB) until consensus on coding was reached. The perceptions were also classified as "barriers" and "facilitators."

Quality assessment

To assess the quality of the included studies, the Joanna Briggs Institute Checklist for Qualitative Research[34] was applied independently by two reviewers (BAVD and JEC). This checklist is designed to assess congruity between objectives, methodology, data, and the interpretation of results in qualitative studies for systematic reviews. Any disagreement between reviewers about the quality of the paper was discussed until consensus was reached.

RESULTS

Study selection

The database search returned 956 papers, 15 of which met the inclusion criteria (Figure 1).

Study characteristics

Study characteristics are outlined in Table 2. Fourteen of the 15 papers were published in the last 10 years. More than half of the studies used a mixed methods study design ($n = 8$) combining interviews or focus groups with observations, surveys, or audits of prescribing data. Eleven papers used interviews and four used focus groups. The majority of digital interventions evaluated in studies comprised decision support for prescribing ($n = 13$) such as prewritten orders,[35] dosing guidance,[36,37] and access to guidelines and protocols.[38] Most studies included doctors as participants ($n = 13$), with some studies also including pharmacists ($n = 6$), nurses ($n = 1$), and microbiology laboratory staff ($n = 1$).

Results of quality assessment

The 15 studies all had congruity between the research objectives, methodology, and methods used for data collection. It was unclear whether there was congruity between the research methodology and the representation and analysis of data in three papers,[41,45,48] as their data analysis was not described. Five studies[40,41,43,44,48] had a statement identifying the researcher culturally or theoretically, and five studies[42–45,49] addressed the influence of the researcher on the research. Twelve papers represented "participants' voices," with the remaining three[36,46,48] not including participant quotes to support their qualitative findings. The results of the quality assessment can be found in Supplementary File S2.

User perceptions of digital interventions for antimicrobial prescribing and monitoring: UTAUT categorization

From the 15 studies, 139 user perceptions of digital interventions were extracted. The perceptions were deductively coded using the UTAUT framework. Their organization and frequency in the domains and constructs of the framework is depicted in Figure 2. Example results and quotes for each UTAUT construct are included in Table 3, with the complete data extraction table provided in Supplementary File S3.

Performance expectancy

Fourteen of the 15 studies contained user perceptions from the domain of *performance expectancy*, highlighting that users were more likely to accept a digital intervention for antimicrobial use if they believed that using the system helped them achieve gains in job performance.

The majority of user perceptions reported[37,41–47,49] aligned with the *perceived usefulness* construct, indicating that user acceptance was influenced by the degree to which users believed that the digital intervention would enhance their job performance. Facilitators included perceptions that the digital intervention was a trusted and credible source of information,[40–42,44] and that it improved the performance of tasks (eg, facilitating decision-making processes[37,44–46,49]). For example, HAITooL, a surveillance system that allows patient monitoring in real time, was reported to be very useful by healthcare workers across three hospitals for supporting prevention and control of antibiotic-resistant infections.[46] Reported barriers, in the *perceived usefulness* construct, were that the information provided from the intervention was not perceived to be useful for the setting (eg, the emergency department[49]) or the patient's condition.[40]

Relative advantage is the degree to which using the digital intervention is perceived to be better than using its precursor. The majority of perceptions classified in the *relative advantage* construct were facilitators and related to increased efficiency.[37,39,44,46,49] For example, increasing efficiency and streamlining prescribing practices were described as beneficial aspects of dose prediction software by prescribers in an Australian teaching hospital.[37]

In the *job-fit* construct reported facilitators related to how the interventions improved job performance such as helping identify patients for interventions, increasing confidence when prescribing, and being useful when on call during the night. Perceptions reported to be barriers were interventions providing outdated information or negatively impacting workflow. For example, a study that implemented a microbiology reporting system found a negative job-fit in the ICU, as it was faster to report first microscopy and first bacterial
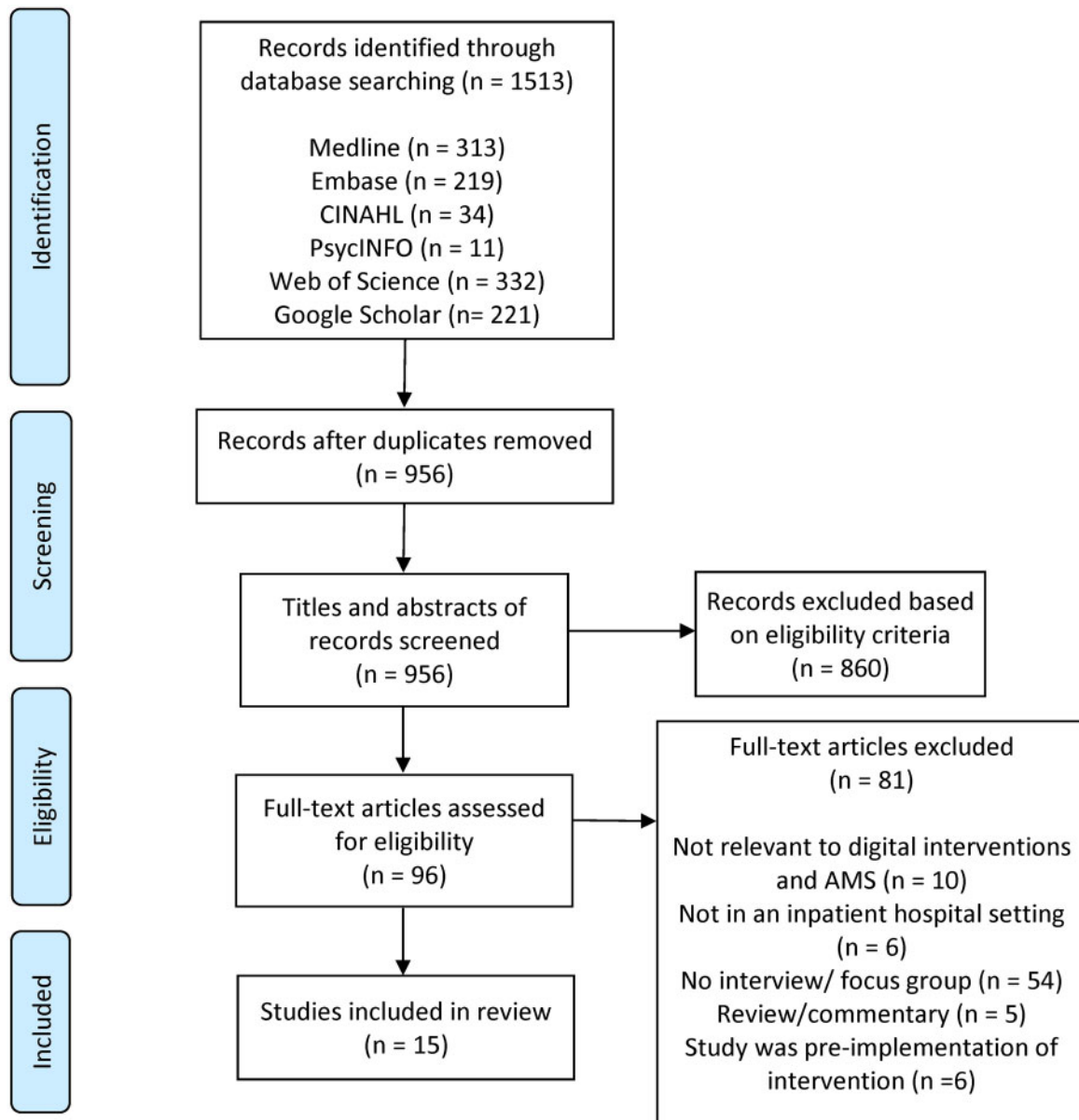
Figure 1. Study selection process.

growth results by telephone, and treatment for these patients was time-critical.[39]

Facilitating conditions

Facilitating conditions was the second largest domain. In the *compatibility* construct, the majority of user perceptions were barriers, such as the digital intervention not being compatible with existing workflow[35,37,49] and prescribing autonomy.[41,44,49] For example, ICU consultants using an antibiotic approval system reported that ICU patients required frequent addition and deletion of antibiotics, therefore seeking approval for every antibiotic was impractical, hence the intervention was not compatible with their workflow.[49]

The *facilitating conditions* construct includes objective factors in the environment that make using the digital intervention easy or difficult. The reported facilitators to system use were related to promotion of the intervention, and the provision of education and training. The barriers included lack of awareness of the intervention or lack of proficient training. For instance, in one UK study, use of a smartphone application that provided antimicrobial recommendations for indications was reportedly facilitated by education and publicity.[45] In an Australian study, pharmacists reported being dissatisfied with the limited promotion of a gentamicin dosing service and CDSS after implementation.[36]

Perceived behavioral control perceptions related to users' own skills or knowledge and internal and external constraints on their use of the system. Reported facilitators were increased frequency of use and understanding of the intervention's capabilities, and reported barriers were a lack of familiarity and/or knowledge in using or understanding the intervention.

Social influence

Within the *social influence* domain, the majority of user perspectives were classified into *subjective norm*[35,37,40,42] and *social factors*.[41,43,49] *Subjective norm* describes a user's perception that most people who are important to them think they should perform the behavior. The major-

Table 2. Study characteristics

Author (year)	Country	Setting	Intervention type	Overall design	Data collection	Sample size	Participants
Baysari et al[35] (2017)	Australia	Teaching hospital, 320 beds	Prewritten orders for restricted antimicrobials	Mixed methods	Interviews	11	Junior doctors (interns, residents, and registrars) and 1 Anesthetist
Bruins et al[39] (2011)	Netherlands	Multisite tertiary care teaching hospital, 1100 beds	Electronic microbiology result reporting system	Qualitative	Interviews	12	Specialist doctors (with highest number of micro test requests)
Carland et al[37] (2021)	Australia	Public teaching hospital, 320 beds	Dose prediction software for vancomycin	Qualitative	Interviews	17	Prescribers
Chow et al[40] (2015)	Singapore	Adult tertiary care hospital, 1500 beds	Antimicrobial Resistance Utilization and Surveillance Control (ARUSC)	Mixed methods	Focus groups	11 (2 focus groups)	Junior and senior doctors
Chow et al[41] (2016)	Singapore	Adult tertiary care hospital, 1500 beds	Antimicrobial Resistance Utilization and Surveillance Control (ARUSC)	Mixed methods	Focus groups	2 focus groups	Junior and senior doctors
Chua et al[42] (2018)	Singapore	Acute tertiary care teaching hospital, 1700 beds	CDSS (Provides patient-specific evidence-based antibiotic recommendations and guides antibiotic selection for empirical therapy based on user input on infection type)	Qualitative	Focus groups	39 (8 focus groups)	Junior and senior doctors
Diasinos et al[36] (2015)	Australia	Single teaching hospital, 320 beds	Gentamicin dosing service (using Bayesian pharmacokinetic prediction software) and medication alerts	Mixed methods	Interviews	12	Specialist doctors, registrars, and a resident
Giuliano et al[43] (2018)	USA	Nonprofit health network of 141 hospitals	SENTRI7 (CDSS)	Qualitative	Interviews	19	Pharmacists
Jones et al[44] (2017)	USA	Single hospital (200 active medical, surgical, and intensive care unit beds)	Timeout intervention: a dashboard, progress note template that both guided clinicians through the	Qualitative	Focus groups	6 focus groups	Attending physicians, residents, pharmacists

Table 2. continued

Author (year)	Country	Setting	Intervention type	Overall design	Data collection	Sample size	Participants
			antimicrobial decision-making process and documented that a time-out took place				
Morquin et al[38] (2018)	France	University hospital, 2000 beds	Tele-expertise system (ID specialist call and remote access to patient ID data form)	Mixed methods	interviews	6	Specialist doctors
Payne et al[45] (2014)	UK	2 hospital sites	Smartphone app (Antibiotic Formulary and Disease Management Protocol)	Mixed methods	Interviews	9	Doctors
Simoes et al[46] (2018)	Portugal	3 hospitals (ICU 8 beds, general and tertiary public hospital, 331 beds, and primary public hospital, 154 beds)	HAITooL (real-time surveillance and CDSS)	Mixed methods	Interviews	NR	Infection control team, physicians, pharmacy, and microbiology laboratory staff
Taber et al[47] (2021)	USA	8 Veterans Affairs hospitals	Antimicrobial stewardship dashboard	Qualitative	interviews	14	Infectious disease doctors, pharmacists
Thursky et al[48] (2007)	Australia	Medical/surgical ICU, 21 beds	ADVISE (real-time microbiology browser and decision support tool for antibiotic prescribing)	Mixed methods	Interviews	NR	Doctors, nurses, pharmacists
Zaidi et al[49] (2013)	Australia	University teaching hospital	iApprove (CDSS that offers clinical guidelines in a decision support format at the point of care)	Qualitative	Interviews	42	Junior and senior doctors, pharmacists

CDSS: Clinical Decision Support System; ICU: Intensive Care Unit; ID: Infectious Disease.

ity of perceptions were barriers, where junior doctors reported not accepting recommendations from digital interventions due to the influence of senior colleagues. For example, junior doctors in a Singapore tertiary hospital were inclined to follow the recommendations provided by the CDSS but reported overriding them when a senior colleague decided on a different antimicrobial.[40] In the *social factors* construct, the majority of reported perceptions were barriers. For example, in an interview study examining an antimicrobial approval system, some senior doctors were not supportive of the approval process as a concept, as they questioned the competence of infectious diseases junior doctors in approving antimicrobials.[49]

The construct *image*, which is the degree to which use of the digital intervention is perceived to enhance one's image or status, was aligned with only a small proportion of user perceptions, all reported in one study.[45] Interviews with doctors about use of a smartphone app that provided antimicrobial recommendations,

Figure 2. Frequency of 139 user perceptions extracted from 15 papers related to digital interventions used for antimicrobial prescribing and monitoring, mapped to the constructs and domains of the UTAUT framework. Number of studies (*n*) provided in brackets.

revealed that users were concerned about looking unprofessional when using the intervention on a smartphone in front of senior colleagues, other hospital staff, and patients (Table 3).

Effort expectancy

Effort expectancy represented the smallest domain. Barriers to acceptance in this domain included challenges using the system due to difficulties with access, and the complexity and time involved in completing tasks. Examples are included in Table 3.

DISCUSSION

This meta-synthesis of user perceptions of digital interventions used to prescribe and monitor antimicrobials in hospitals revealed that the main perception driving acceptance of these technologies was a belief that the system helped users achieve gains in job performance. Key facilitators promoting acceptance of digital interventions included systems being trusted and credible sources of information, systems improving task performance and increasing efficiency. Key barriers were digital interventions not considered to be useful for particular settings or patient conditions. Perceptions driving system

use were the presence of organizational and technical infrastructure. Key barriers to use included the systems conflicting with workflow and prescriber autonomy, and lack of user training or poor awareness of the system.

The current review showed that a large proportion of user perceptions of digital interventions for antimicrobial use were related to the perceived usefulness of the system. Perceived usefulness has been shown to be a key predictor of user acceptance in previous literature reviews of acceptance of technology in health care more generally,[50,51] demonstrating that this driver is not unique to the antimicrobial prescribing context. Specifically, we found a large number of perceptions were related to improved efficiency and safety, which is consistent with reviews exploring user perceptions of CDS systems for medications.[52,53] These findings suggest that focusing implementation strategies on ensuring users are aware of the utility of the digital intervention can increase uptake.

Effort expectancy, the degree of ease associated with using the system, did not emerge as a common user perception across the 15 papers in this review. This is at odds with previous reviews on health information systems[54] and electronic prescribing systems,[55] where effort expectancy and in particular, ease of use, are frequently mentioned factors impacting system uptake. The lack of focus on effort

Table 3. Examples of user perceptions of digital interventions for antimicrobial prescribing and monitoring from each UTAUT construct

UTAUT	Result, as reported in papers	Example participant quote
Performance expectancy		
• Perceived usefulness	Junior physicians trusted the credibility of ARUSC's (CDSS) recommendations and would use them as a "confidence booster" and to "cross-reference" their antibiotic choices[40]	"…you can back it up if the next day the next team asks you why it's like that, then you say "ARUSC (CDSS) recommended," so in that way, you're covered."
• Extrinsic motivation	One of the most common beliefs expressed by prescribers was that information recorded in the CPOE system was not being read or used. Therefore, there were no consequences for individual prescribers when they recorded an incorrect indication[35]	"The pharmacy is not going to be any wiser to the fact that the indication is wrong and it is not the indication"
• Job-fit	Helps find problems—pharmacists always reported CDSS use as a good method of identifying patients for interventions[43]	"I have learned things that I didn't even realize and I inquire and you know get an order changed and I know that I never would have caught before."
• Relative advantage	Redirects decision direction by making inappropriate vancomycin and piperacillin/tazobactam discontinuation easier than continuation—changes in the burden of clinical decision time and effort management made the antibiotic time-out system appealing.[44]	"I think [the approval template is] definitely a lot quicker and easier [than the old system]."
• Outcome expectations	Doctors explained that the CPOE system and the approval process in general were easy to override[35]	"The system lets you move, click forward even if you haven't given an appropriate indication or any indication at all—you just have to hit a letter"
Effort expectancy		
• Perceived ease of use	Double or triple documentation was typically viewed as due to lack of integration with the CDSS and the electronic medical record, necessitating documentation of interventions in both locations[43]	"I'm double documenting to a large degree. I do my antimicrobial stewardship and then I double document … I copy paste it into SENTRI7 (CDSS)"
• Complexity	Time and complexity of the CDSS are barriers to accepting ASP recommendations[42]	"It can be very time consuming to use (the CDSS) if you are not familiar with it" and "It's very frustrating (to use the CDSS) when you're on-call or called to see very sick patients, because all you want to do is to order a dose of antibiotic but you end up having to argue with the computer system."
• Ease of use	The fact that a request received for processing was marked in the system[39]	NR
Social influence		
• Subjective norm	Endorsed by peers and perceived experts[37]	"… if I knew that and if I was recommended by the pharmacists and by ID and micro then I am more than happy to use it."
• Social factors	Although pharmacists were comfortable making recommendations surrounding antibiotic use to non-ID physicians, pharmacists typically avoided making the same recommendation to ID specialists[43]	"So typically actually when our ID physicians are following … we kind of … you know they're part of the antimicrobial stewardship team and they lead us and we kind of back off of those"
• Image	Unprofessionalism—uncomfortable using smartphone in front of senior colleagues, other hospital staff, and patients[45]	"I feel it looks bad and unprofessional playing on your phone even if you explain its often a bit long-winded explaining why you have your phone out so it is easier not to do"
Facilitating conditions		
• Perceived behavioral control	Most of them did not notice that the system had links to the corresponding sections of the electronic version of the TGA[49]	"I must admit I usually turn to the TG (Antibiotic Guidelines) to decide on appropriate antibiotics for my patients so it would be good to have links to TG."
• Facilitating conditions	Most doctors had not used the computerized dose recommendation service that was accessible through the electronic-prescribing system because they were not aware that it was available.[36]	NR
• Compatibility	Clinical judgment was used to rationalize continued vancomycin, even when the evidence present would suggest stopping vancomycin.[44]	"Given the nature of how ugly the infection was, we wanted to continue the vanco even though we had some blood cultures growing or some wound cultures growing out that were not actually MRSA."

ASP: Antimicrobial Stewardship Program; CDSS: Clinical Decision Support System; CPOE: Computerized Provider Order Entry; ID: Infectious Disease; NR: Not Reported; MRSA: Methicillin-Resistant *Staphylococcus aureus*.

expectancy by users of digital interventions for antimicrobials could be due to systems being designed specifically for antimicrobial prescribing and monitoring, and so easier to use than more generic technologies. Research has also shown that effort expectancy becomes less important over time with extended and sustained use of the system,[33] which could be the case for some of the technologies explored here. Research is needed to explore these differences further.

A large proportion of user perceptions of digital interventions for antimicrobial use were associated with facilitating conditions, which highlighted the importance of users having an organizational infrastructure (eg, protocols, policies, governance) and technical infrastructure to support their use of the digital intervention. Many barriers to system use related to poor compatibility with existing organizational workflows and a lack of knowledge or training. These barriers have also been identified in studies of medication-related CDSS[52] and electronic medical records.[56] Working to overcome barriers by understanding user's workflow to ensure better integration, and providing organizational support through protocols and training, could lead to increased use of digital interventions.

We found several perceptions related to social influence, the majority of which were barriers relating to the senior-junior doctor relationship. Most antimicrobial prescribing interventions impact junior doctors, as they carry out most of the prescribing in hospital settings.[57] A key barrier to acceptance of digital interventions by junior doctors was identified to be the influence of senior colleagues, with junior doctors having to decide between following recommendations from digital interventions, or adhering to the prescribing etiquette set by their senior colleagues. This result is in line with previous research on antimicrobial prescribing,[57] and indicates that in this context of use, acceptance and use of digital interventions by senior doctors are critical to ensure junior doctors follow suit.

Our review demonstrates the importance of qualitative evaluation when implementing interventions to improve antimicrobial prescribing. The practice of antimicrobial prescribing is unique. Prescribing decisions are influenced by prescribing etiquette, including unspoken rules that encourage a culture of noninterference, and individual experience, that can "trump" formal policies and protocols.[57] Therefore, the effectiveness of digital interventions targeted to improve antimicrobial prescribing is likely to be strongly linked with user perceptions and acceptance. Three papers identified in our review used both qualitative methods to understand user perceptions, alongside quantitative methods to assess intervention efficacy.[35,36] Both Baysari et al[35] and Diasinos et al[36] described interventions that were not accepted or used by prescribers, that also failed to improve quantitative measures of prescribing. Similarly, Thursky et al[48] found high uptake and satisfaction with their intervention, alongside a reduction in the use of broad-spectrum antibiotics. This apparent correlation is further evidence of the need to gain user acceptance of an intervention in order to ensure uptake and therefore improve prescribing outcomes. However, more research is needed to definitively characterize this relationship.

This review has several limitations. The UTAUT framework facilitated the categorization of user perceptions into different constructs, but we found some overlap in the UTAUT domains and as a result some perceptions were able to be categorized under multiple constructs. To improve the reliability of coding, two independent reviewers categorized perceptions and discussed all discrepancies in coding, with a third reviewer used to reach a consensus if discrepancies could not be resolved. The quality of the included studies was also a limitation, with some lacking participant quotes to support findings. Additionally, some studies used mixed methods designs and provided little detail on their interview component as this was supplementary to the main evaluation; therefore, it was difficult to ascertain specifics of user perceptions, such as the demographics of participants or time using the system.

In conclusion, many of the factors that drive users to use digital interventions for antimicrobial prescribing and monitoring are consistent with those that drive uptake of other health technologies, but performance expectancy and social influence, specifically from senior clinicians, appear to be particularly important for this context of use. To ensure that digital interventions for antimicrobial prescribing are accepted and ultimately used, we recommend organizations ensure that systems are evaluated, that the benefits are visible to users, and that utility meets expectations. Crucially, senior clinicians' acceptance of systems should be prioritized to support junior clinician acceptance. Furthermore, organizations should ensure appropriate policies and training is in place to encourage and facilitate system use.

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AUTHOR CONTRIBUTIONS

All authors were involved in the study conception. BAVD, JEC, and MTB reviewed search results completed data extraction and analyzed data. BAVD drafted the manuscript and JEC, MTB, JP, and AR critically revised it. All authors read and approved the final manuscript.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *Journal of the American Medical Informatics Association* online.

CONFLICT OF INTEREST STATEMENT

None declared.

DATA AVAILABILITY

The data underlying this article are available in the article and in its online supplementary material.

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