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Barriers and Facilitators of Use of an Evidence-Based Clinical Resource among Clinicians in Limited-Resource Settings: An observational study using surveys and clickstream data

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Abstract

Objectives: This research aimed to understand the barriers and facilitators of using a digital evidence-based clinical resource (EBCR) known to improve patient outcomes among clinicians in resource-limited health facilities around the globe.

Design: We used an observational study design that enrolled 1,681 clinicians (physicians, surgeons, or physician's assistants) who applied for free access to an EBCR through our established donation program during a 9-week study enrollment period. Eligibility included working outside of the United States for a public or non-profit health facility serving vulnerable populations, having at least intermittent internet access, completing the application in English; and not being otherwise able to afford the subscription.

Interventions: After consenting to study participation, clinicians received a one-year subscription to a popular EBCR, UpToDate. They completed a series of surveys over the year, and we collected clickstream data tracking use of the EBCR.

Primary and secondary outcome measures:

1) the variation in EBCR use by demographic

2) the prevalence of barriers and facilitators of EBCR use

3) the relationship between barriers, facilitators, and EBCR use

Results:

Of 1,681 study enrollees, 69% were male and 71% were between 25 and 35 years old, with the plurality practicing general medicine and the majority in sub-Saharan Africa or Southeast Asia. Of the 11 barriers we assessed, fitting the tool into the workflow was a statistically significant barrier, making clinicians 50% less likely to use it. Of the 10 facilitators, a supportive professional context and utility were significant drivers of use.

Conclusions:

We recommend implementing EBCR use in cohorts of clinicians to generate a positive professional context, encouraging the use of EBCRs to increase exposure and help people realize their utility, and working with health systems to fit EBCR use into workflows.

Strengths and limitations:

- This study is the first of its kind to combine clickstream and survey data from clinicians around the globe to understand what drives their use of a digital EBCR. Using clickstream data – the very data that clinicians generate in accessing the digital tool—provides a robust data source that does not impede upon clinicians' time.
- This research contributes to a gap in the literature about what drives and impedes clinicians in resource-limited settings to use EBCRs and suggests key considerations for implementing new digital tools.
- Due to time and resource constraints, we could not measure all components of the logic model we built relating the use of EBCRs to patient outcomes. While we hypothesize that access to EBCRs can improve clinicians' sense of self-efficacy, the psychometrics of the self-efficacy scale we instituted did not function properly in this study and resulted in null results.

Background

Diagnostic and treatment errors account for a significant amount of harm across high-, middle-, and low-income settings. While some errors may be caused by opportunity challenges, such as inadequate supplies and equipment, an unknown proportion are due to gaps in knowledge and competence.[1] Frontline healthcare workers face a demanding cognitive load from the need to keep up with new evidence and incorporate it into care delivery, with more than 950,000 new publications indexed in MEDLINE every year.[2] The coronavirus pandemic has further increased the speed and volume of clinical evidence, exacerbating the challenges of keeping up with and incorporating the evidence into care decisions.[3]

Digital tools like evidence-based clinical resources (EBCRs), apps and websites that bring the most recent medical evidence to the clinician at the bedside, have become essential to sound decision-making. In 2019, before the outbreak of COVID-19, the World Health Organization acknowledged digital tools as important levers for ensuring effective, high-quality, equitable care.[4] Previous research has demonstrated a positive connection between EBCRs and clinician capacity; the use of a popular EBCR, UpToDate, was shown to increase performance on standardized exams among US clinicians[5] and, most importantly, to reduce risk-adjusted mortality rates at non-teaching hospitals.[6]

Despite these proven benefits, EBCR uptake and use among clinicians in resource-limited settings remain inconsistent.[7,8] In fact, the World Medical Association recently acknowledged that lack of access to timely, current, evidence-based healthcare information—which EBCRs can provide—is a major contributor to morbidity and mortality in resource-limited settings.[9] For some, the cost of an EBCR subscription, which can be up to $580 for an individual, limits access.

In 2009, we started a program that removed the cost barrier by offering free access to UpToDate for clinicians serving vulnerable communities at resource-limited health facilities, with the goal of improving patient outcomes and health equity. Eliminating the UpToDate subscription cost led to increased use of the tool; however, we observed wide discrepancies in use patterns, suggesting that other barriers to use persisted.[10] In order to better leverage the potential impact of EBCRs in limited-resource settings, it is important to understand what factors affect their uptake and use.

Using data from a global sample of clinicians who received UpToDate subscriptions through our donation program, our observational study aimed to describe:

1) the variation in EBCR use by demographic characteristics of users,

2) the prevalence of barriers to and facilitators of EBCR use in clinical practice, and

3) the relationship between barriers, facilitators, and EBCR use.

Study participants reported barriers and facilitators in repeated surveys over one year, and actual use of the tool was measured through clickstream data gathered from UpToDate.

Methods

Study sample

All clinicians who applied to the donation program during our 9-week enrollment period (March 1, 2018 to May 4, 2018) were invited to participate in and consent to the study. Eligibility criteria for the donation program included being a physician, surgeon, or physician's assistant outside of the United States; working for a public or non-profit limited-resource health facility; having at least intermittent internet access; being able to complete the application in English; verifying they are serving vulnerable populations; and not otherwise being able to afford the subscription. Recruitment activities were standard for the donation program with no additional recruitment efforts for study purposes.[1]

Patient and public involvement

No patients involved.

Logic model

We built a logic model detailing how access to an EBCR could eventually affect patient outcomes (Figure 1). In this model, the inputs were the donation itself and technical supports such as a functioning internet connection. These enabled users to log on to UpToDate and learn about it through the included orientation materials. These activities would then enable several short-term outcomes, including actual use of UpToDate, ability to navigate the tool, and perceived utility of the tool in practice. Medium-term outcomes included increased medical knowledge, integration of that knowledge into practice, and increased self-efficacy. In the longer term, these elements could lead to faster and more accurate

[1] Application and eligibility criteria are available at www.better-evidence.org.

diagnoses and clinical management, which would eventually translate to improved patient outcomes. This overall process would be facilitated by a professional context that supported EBCR use in clinical care.

Due to time and resource constraints, we could not measure all components of this logic model, but we measured several elements through two data streams: surveys and clickstream data.

Surveys

The survey included demographic, quantitative, and open-text response fields. We captured respondents' gender, age, years of experience, country of practice, urban/rural setting, patient load per week, and employment type (full-time paid vs. other).

We developed survey questions based on seven factors in the logic model downstream of the inputs as delineated in Table 1 [see Supplementary File 1 for survey questions].

Table 1: Barriers and facilitators measured in surveys

Factor	Measure	Surveyed at months
Barriers		
1 Access to the EBCR	Having a device	2,4,6,12
	Access to internet	2,4,6,12
	Cost of data plan	2,4,6,12
	Ability to download the tool	2,4,6
	Slow internet speed	6,12
2 Ability to navigate the EBCR	Knowing what is available	6,12
	Finding the information I need	2,4,6,12
3 Integration of the EBCR's information into practice	Having what I need to apply the information	2,4,6,12
	Understanding the medical content	2,4,6,12
	Lack of time	2,4
	Difficult to fit into work flow	6,12
Facilitators		
4 Orientation materials	Accessed orientation materials	6,12
5 Utility of the EBCR in practice	Compared to before had the tool, able to find answers more often about:	6,12

	Diagnosis Treatment Procedure Device	
6 Professional context	Clinician level:	6,12
	Most clinical colleagues use the tool Typical provider views tool use positively Use the tool in front of other clinicians	
	Patient level:	6,12
	Typical patient views tool use positively Use the tool in front of patients	

Factors 1 to 3 were measured as barriers to use. Factors 4 to 6 were measured as facilitators of use. Four types of clinical decisions were covered in the survey: treatments, diagnoses, devices, and procedures. We measured Factor 7, a sense of self-efficacy, with the 8-item New General Self Efficacy scale.[11] We added a contextualizing frame at the start of the scale: "When providing clinical care, how true are the following statements for you?"

We collapsed 34 categories of specialties into 8 groups (see Appendix A). Twelve prior donation recipients provided feedback on the survey's clarity, wording, response options, and acceptability. The survey was adapted accordingly.

We integrated the baseline survey and the UpToDate donation application. Following the application approval, survey links were then triggered to be sent by email for the 2-month survey (sent 60 days after approval), 4-month survey (120 days after), 6-month survey (180 days after), and 12-month final survey (350 days after). We excluded survey answers that were completed more than 30 days after the survey link was sent.

The baseline, 6-, and 12-month surveys covered all topics; to reduce respondent burden, the 2- and 4-month surveys only measured self-efficacy and barriers to use. Participants automatically received a 6-month subscription extension for completing the 6-month survey and another 6-month extension for completing the 12-month survey. In addition, those completing the 12-month survey were entered into a drawing for 10 prizes of $100. The survey was built and administered in RedCap.[12]

Clickstream data

We measured the actual use of UpToDate (purple box in Figure 1) through the tool's clickstream data, a machine-generated record of each click from every user, identifying which pages users visited and when, starting from the day the subscription link was sent out for 365 days. UpToDate recorded and shared clicks across all mobile and desktop applications as well as during offline use.

We linked the survey data to the clickstream data through a unique identifier. We qualified online use in two ways: first, we created a binary indicator of whether a user ever logged on through the donated link, called "ever-users" and, second, we calculated the total amount of time ever-users spent using UpToDate over the yearlong study period. We estimated the length of specific user sessions as a function of 1) the time between clicks, 2) the content or function clicked on, and 3) overall estimates of the amount of time spent reading content, navigating the site, and managing user accounts. These methods have been detailed elsewhere.[13]

Quantitative analysis

We grouped countries into the six geographic regions used by the World Health Organization. We determined the total number of donees in each respondent's country using historical administrative data from the donation program. We reported the percent distributions of all demographic characteristics of the study sample.

We then calculated the percent of each demographic subgroup who were ever-users, and among them, the median number of hours they spent using the tool over the year. We used median hours instead of means

due to a highly logged distribution. We presented the proportion of users who experienced each barrier or facilitator once they had the subscription, at the 2-, 4-, 6-, or 12-month mark.

Next, we modeled the relationship between barriers, facilitators, and use of the tool. The first set of regression models predicted the use of the tool around the time of the survey. For each user, we first identified the date they completed the 2-, 4-, 6-, or 12-month survey, and summed up the amount of time they spent using the tool in the two weeks around that date (7 days before to 7 days after), using the clickstream data. We fit 21 statistical models, one for each barrier or facilitator we measured, of the form:

$$Y_{im} = \beta_0 + \beta_1 m + \beta_2 BF_{im} + \beta_x [X]_i + \varepsilon$$

Where: β_n = regression coefficient

Y_i = any use of the tool by subject i in the two weeks around survey month m (binary)

m = month of survey (encoded as a continuous variable with values 2,4,6, and 12)

BF_{im} = presence of barrier or facilitator for subject i at survey month m (binary)

X_i = vector of demographic characteristics for subject i.

These 21 generalized linear models used a binary link function to the outcome and accounted for repeated measures over each subject.

The second set of models included only ever-users of the tool and predicted the minutes spent using the tool around the time that a barrier or facilitator was reported to be present. Like the first set of models, these accounted for repeated measures over subjects. The dependent variable—the minutes of use around each survey—was logged to bring its distribution closer to normality, and no link function was applied.

To select demographic variables to include in the model, we tested each variable for the strength of its relationship to both outcomes and for collinearity with other demographic variables. This process identified three controls to include in the model: age category, specialty, and the total number of UpToDate donation recipients in the user's country. In order to constrain the risks of multiple testing over

the full set of (42) models, we set the alpha level for each coefficient at 0.0012, which is the standard alpha of 0.05 divided by 42. In line with this alpha threshold, we present 99.9% confidence intervals. All analyses were done in SAS 9.4 (Cary, NC: SAS Institute. Inc.).

Qualitative analysis

We imported the free-text responses from the surveys into NVivo 12 (QSR International Pty Ltd.) for coding and analysis. The coding scheme included high-level themes developed deductively from the research questions and sub-themes developed inductively based on the content of the responses. Responses tended to be brief, containing a single idea closely aligned with the theme, so codes were applied with little need for interpretation or subjectivity. We included a sample of 250 surveys for analysis, choosing at random from across the spectrum of EBCR use.. One person coded all the responses for consistency.

Results

We had 1,681 study enrollees and collected baseline data on all. Follow-up survey response rates were 67% at month 2, 60% at month 4, 54% at month 6, and 58% at month 12. Eighteen percent of respondents answered all four follow-up surveys, and 36% answered none. Based on the clickstream data, 249 (15%) of the enrollees never used the tool at all; although, 245 (98%) of these did respond to at least one follow-up survey.

Demographic characteristics

The vast majority (69%) of study enrollees were male, and most respondents (71%) were between 25 and 35 years old. As is typical, years of experience was highly correlated with age, and most respondents (55%) had four or fewer years of experience. A plurality of subjects (42%) were general practitioners, with 22% in a medical subspecialty. Surgery, pediatrics, and other specialties each had under 10% of respondents. Nearly two-thirds of the sample (61%) was in full-time paid work. Patient load fell into

rough quartiles: 20% saw under 50 patients per week, 25% saw 50 to 99 patients, 29% saw 100 to 199 patients, and the remaining 26% saw 200 or more patients. Most subjects (57%) were in urban settings, with 26% in rural settings, and the remainder in mixed areas (Figure 2).

Two-thirds of our sample came from countries with 200 or more other donation recipients. A quarter of respondents came from countries with 50–199 donation recipients, and the remaining 9%, from countries with only 1–49 other donation recipients. Eighteen study participants were the first and sole donation recipients in their entire country. Finally, the study sample included clinicians from all six geographic regions, mainly from Southeast Asia (35%) and sub-Saharan Africa (33%).

Variation in EBCR use by demographic characteristics

While 85% of the sample used the tool at least once, percent of ever-users ranged from 77% to 89% depending on the demographic group (Figure 2).

Ever-users of the tool (N = 1,432) spent a median of 5.0 hours using it over the course of the study year, a number that varied strongly by some demographic groups (Figure 2). Variation by specialty was marked, ranging from 1.9 hours for surgical subspecialists to 7.3 hours for medical practitioners. Similarly, variation by geographic region was large, from 3.3 hours for users in Sub-Saharan Africa to 7.2 hours for users in Europe.

As for age, the middle age group (25 to 35 years) used the tool for 5.8 median hours, while the younger users (under 25) used it for 4.2 hours, and the older users (over age 35) used it for 3.2 hours. The lower use among older users was also reflected in the results by years of experience: those with seven or more years of experience used the tool for less time than others (3.9 hours vs. 5.4 or more hours).

Those with the highest patient load (200 or more patients per week) used the tool for comparatively longer over the year, 6.2 median hours, compared to the median across other groups, 4.5 to 4.8 hours. Users in countries with many donation recipients (200 or more) used the tool for 5.6 median hours over

the year, while those from countries with fewer than 200 recipients used it less, for 3.8 to 4.0 median hours. There was very little variation in median hours of use by gender, employment type, or urban/rural setting.

Prevalence of barriers and facilitators to EBCR use in clinical practice

The least common technical barrier (Figure 3, Factor 1) was lack of a device (6% or less at all time points), and the most common barrier was slow internet speed (reported by about 33% of users at months 6 and 12). The percent of users reporting difficulties with access to the internet declined over time, from 31% at month 2 to 16% at month 12 (Figure 3, Factor 1).

Few users reported barriers to navigating the tool (Figure 3, Factor 2). In each follow-up survey in which these questions were asked, 9% or fewer respondents reported that they faced barriers either in knowing what was available or in finding the information they needed in the tool.

Fewer than 20% of users at any time point faced the barriers of lack of time, understanding the medical content, or finding it difficult to fit into their workflow. One clinician mentioned in a free-text response, “Even though I don't speak English fluently, I can understand easily because the terms they use are not complicated...it's very easy when you want to find out something...you get it quickly.” However, enrollees also explained workflow concerns: "Patient flow is way too high. So I don't get time to open UpToDate at that time..." and "[It's] tough opening UpToDate and checking patients in a crowded and hurr[ied] situation.” Regarding having what was needed to apply the information learned from the tool in practice, the percentage of users reporting this barrier rose from 13% at month 2 to 32% at month 12 (Figure 3, Factor 3).

As for facilitators, approximately 40% of respondents at months 6 and 12 reported that they had ever referred to the orientation materials (Figure 3, Factor 4). The utility of the tool in practice, measured as the percentage of users who reported being able to find answers to questions more readily as compared to

before they had the tool, was stable across months 6 and 12:47% of respondents were better able to find answers to treatment questions, 43% to find answers to diagnostic questions, 34% to procedure questions, and 33% to device questions (Figure 3, Factor 5). Clinicians shared examples of using the tool:

> "Let me exemplify a case of pneumothorax. There was a lot of debate regarding the tube thoracostomy. One of the residents read out the contents of UpToDate, and thence the tube thoracostomy was planned."

> "I have been using UpToDate to make management plans for my patients and to optimize their care. Whenever I am having a problem getting a diagnosis for a patient, I go to UpToDate and read around the topic."

The professional context results were fairly consistent across months 6 and 12. Approximately 80% of respondents reported that clinicians typically viewed the use of an EBCR positively, and roughly 70% said that most of their clinical colleagues used such tools. About 65% reported using the tools often or very often in front of other clinicians (Figure 3, Factor 6). Open text answers related to this factor include responses such as "Senior [attendings] recommend it" and "It is commonly known and most colleagues use it." One clinician explained, "I came to know about the subscription of UpToDate through my colleague. There was an incident when I was working late night duty. I was confused about the latest recommendation, and my colleague helped me with the help of UpToDate."

Clinicians did not feel patients were as supportive of tool use. Only 30% of subjects reported that they believed their typical patient viewed the use of UpToDate during care positively, and about a quarter used the tool often or very often in front of patients during clinical care (Figure 3, Factor 6).

Self-efficacy

The self-efficacy results were problematic, including ceiling effects and evidence of straightlining (24% of all administrations of the scale had the same response for all eight questions). Moreover, we found

almost no group-level variation where it might be expected: across age, years of experience, specialty, geographic region, or any other demographic group. Self-efficacy scores showed no consistent or notable increase or decrease over time, either on the group level or the individual level. By comparison, other survey questions did exhibit these basic features of item validity and functioning. Given it is implausible that the self-efficacy of all clinicians was identical and unchanging, we concluded that the psychometrics of the self-efficacy scale did not function properly in this study. For this reason, we dropped self-efficacy (Factor 7) from our presentation of results.

Relationship between barriers, facilitators, and EBCR use.

Results of the statistical models are presented in Figure 4. Panel A shows the estimated odds ratios of using the tool around the time when a barrier or facilitator was present compared to when it was not present, adjusted for age, specialty, and number of donation recipients in the subject's country. For the 11 barriers, most estimates were less than 1, suggesting that the odds of using the tool was lower when the barrier was present. However, only one of these relationships rose to statistical significance under the multiplicity adjusted alpha threshold: when clinicians reported that it was difficult to fit the tool into their workflow, they were 42% less likely to use it (OR 0.56, $p = 0.0003$).

For facilitators, most odds ratios were near or above 1, suggesting that the odds of using the tool may have been higher when the facilitator was present. Of the 10 facilitators, two were statistically significant. First, users were 1.5 times more likely to log on if they reported that using UpToDate increased their ability to find answers to their clinical questions about treatments (OR 1.5, $p = 0.0001$). Second, users were 1.7 times more likely to log on to the tool if their professional context supported using the tool in front of other clinicians (OR 1.7, $p < 0.0001$).

Panel B shows the estimated ratio of minutes using the tool around the time that the barrier or facilitator was present. For the 11 barriers, none of these coefficients were statistically significant, although most were below 1, which was in the expected direction. Among the 10 facilitators, most were above 1,

suggesting longer use of the tool at the time that the facilitator was present. One coefficient reached statistical significance: when users felt that they could more easily find answers to questions about diagnoses, they spent 1.4 times as many minutes using the tool, compared to when they did not feel they could answer more questions (ratio of minutes 1.4, p = 0.0004).

Discussion

Our results drew attention to three factors relating to clinicians' uptake and usage of EBCRs. The first factor (Factor 3) highlighted the ability to integrate EBCRs into practice. Of statistical significance, when clinicians reported difficulty fitting the tool into their daily workflow, they were only about half as likely to log on to the tool as when they did not face that difficulty. Although under 20% of clinicians reported lack of time, difficulty fitting the tool into their workflow, or problems understanding the medical content, and not all had statistically significant findings, clinicians who faced such barriers did appear to use the EBCR less. Interestingly, over the study year, the prevalence of not having what was needed to apply the information in UpToDate (Factor 3) rose from 14% to 33%. This increase over time could demonstrate decreasing resource levels for clinicians or clinicians' increased knowledge of the resources they lack. In other words, clinicians may have been more aware than previously of newer supplies and tests that were unavailable to them after a year of using UpToDate. Regardless, the presence of this barrier did not deter EBCR use: it was not associated with how likely users were to log in nor the number of minutes they spent using the tool.

Second, the facilitator of perceived utility of the tool (Factor 5) seemed to matter for uptake. For example, the percentage of subjects reporting an improved ability to find answers to questions about treatments and diagnoses (as compared to before having access to the tool) was consistently above 40%. Moreover, though not all correlations were statistically significant at the multiplicity adjusted threshold, donees recognizing the tool's utility for treatment and diagnostic decision making were more likely to log in to the tool and spent more minutes on the tool than those who did not report increased ability to find answers

with the tool. In other words, positive perceptions of the tool's utility for diagnoses and treatment correlated with more use of the tool.

Third, a positive professional context (Factor 6) also seemed to facilitate tool use. Measures of professional context (the belief that colleagues viewed the use of the tool positively, most clinical colleagues used the tool, and used the tool in front of other clinicians) were all consistently reported by more than 60% of participants. When subjects reported feeling comfortable using the tool in front of other clinicians, they were approximately 70% more likely to log in to the EBCR (statistically significant) and spent 30% more minutes on the tool (not statistically significant at multiplicity adjusted threshold). Study participants in countries with 200 or more donation recipients used the tool for longer over the year compared to those in countries with fewer donation recipients. A professional context in which more clinicians had access to the tool and felt comfortable using it in front of other clinicians was associated with more use of the tool.

Other barriers and facilitators we tested did not show these kinds of relationships. For example, facing technical access barriers did not significantly change the odds of using the tool or of the amount of time spent using it. This result may seem counterintuitive but likely points toward the determination of these motivated users. For example, at months 2 and 4, about a third of users reported that access to the internet was a barrier for them, but this proportion fell to about 20% at months 6 and 12, and limited access to the internet was not related to the likelihood of logging on or how long was spent using the tool. This could have resulted from differential dropout—those with worse internet access stopped responding to surveys—or the users may have learned how to download and use the tool offline or secured better internet connections. These technical considerations were not the barriers to use that we might have expected. Similarly, users did not report high levels of difficulty navigating the tool or finding information on it. About 40% of clinicians reported using the orientation materials, but reading those materials was not a significant facilitator of tool use.

Our study had several limitations. First, while our sample of clinicians was large and diverse, it was non-representative across countries and types of clinicians because we accepted all clinicians who applied during the study period. Second, any of the factors can be framed and measured as either barriers or facilitators; we measured some as barriers and others as facilitators, which may have impacted how participants answered the questions. Third, the sample clearly included only clinicians motivated to apply to the program, making it non-representative of the general clinician population. The self-selecting nature of our sample limits the generalizability of our conclusions; Finally, we were able to integrate the baseline survey into our application process in order to not alter the application experience dramatically; however, other surveys may have influenced tool use by reminding users about the tool when they normally would receive no such reminder.

Globally, the healthcare workforce faces scarce time and attention, high demand for services, varied patient populations, and ever-growing medical literature. As a result, clinicians must remember, apply, and integrate a massive volume of information under difficult circumstances. Digital tools can help, but only if clinicians can and do use them in clinical care. We believe that the patterns suggested here can serve as the basis for further implementation work and research to better understand how to best reach diverse both more and less motivated populations of clinicians.

Conclusion

This study can inform future implementation work in resource-limited settings. Findings suggest implementing EBCR use in cohorts of clinicians to generate supportive professional contexts, encouraging the use of EBCRs over time to increase exposure and help clinicians realize the utility of EBCRs, and working with health systems to promote EBCR use in workflows.

There is great potential for EBCRs to help ensure effective and high-quality care. By learning how to better facilitate use and minimize barriers among clinicians around the globe, we can take an important

step toward more accurate, faster diagnostic and clinical management leading to better, more equitable health outcomes.

Declarations

Author contributions:

JR conceived the design of the work, contributed to survey design and data collection, to data analysis and interpretation, to drafting and critical revision of the article, and to final approval of the version to be published. KM contributed to the design of the work, survey design, data analysis and interpretation, drafting and critical revision of the article and final approval of the version to be published. OP contributed to data collection, data analysis and interpretation, and final approval of the version of the article to be published. NH contributed to survey design and data collection, to data analysis and interpretation, and to revision and approval of the final version of the article to be published. AK contributed to drafting the article, critical revision, and final approval of the version to be published. RW conceived of the design of the work, contributed to survey design, to data analysis and interpretation, critical revision of the article and final approval of the version to be published.

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Data Sharing: Restrictions apply to the availability of study data, which were used under a data use agreement for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of UpToDate.

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Ethics Approval:

This study received ethical approval from the Partners Human Research Committee (Protocol: 2018P001183; now called Mass General Brigham Institutional Review Board). The Harvard T. H. Chan School of Public Health institutional review board ceded review to the Partners Human Research Committee. All participants provided informed consent. The informed consent addressed the collection of both the survey and clickstream data.

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Figure Legends:

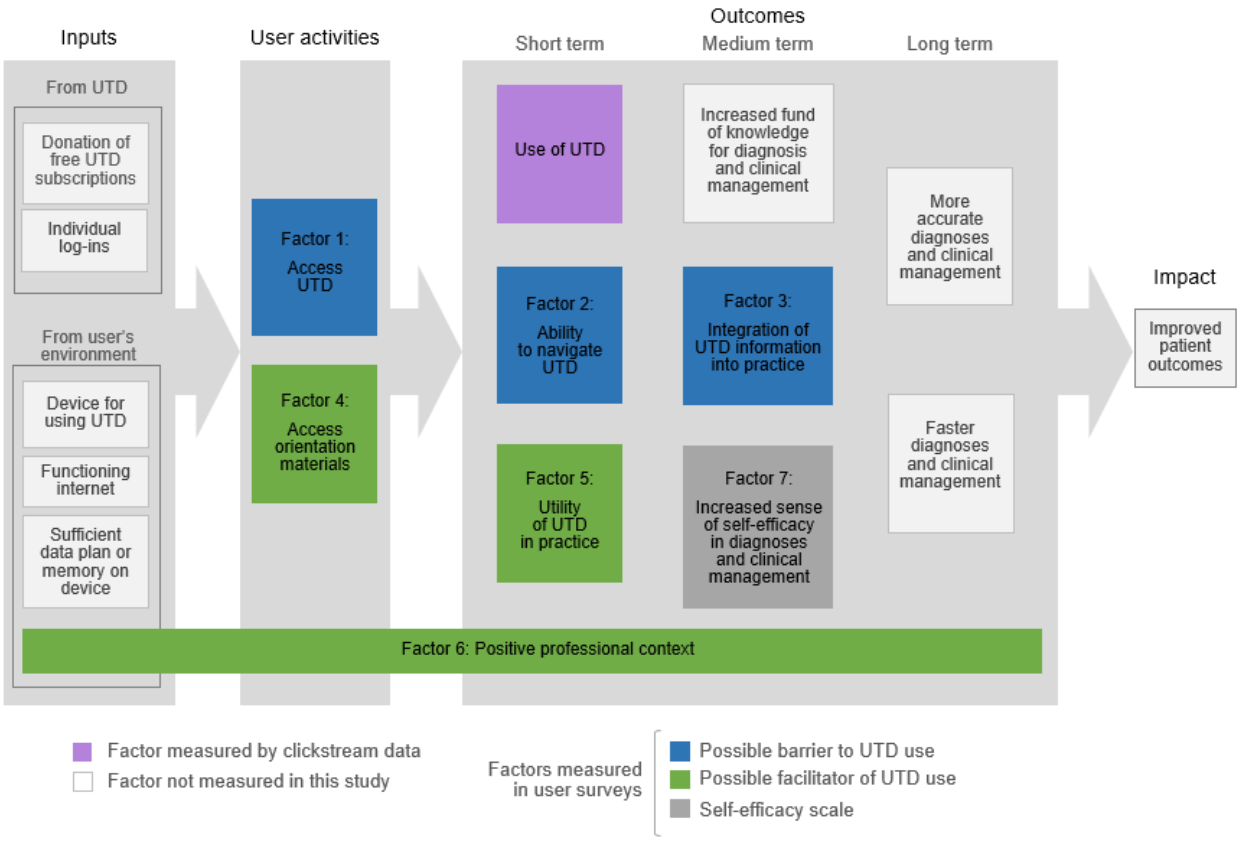
Figure 1: Logic Model

Figure 2: Population Demographics and Use of the Tool

Figure 3: Percent of users reporting presence of each barrier or facilitator by survey month

Figure 4: Relationship between barriers, facilitators and use of the tool around the time of the survey

Figure 1: Logic model



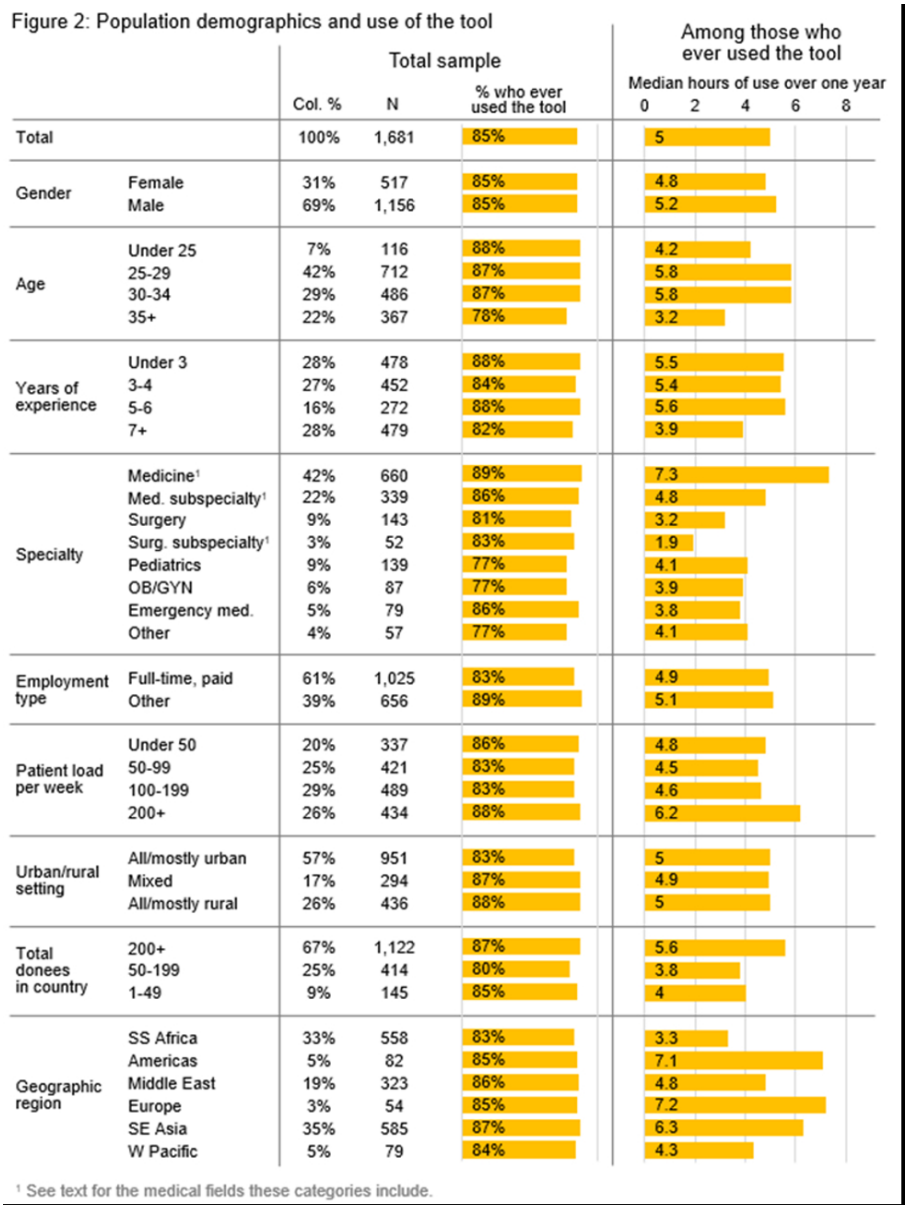


Figure 2: Population Demographics and Use of the Tool

165x220mm (150 x 150 DPI)

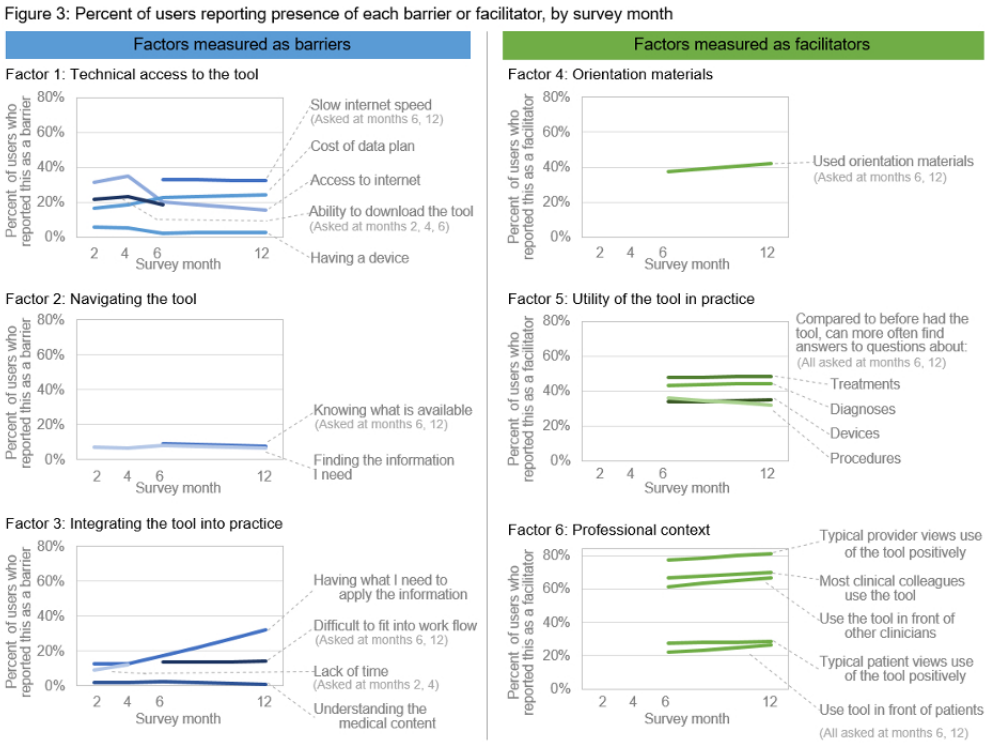


Figure 3: Percent of users reporting presence of each barrier or facilitator by survey month

165x123mm (144 x 144 DPI)

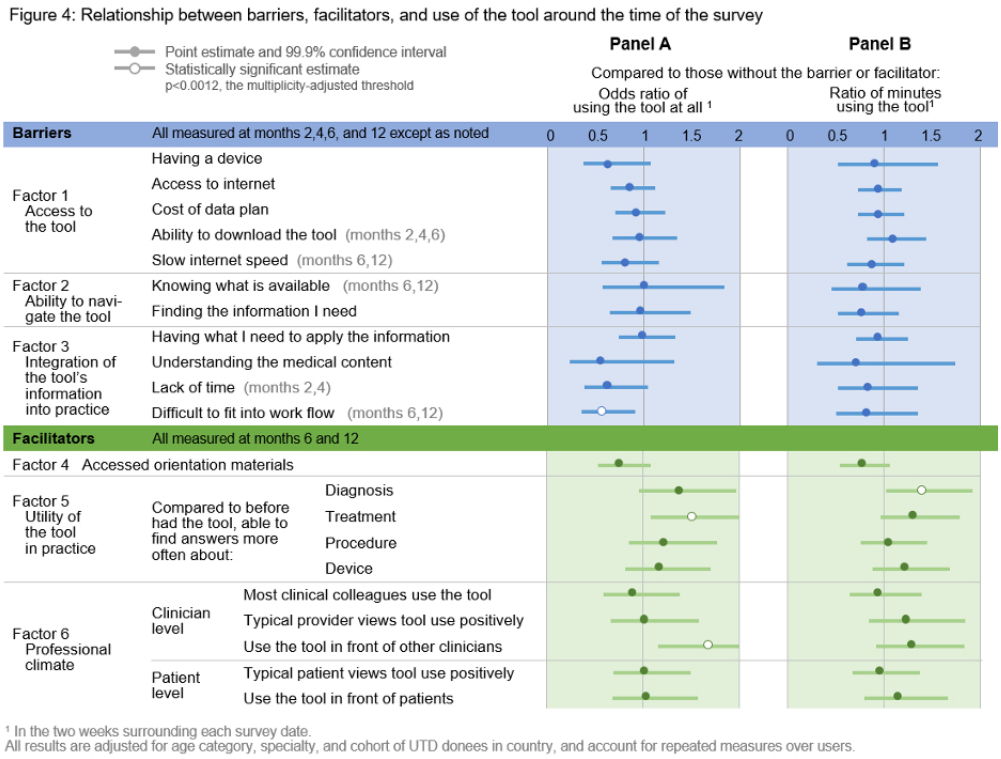


Figure 4: Relationship between barriers, facilitators and use of the tool around the time of the survey

165x125mm (144 x 144 DPI)

Appendix A

The 34 categories of medical specialties were collapsed into 8 groups as follows:

1. Medicine: family medicine, general practice, and internal medicine
2. Medical subspecialty: allergy and immunology, anesthesiology, cardiology, dermatology, endocrinology, gastroenterology, geriatrics, hematology, hospital medicine, infectious disease, nephrology, neurology, oncology, psychiatry, pulmonary, rheumatology, sports medicine, and women's health
3. Surgical subspecialty: ophthalmology, orthopedic surgery, otorhinolaryngology, and urology.
4. Other specialty: pathology, radiology, and other
5. Emergency medicine: no subgroups
6. OB/GYN: no subgroups
7. Pediatrics: no subgroups
8. Surgery: no subgroups

UpToDate-GHD Donation Application

* Required

Terms and conditions

Grant Privacy Policy, Requirements and Termination Clause
http://www.globalhealthdelivery.org/files/ghd/files/grant-privacy-policy-requirements-termination-clause.pdf

UpToDate, Inc. Subscription and License Agreement
http://www.globalhealthdelivery.org/files/ghd/files/uptodate-license-agreement.pdf

Note: Some UpToDate donations have subsequently led to paid subscription accounts; in some circumstances, applicants may be contacted by UpToDate sales representatives to facilitate such arrangements.

1. **I agree to the terms and conditions** *
   Mark only one oval.

   ◯ Yes

Tell us about yourself

2. **First name / given name** *

3. **Last name / family name** *

4. **Suffix** *
Check all that apply.

- [ ] MD
- [ ] DO
- [ ] RN
- [ ] MBBS
- [ ] PhD
- [ ] MPH
- [ ] MBA
- [ ] N/A
- [ ] Other: _____

5. **What is your age?** *

_____

6. **If you are a clinician, please tell us where and when you received your highest level of training.**

_____

7. **How many years of clinical experience do you have?** *

_____

8. **Preferred email address** *

_____

9. **Preferred email address (please re-type)** *

_____

10. **Preferred phone number (please do not include any special characters)** *

_____

Tell us about your work

11. **Name of your organization** *

12. **Organization mailing address** *

13. **City where you work with the organization** *

14. **Country where you work with the organization** *

15. **Your organization is:** *
Check all that apply.

- [ ] A government agency
- [ ] A university, college, or other education
- [ ] A non-governmental organization (NGO)
- [ ] A public hospital
- [ ] A mission hospital
- [ ] A physician solo practice
- [ ] A group/family practice
- [ ] Other: _____

16. **Where does funding/revenue for your organization's services come from?** *
Check all that apply.

- [ ] Government
- [ ] International donors (PEPFAR, USAID, DFID, Global Fund, etc.)
- [ ] Patients' insurance
- [ ] Patients' payments and fees
- [ ] Private philanthropy
- [ ] Other: _____

17. **Is your organization in a rural or urban setting?** *
Mark only one oval.

- ◯ Mostly urban
- ◯ Mostly rural
- ◯ All rural
- ◯ All urban
- ◯ 50/50

18. **What is your status with this organization?** *
Mark only one oval.

- ◯ Full-time paid employee
- ◯ Part-time paid employee
- ◯ Volunteer
- ◯ Contractor
- ◯ Consultant
- ◯ Invited guest
- ◯ Other: _____

19. **What is your role/profession?** *
Mark only one oval.

- ◯ Physician
- ◯ Physician assistant
- ◯ Nurse
- ◯ Nurse practitioner
- ◯ Pharmacist
- ◯ Corporate
- ◯ Medical librarian
- ◯ Medical student
- ◯ Resident
- ◯ Other: _____

20. **What is your medical specialty?**
Mark only one oval.

- ◯ Allergy and immunology
- ◯ Anesthesiology
- ◯ Cardiology

- [ ] Dermatology
- [ ] Emergency medicine
- [ ] Endocrinology
- [ ] Family medicine
- [ ] Gastroenterology
- [ ] General practice
- [ ] Geriatrics
- [ ] Hematology
- [ ] Hospital medicine
- [ ] Infectious disease
- [ ] Internal medicine
- [ ] Nephrology
- [ ] Neurology
- [ ] OB/GYN
- [ ] Oncology
- [ ] Ophthalmology
- [ ] Orthopedic surgery
- [ ] Otorhinolaryngology
- [ ] Palliative care
- [ ] Pathology
- [ ] Pediatrics
- [ ] Psychiatry
- [ ] Pulmonary
- [ ] Radiology
- [ ] Rheumatology
- [ ] Sleep medicine
- [ ] Sports medicine
- [ ] Surgery
- [ ] Urology
- [ ] Women's health
- [ ] Other: _____

Tell us why you need a donated subscription

21. **In a short paragraph, please tell us more about your work:** *
Please describe the mission of your organization, why and when you got involved, and what you work on.

22. **In a short paragraph, please tell us why you should receive a donated UpToDate subscription and its potential impact on the community you serve.** *

UpToDate features

23. **Please check the offline features you will need with your subscription.** *
Check all that apply.

☐ MobileComplete: An application that enables offline access on a smartphone or tablet after an initial Internet-powered install for Apple and Android devices

☐ Downloadable Desktop: An application that enables offline access on a desktop computer or laptop after an initial Internet-powered download.

Baseline Survey (Pre-donation)

1. Which of the following are important when you are deciding whether or not to look up clinical information online? (Select all that are apply.)

    a. Having ready access to a device to use, such as a smart phone or computer
    b. Access to internet
    c. Cost of data access plan
    d. Anticipated ease of finding the information I need
    e. Likelihood of having the tests or medicines I need to apply the information in clinical practice
    f. The potential of the content to improve the care I provide
    g. The ability to use it in my usual workflow

2.

	Never	Rarely	Sometimes		Often	
a. How often do you look for information online when a patient presents with a condition you treat frequently?	1	2	3	4	5	6
b. How often do you look for information online when a patient presents with a condition you have not treated before?	1	2	3	4	5	6

3. Why did you decide to apply for an UpToDate subscription? (Select all that apply)

    a. I saw other practitioners using it.
    b. It was recommended to me.
    c. I received a promotional email.
    d. It seemed like a good deal (free).
    e. I want to improve my clinical practice.
    f. Other (please describe)

    g. If other: Please describe the reason. [open text]

4. How often do you have access to a smartphone, tablet or computer while providing clinical care?

    a. Never
    b. Rarely
    c. Sometimes
    d. Often
    e. Almost always
    f. Always

5. Approximately how many of the clinical care providers that you work with use UpToDate? (Select one)

a. 100%
b. 75%
c. 50%
d. 25%
e. 0%
f. I don't know
g. N/A (I don't work with other clinical providers.)

6.	Negatively		Neutrally	Positively	It's highly variable	I don't know
a. How do you think clinicians in your area would view the use of an online tool like UpToDate for clinical care?	1	2	3	4	5	
b. How do you think your patients would view the use of an online tool like UpToDate during clinical care?	1	2	3	4	5	

7.	Never	Rarely	Sometimes	Often	Almost always	Always	N/A
a. In the last month, when you've had diagnostic questions, how often have you been able to find the answers?	1	2	3	4	5	6	7
b. In the last month, when you've had questions about creating a treatment plan, how often have you been able to find the answers?	1	2	3	4	5	6	7
c. In the last month, when you've had questions about using a medical device, how often have you been able to find the answers?	1	2	3	4	5	6	7
d. In the last month, when you've had questions about preparing for a procedure, how often have you been able to find the answers?	1	2	3	4	5	6	7

8. Approximately how often do you learn useful information from the following sources?

	Never	A few times per year	Monthly	Weekly	Daily

a. Colleagues	1	2	3	4	5
b. UpToDate	1	2	3	4	5
c. Other online resources	1	2	3	4	5
d. Textbooks	1	2	3	4	5
e. WHO protocols	1	2	3	4	5
f. In-person lectures or trainings	1	2	3	4	5

9. When providing clinical care, how true are the following statements for you?

	Not at all true	Hardly true	Moderately true	Exactly true
a. I will be able to achieve most of the goals that I have set for myself.	1	2	3	4
b. When facing difficult tasks, I am certain that I will accomplish them.	1	2	3	4
c. In general, I think that I can obtain outcomes that are important to me.	1	2	3	4
d. I believe I can succeed at most any endeavor to which I set my mind.	1	2	3	4
e. I will be able to successfully overcome many challenges.	1	2	3	4
f. I am confident that I can perform effectively on many different tasks.	1	2	3	4
g. Compared to other people, I can do most tasks very well.	1	2	3	4
h. Even when things are tough, I can perform well.	1	2	3	4

12 month survey

Thank you for your interest in helping us improve our impact by completing this brief survey. In exchange for your participation, you will get an additional 6 months of UpToDate access added to your subscription.

Filling out this survey serves as a statement of informed consent from you, meaning that you agree to participate in the study. Participation in this study is completely voluntary, and refusal to participate will not affect your future eligibility for free access to UpToDate or for any other benefits to which you may be entitled. You may discontinue your participation in this study at any time. We anticipate enrolling approximately 1,600 participants.

How: The following survey will ask you about your thoughts on UpToDate and your experiences using it as well as your clinical confidence. The survey should take approximately 20 minutes. We will also review your activity on UpToDate using your username to understand how frequently you log on, what you search for, and what topics you view.

Benefits: By opting in to the study extension and completing the final survey, participants will receive an additional six months for a total of a 24-month subscription and will be eligible to renew their subscriptions and continue receiving access. You may use UpToDate from any device or network. Currently, a year of subscription to UpToDate for an individual medical professional in the US costs $495 US Dollars. You will not receive any monetary compensation for your participation.

Privacy: Your data (survey responses, UpToDate usage) will be linked to your email but will be kept fully confidential in password-protected computers. Your personal information, individual responses, and data use will not be shared with anyone beyond our research team, but study results in aggregate may be published.

Questions: If you have any questions about the research, please email Julie@globalhealthdelivery.org.

If you would like to speak to someone not involved in this research about your rights as a human research subject, or any concerns or complaints you may have about the research, please contact the Partners Human Research Committee at 857-282-1900.

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Note: Some UpToDate donations have subsequently led to paid subscription accounts; in some circumstances, applicants may be contacted by UpToDate sales representatives to facilitate such arrangements.

I agree to the terms and conditions

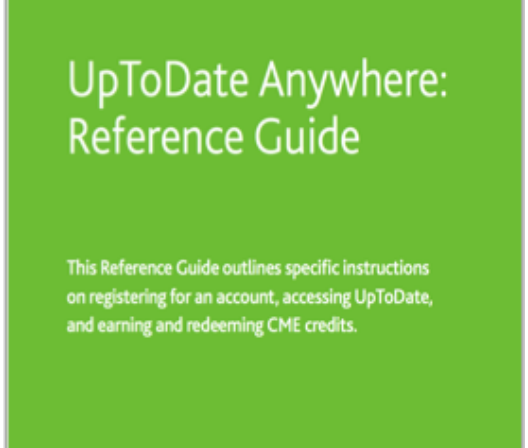
◯ Yes
◯ No

Did you use the quick reference guide or online trainings in UpToDate's Training Resource Center shown below in the past 6 months?

◯ Yes
◯ No
◯ I don't know

Please tell us why you did not use the quick reference guide or online trainings in UpToDate's Training Resource Center.

_____



Have you had these problems accessing UpToDate? (Select all that apply)

	This has never been a problem	This was a problem in the past but not anymore	This is a problem now
Not having a device to use	☐	☐	☐
Accessing the internet	☐	☐	☐
Cost of the data plan	☐	☐	☐
Slow internet speed	☐	☐	☐
Other	☐	☐	☐

Not having a device to use: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

Accessing the internet: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

Cost of the data plan: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

Slow internet speed: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

Other: please describe the problem you experienced.

_____

Have you had problems using and applying UpToDate? (Select all that apply)

	This has never been a problem	This was a problem in the past but not anymore	This is a problem now
Understanding the medical content in UpToDate	☐	☐	☐
Understanding UpToDate because it is written in English	☐	☐	☐
Finding the information I need	☐	☐	☐
Knowing what is available in UpToDate, such as tables or dosage calculators	☐	☐	☐
Not having the tests, data, or medicines recommended by UpToDate	☐	☐	☐
Other	☐	☐	☐

If other, please describe the problem and when it started.

_____

Understanding the medical content in UpToDate: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

Understanding UpToDate because it is written in English: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

Finding the information I need: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

Knowing what is available in UpToDate, such as tables or dosage calculators: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

Not having the tests, data, or medicines recommended by UpToDate: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

When you do not have the tests, data, or medicines recommended by UpToDate, what do you typically do?

_____

Do you have advice for dealing with this challenge?

_____

How often do you use UpToDate for...?

	Never	Rarely	Sometimes	Often	Almost Always	Always	N/A
Determining a diagnosis	○	○	○	○	○	○	○
Developing a treatment plan	○	○	○	○	○	○	○
Using a medical device	○	○	○	○	○	○	○
Preparing for a procedure	○	○	○	○	○	○	○
Earning continuing medical education credit (CME credit)	○	○	○	○	○	○	○
General learning (not patient-specific)	○	○	○	○	○	○	○
Teaching students/colleagues	○	○	○	○	○	○	○
Educating patients	○	○	○	○	○	○	○
Other	○	○	○	○	○	○	○

Please describe the other ways you use UpToDate and how often you use it that way.

_____

	Never	Rarely	Sometimes	Often	Almost Always	Always	N/A
How often do you look for information online when a patient presents with a condition you treat infrequently?	○	○	○	○	○	○	○
How often do you look for information online when a patient presents with a condition you have not treated before?	○	○	○	○	○	○	○

Approximately how often do you learn useful information from these sources?

	Never	A few times per year	Monthly	Weekly	Daily
Colleagues	◯	◯	◯	◯	◯
UpToDate	◯	◯	◯	◯	◯
Other online resources	◯	◯	◯	◯	◯
Textbooks	◯	◯	◯	◯	◯
WHO protocols	◯	◯	◯	◯	◯
In-person lectures or trainings	◯	◯	◯	◯	◯

How easy or difficult is it for you to use UpToDate in your usual workflow?

◯ Very easy
◯ Somewhat easy
◯ Somewhat difficult
◯ Very difficult
◯ N/A

What makes UpToDate easy to use in your usual workflow?

_____

What makes UpToDate difficult to use in your usual workflow?

_____

Do you use UpToDate's offline mode (MobileComplete or Downloadable Desktop)?

◯ Yes
◯ No

If no, why not?

_____

Approximately how many of the clinical care providers that you work with use UpToDate?

◯ 100%
◯ 75%
◯ 50%
◯ 25%
◯ 0%
◯ I don't know
◯ N/A (I don't work with other clinical providers)

How often do you refer to UpToDate with patients during clinical care so that they can see you using it?

◯ Never
◯ Rarely
◯ Sometimes
◯ Often
◯ Very often

If you did use UpToDate during clinical care, how do you think the typical patient would view your use?

◯ Negatively
◯ Neutrally
◯ Positively
◯ It's highly variable
◯ I don't know

How do you think the typical patient views your use of UpToDate during clinical care?

◯ Negatively
◯ Neutrally
◯ Positively
◯ It's highly variable
◯ I don't know

How often do you refer to UpToDate in the presence of other clinical care providers?

◯ Never
◯ Rarely
◯ Sometimes
◯ Often
◯ Very often

If you did use UpToDate in the presence of other clinical care providers, how do you think the typical provider would view your use?

◯ Negatively
◯ Neutrally
◯ Positively
◯ It's highly variable
◯ I don't know

How do you think the typical provider views your use of UpToDate?

◯ Negatively
◯ Neutrally
◯ Positively
◯ It's highly variable
◯ I don't know

In the past month, how often have you been able to find answers...?

	Never	Rarely	Sometimes	Often	Almost Always	Always	N/A
When you have had diagnostic questions	○	○	○	○	○	○	○
When you have had questions about creating a treatment plan	○	○	○	○	○	○	○
When you have had questions about using a medical device	○	○	○	○	○	○	○
When you have had questions about preparing for a procedure	○	○	○	○	○	○	○

Before you had this UpToDate subscription, how often were you able to find answers...?

	Never	Rarely	Sometimes	Often	Almost Always	Always	N/A
When you have had diagnostic questions	◯	◯	◯	◯	◯	◯	◯
When you have had questions about creating a treatment plan	◯	◯	◯	◯	◯	◯	◯
When you have had questions about using a medical device	◯	◯	◯	◯	◯	◯	◯
When you have had questions about preparing for a procedure	◯	◯	◯	◯	◯	◯	◯

How likely are you to recommend the Better Evidence UpToDate donation program to a friend or a colleague?

Please rate on a scale of 1 to 10, with 1 meaning "not likely to recommend" and 10 meaning "extremely likely to recommend."

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ 10

Now please answer in words:
How likely are you to recommend the Better Evidence UpToDate donation program to a friend or a colleague?

◯ Highly unlikely
◯ Somewhat unlikely
◯ Undecided (neither likely nor unlikely)
◯ Somewhat likely
◯ Highly likely

In the past 6 months, have you noticed changes in the way you use UpToDate, such as what you use it for, how often you use it, or when you use it?

◯ Yes
◯ No

Please describe these changes and what caused them.

_____

How has UpToDate changed your confidence in your clinical decisions?

◯ I am much less confident
◯ I am a little less confident
◯ No change in confidence due to UpToDate
◯ I am a little more confident
◯ I am much more confident

In the last 6 months, I feel that using UpToDate CAUSED me to at least once: (select all that apply)

☐ Make a diagnostic error
☐ Make an inaccurate treatment plan
☐ Over use resources (e.g., tests, consultations)
☐ Spend too much time searching or reading UpToDate when unsure about a diagnosis or treatment option
☐ None of the above

In the last 6 months, I feel that using UpToDate HELPED me to at least once: (select all that apply)

☐ Make an accurate diagnosis that I otherwise would not have made
☐ Make a more accurate treatment plan than I would have without UpToDate
☐ More efficiently use resources (e.g., tests, consultations)
☐ Save time by searching or reading UpToDate when unsure about a diagnosis or treatment option
☐ None of the above

When providing clinical care, how true are the following statements for you?

	Not true at all	Hardly true	Moderately true	Exactly true
I will be able to achieve most of the goals that I have set for myself.	○	○	○	○
When facing difficult tasks, I am certain that I will accomplish them.	○	○	○	○
In general, I think that I can obtain outcomes that are important to me.	○	○	○	○
I believe I can succeed at most any endeavor to which I set my mind.	○	○	○	○
I will be able to successfully overcome many challenges.	○	○	○	○
I am confident that I can perform effectively on many different tasks.	○	○	○	○
Compared to other people, I can do most tasks very well.	○	○	○	○
Even when things are tough, I can perform well.	○	○	○	○

Is there a topic that UpToDate did not cover or do you have any other comments? Please explain.

_____

Would you be willing to be contacted in the future about your experience with the Better Evidence Donation Program?

○ Yes
○ No

What are the barriers to using UTD? Please check all that apply.

a. Having a device to use

b. Access to internet

c. Cost of data access plan

d. Ability to find the information I need

e. Ability to download UpToDate/MobileComplete

f. Relevancy of the information--having the tests or medicines I need to apply the information in clinical practice

g. Understanding the medical content in UpToDate

h. Colleagues—I don't want to use it in their presence and don't have privacy

i. Lack of time

j. Language-- Understanding UpToDate because it is written in English

a. Other (describe below)

b. No barriers

If other: Please describe. [open text]

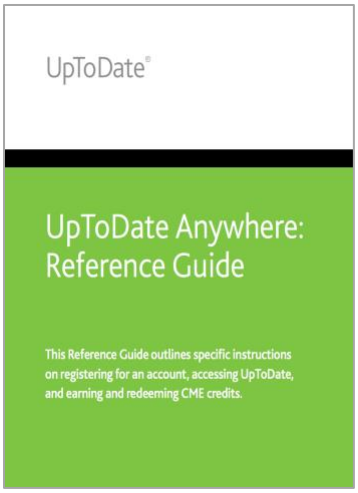
When providing clinical care, how true are the following statements for you?

	Not at all true	Hardly true	Moderately true	Exactly true
a. I will be able to achieve most of the goals that I have set for myself.	1	2	3	4
b. When facing difficult tasks, I am certain that I will accomplish them.	1	2	3	4
c. In general, I think that I can obtain outcomes that are important to me.	1	2	3	4
d. I believe I can succeed at most any endeavor to which I set my mind.	1	2	3	4
e. I will be able to successfully overcome many challenges.	1	2	3	4
f. I am confident that I can perform effectively on many different tasks.	1	2	3	4
g. Compared to other people, I can do most tasks very well.	1	2	3	4
h. Even when things are tough, I can perform well.	1	2	3	4

Follow-up at 6 months

1. Did you use the quick reference guide or online trainings in UpToDate's Training Resource Center shown below? (Select one)

    a. Yes
    b. No (describe below)
    c. I don't know
    d. Please tell us why you did not use the quick reference guide or online trainings in UpToDate's Training Resource Center. [open text]



2. Do you have any problems with **accessing** UpToDate? (Select yes or no for each row and column)

	This was a problem in the beginning	This is an ongoing problem
a. Not having a device to use	yes/no	yes/no
b. Accessing the internet	yes/no	yes/no
c. Cost of the data plan	yes/no	yes/no
d. Downloading UpToDate	yes/no	yes/no
e. Slow internet speed	yes/no	yes/no
f. Other (describe below)	yes/no	yes/no

g. If other: Please describe the problem you experience in the beginning and when it started. [open text]
h. If other: Please describe the ongoing problem and when it started. [open text]

3. Do you have any problems with **using and applying** UpToDate? (Select yes or no for each row and column)

	This was a problem in the beginning	This is an ongoing problem
a. Understanding the medical content in UpToDate	yes/no	yes/no
b. Understanding UpToDate because it is written in English	yes/no	yes/no
c. Finding the information I need	yes/no	yes/no
d. Knowing what is available in UpToDate, such as tables or dosage calculators	yes/no	yes/no
e. Not having the tests, data, or medicines recommended by UpToDate	yes/no	yes/no
f. Other (describe below)	yes/no	yes/no

g. If other: Please describe the problem you experienced in the beginning and when it started. [open text]
h. If other: Please describe the ongoing problem and when it started. [open text]

(If 3e is no in both columns, skip to 5)

4.

a. When you do not have the tests, data, or medicines recommended by UpToDate, what do you typically do? [open text]
b. Do you have advice for dealing with this challenge? [open text]

5. How often do you use UpToDate for ...?

	Never	Rarely	Some-times	Often	Almost always	Always	N/A
a. Determining a diagnosis	1	2	3	4	5	6	7
b. Developing a treatment plan	1	2	3	4	5	6	7
c. Using a medical device	1	2	3	4	5	6	7
d. Preparing for a procedure	1	2	3	4	5	6	7
e. Earning continuing medical education credit (CME credit)	1	2	3	4	5	6	7
f. General learning (not patient-specific)	1	2	3	4	5	6	7
g. Teaching students/colleagues	1	2	3	4	5	6	7
h. Educating patients	1	2	3	4	5	6	7
i. Other (describe below)	1	2	3	4	5	6	7

j. If other, please describe the other ways you use UpToDate and how often you use it that way. [open text]

6.	Never	Rarely	Sometimes	Often	Almost Always	Always
a. How often do you look for information online when a patient presents with a condition you treat frequently?	1	2	3	4	5	6
b. How often do you look for information online when a patient presents with a condition you have not treated before?	1	2	3	4	5	6

7. Approximately how often do you learn useful information from these sources?

	Never	A few times per year	Monthly	Weekly	Daily
c. Colleagues	1	2	3	4	5
d. UpToDate	1	2	3	4	5
e. Other online resources	1	2	3	4	5
f. Textbooks	1	2	3	4	5
g. WHO protocols	1	2	3	4	5
h. In-person lectures or trainings	1	2	3	4	5

8. How easy or difficult is it for you to use UpToDate in your usual workflow? (Select one)

a. Very easy
b. Somewhat easy
c. Somewhat difficult (Skip to 10)
d. Very difficult (Skip to 10)
e. N/A (Skip to 11)

9. What makes it easy to fit UpToDate into your usual workflow? [open text]
(Skip to 11)

10. What makes it difficult to fit UpToDate into your usual workflow? [open text]

11. Approximately how many of the clinical care providers that you work with use UpToDate? (Select one)

a. 100%
b. 75%
c. 50%
d. 25%
e. 0%
f. I don't know
g. N/A (I don't work with other clinical providers.)

12. How often do you refer to UpToDate **with patients during clinical care**, so that they can see you using it? (Select one)

a. Never
b. Rarely (Skip to 14)
c. Sometimes (Skip to 14)
d. Often (Skip to 14)
e. Very often (Skip to 14)

13. If you did use UpToDate during clinical care, how do you think the typical **patient** would view your use? (Select one)

a. Negatively
b. Neutrally
c. Positively
d. It's highly variable
e. I don't know
(Skip to 15)

14. How do you think your typical **patient** views your use of UpToDate during clinical care? (Select one)

a. Negatively
b. Neutrally
c. Positively
d. It's highly variable
e. I don't know

15. How often do you refer to UpToDate **in the presence of other clinical care providers**? (Select one)

a. Never
b. Rarely (Skip to 17)
c. Sometimes (Skip to 17)
d. Often (Skip to 17)
e. Always (Skip to 17)

16. If you did use UpToDate in the presence of other clinical care providers, how do you think the typical **provider** would view your use? (Select one)

a. Negatively
b. Neutrally
c. Positively
d. It's highly variable
e. I don't know (Skip to 18)

17. How do you think the typical **provider** would view your use of UpToDate? (Select one)

a. Negatively
b. Neutrally
c. Positively

d. It's highly variable
e. I don't know

18.	Never	Rarely	Sometimes	Often	Almost always	Always	N/A
a. In the last month, when you've had diagnostic questions, how often have you been able to find the answers?	1	2	3	4	5	6	7
b. In the last month, when you've had questions about creating a treatment plan, how often have you been able to find the answers?	1	2	3	4	5	6	7
c. In the last month, when you've had questions about using a medical device, how often have you been able to find the answers?	1	2	3	4	5	6	7
d. In the last month, when you've had questions about preparing for a procedure, how often have you been able to find the answers?	1	2	3	4	5	6	7
e. Before you had this UpToDate subscription, when you had diagnostic questions, how often were you able to find the answers?	1	2	3	4	5	6	7
f. Before you had this UpToDate subscription, when you had questions about creating a treatment plan, how often were you able to find the answers?	1	2	3	4	5	6	7
g. Before you had this UpToDate subscription, when you had questions about using a medical device, how often were you able to find the answers?	1	2	3	4	5	6	7
h. Before you had this UpToDate subscription, when you had questions about preparing for a procedure, how often were you able to find the answers?	1	2	3	4	5	6	7

19. How likely are you to recommend the GHD-UpToDate donation program to a colleague?

a. Highly unlikely
b. Somewhat unlikely
c. Undecided (neither likely nor unlikely)
d. Somewhat likely
e. Highly likely

20. In the past 6 months, have you noticed changes in the way you use UpToDate, such as what you use it for, how often you use it, or when you use it? (Select one)

    a. Yes
    b. No (Skip to 22)

21. Please describe these changes and what caused them. [open text]

22. How has UptoDate changed your confidence in your clinical decisions?

    a. I am much less confident
    b. I am a little less confident
    c. No change in confidence due to UpToDate
    d. I am a little more confident
    e. I am much more confident

23. In the last 6 months, I feel that using UpToDate **caused** me to at least once: (select all that apply)
    a. Make a diagnostic error
    b. Make an inaccurate treatment plan
    c. Over use resources (e.g., tests, consultations)
    d. Spend too much time searching or reading UpToDate when unsure about a diagnosis or treatment option
    e. None of the above

24. In the last 6 months, I feel that using UpToDate **helped** me to at least once: (select all that apply)
    a. Make an accurate diagnosis that I otherwise would not have made
    b. Make a more accurate treatment plan than I would have without UpToDate
    c. More efficiently use resources (e.g., tests, consultations)
    d. Save time by searching or reading UpToDate when unsure about a diagnosis or treatment option
    e. None of the above

25. When providing clinical care, how true are the following statements for you?

	Not at all true	Hardly true	Moderately true	Exactly true
a. I will be able to achieve most of the goals that I have set for myself.	1	2	3	4
b. When facing difficult tasks, I am certain that I will accomplish them.	1	2	3	4
c. In general, I think that I can obtain outcomes that are important to me.	1	2	3	4
d. I believe I can succeed at most any endeavor to which I set my mind.	1	2	3	4
e. I will be able to successfully overcome many challenges.	1	2	3	4
f. I am confident that I can perform effectively on many different tasks.	1	2	3	4
g. Compared to other people, I can do most tasks very well.	1	2	3	4
h. Even when things are tough, I can perform well.	1	2	3	4

26. Any other comments? [open text]

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	4
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5-8
Bias	9	Describe any efforts to address potential sources of bias	12-13 (self-efficacy scale)
Study size	10	Explain how the study size was arrived at	4-5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-8
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9-10
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) Summarise follow-up time (eg, average and total amount)	

Outcome data	15*	Report numbers of outcome events or summary measures over time	9-14

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (*b*) Report category boundaries when continuous variables were categorized (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	
Generalisability	21	Discuss the generalisability (external validity) of the study results	
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

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Barriers and Facilitators to Use of a Digital Clinical Decision Support Tool: A cohort study combining clickstream and survey data

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Abstract

Objectives: This research aimed to understand the barriers and facilitators clinicians face in using a digital clinical decision support tool —UpToDate — around the globe.

Design: We used a mixed-methods cohort study design that enrolled 1,681 clinicians (physicians, surgeons, or physician's assistants) who applied for free access to UpToDate through our established donation program during a 9-week study enrollment period. Eligibility included working outside of the United States for a public or non-profit health facility serving vulnerable populations, having at least

intermittent internet access, completing the application in English; and not being otherwise able to afford the subscription.

Interventions: After consenting to study participation, clinicians received a one-year subscription to UpToDate. They completed a series of surveys over the year, and we collected clickstream data tracking their use of the tool.

Primary and secondary outcome measures:

1) the variation in use by demographic

2) the prevalence of barriers and facilitators of use

3) the relationship between barriers, facilitators, and use

Results:

Of 1,681 study enrollees, 69% were male and 71% were between 25 and 35 years old, with the plurality practicing general medicine and the majority in sub-Saharan Africa or Southeast Asia. Of the 11 barriers we assessed, fitting the tool into the workflow was a statistically significant barrier, making clinicians 50% less likely to use it. Of the 10 facilitators, a supportive professional context and utility were significant drivers of use.

Conclusions:

There are several clear barriers and facilitators to promoting the use of digital clinical decision support tools in practice. We recommend tools like UpToDate be implemented with complementary services. These include generating a supportive professional context, helping clinicians realize the tools' utility, and working with health systems to better integrate digital, clinical decision support tools into workflows.

Strengths and limitations:

- This study combines surveys with clickstream data from the digital tool—data that clinicians directly generate in using the tool—which provides precise, robust data.

- We only included clinicians who applied and met criteria for a donated subscription; this included those who were able to complete the application in English and those working in limited-resource settings, limiting generalizability.

- Due to time and resource constraints, we could not measure all components of the logic model we built relating the use of UpToDate to patient outcomes.

- While we hypothesized that access to UpToDate can improve clinicians' sense of self-efficacy, the psychometrics of the self-efficacy scale we instituted did not function properly in this study and resulted in null results.

Background

Diagnostic and treatment errors account for a significant amount of harm across high-, middle-, and low-income settings and represent a serious public health problem. Most people will likely experience a diagnostic error in their lifetime.[1] In a high-income country in an outpatient setting, one study found that 5% of adults experienced diagnostic errors each year. Over half of these errors had the potential for severe harm. The researchers suggested that their findings were likely an underestimate and that the rate of diagnostic errors in low-income countries may be much higher. Other studies analyzing mortality data from autopsies have shown that 10– 15% of deaths are due to missed diagnoses.[2] Even in cases that are ultimately correctly diagnosed and treated, errors leading to delay may result in poor quality of care, patient safety risks, increased costs, and, in some cases, malpractice litigation.[3]

Diagnostic and treatment errors can happen at any point in the care process, including initial assessment, performing and interpreting diagnostic tests, determining treatment, follow-up visits and tracking. These errors involve the failure to provide a timely, accurate determination of a patient's health condition or

treatment option and/or to communicate necessary, accurate, timely information to a patient.[4] They represent missed opportunities to provide quality, effective care based on the best available clinical evidence.

More than half of the cases of diagnostic error are due to cognitive errors. Frontline healthcare workers face a demanding cognitive load. They need to keep up with new evidence and incorporate it into care decisions; more than 950,000 new publications are indexed in MEDLINE every year.[5] The coronavirus pandemic has further increased the speed and volume of clinical evidence, exacerbating the challenges.[6] Health information technology or digital tools used at the point of care–clinical decision support tools–can reduce diagnostic errors. In 2019, the World Health Organization acknowledged digital tools as important levers for ensuring effective, high-quality, equitable care.[7] They can support clinicians' decision making, enabling quick, better informed decisions that lead to better health outcomes.[8] Such tools include computerized alerts or reminders; clinical guidelines; focused patient data reports and analyses, and contextually relevant reference information, among other offerings.[8]

Clinical decision support tools like Merck Manuals, epocrates, UpToDate, DynaMed, and VisualDx are apps and websites that bring the most recent medical evidence to the clinician at the bedside. Editors working behind the scenes review scientific literature and integrate it into relevant clinical guidance. At UpToDate, for example, more than 7,400 subject matter experts review emerging research related to their topic areas and update the tool's guidance as relevant to make sure clinicians can easily access the most current evidence when caring for patients. Clinical decision support tools can suggest key follow up questions or tests to consider, support in weighing diagnostic probabilities, show visual images to help with identification of disease or rashes, and more. Previous research has demonstrated a positive connection between evidence-based clinical decision support tools and clinician capacity; the use of

UpToDate, for example, was shown to increase performance on standardized exams among US clinicians[5] and, most importantly, to reduce risk-adjusted mortality rates at non-teaching hospitals.[6]

Despite these proven benefits, uptake and use of digital tools among clinicians around the globe remain inconsistent.[9–11] In fact, the World Medical Association recently acknowledged that lack of access to timely, current, evidence-based healthcare information—which such digital tools can provide—is a major contributor to morbidity and mortality in resource-limited settings.[12] For some, the cost of a subscription, which can be up to $580 for an individual, limits access.

In 2009, we started a program that removed the cost barrier by offering free access to UpToDate for clinicians serving vulnerable communities at resource-limited health facilities, with the goal of improving patient outcomes and health equity. Eliminating the UpToDate subscription cost led to increased use of the tool; however, we observed wide discrepancies in use patterns, suggesting that other barriers to use persisted.[13] In order to better leverage the potential impact of evidence-based clinical decision support tools s in limited-resource settings, it is important to understand what factors affect their uptake and use.

Using data from a global sample of clinicians who received UpToDate subscriptions through our online donation program, we conducted a mixed-methods cohort study. The general objective was to describe and explain the barriers and facilitators to use of the tool. Specifically, we aimed to describe:

1) the variation in UpToDate use by demographic characteristics of users,
2) the prevalence of barriers to and facilitators of UpToDate use in clinical practice, and
3) the relationship between barriers, facilitators, and UpToDate use.

Study participants reported barriers and facilitators in repeated surveys over one year, and actual use of the tool was measured through clickstream data gathered from Wolters Kluwer/UpToDate.

Methods

Study sample

All clinicians who went to the online donation program during our 9-week enrollment period (March 1, 2018 to May 4, 2018) were invited to participate in and consent to the study electronically before applying. Informed consent covered the collection of the application, survey, and clickstream data.

Eligibility criteria for the donation program included being a physician, surgeon, or physician's assistant outside of the United States; working for a public or non-profit limited-resource health facility; having at least intermittent internet access; being able to complete the application in English; attesting they are serving vulnerable populations (patients with limited-resources); and attesting they are not otherwise able to afford the subscription. Team members looked up health facilities and verified consistency in application information to confirm eligibility. Recruitment for the donation program relies primarily on word of mouth and occasional communications to beneficiaries suggesting they invite their colleagues to join. No additional recruitment efforts were undertaken for study purposes.[1] The decision to limit participation to those able to complete the application in English stems from the fact that the content within UpToDate is only available in English. We acknowledge that language is a barrier to access and did not feel it was necessary to test this hypothesis at the time.

Patient and public involvement

No patients involved.

Logic model

We built a logic model detailing how access to UpToDate could eventually affect patient outcomes (Figure 1). In this model, the inputs were the donation itself and technical supports such as a functioning internet connection. These enabled users to login to UpToDate and learn about it through the included orientation materials. These activities would then enable several short-term outcomes, including actual use of UpToDate, ability to navigate the tool, and perceived utility of the tool in practice. Medium-term

[1] Application and eligibility criteria are available at www.better-evidence.org.

outcomes included increased medical knowledge, integration of that knowledge into practice, and increased self-efficacy. In the longer term, these elements could lead to faster and more accurate diagnoses and clinical management, which would eventually translate to improved patient outcomes. This overall process would be facilitated by a professional context that supported the use of digital clinical decision support tools in practice.

Due to time and resource constraints, we could not measure all components of this logic model, but we measured several elements through two data streams: surveys and clickstream data.

Surveys

The survey included demographic, quantitative, and open-text response fields. We captured respondents' gender, age, years of experience, country of practice, urban/rural setting, patient load per week, and employment type (full-time paid vs. other).

We developed survey questions based on seven factors in the logic model downstream of the inputs as delineated in Table 1 [see Supplementary Materials for survey questions].

Table 1: Barriers and facilitators measured in surveys

Factor	Measure	Surveyed at months
Barriers		
1 Access to the tool	Having a device	2,4,6,12
	Access to internet	2,4,6,12
	Cost of data plan	2,4,6,12
	Ability to download the tool	2,4,6
	Slow internet speed	6,12
2 Ability to navigate the tool	Knowing what is available	6,12
	Finding the information I need	2,4,6,12
3 Integration of the tool's information into practice	Having what I need to apply the information	2,4,6,12
	Understanding the medical content	2,4,6,12
	Lack of time	2,4
	Difficult to fit into work flow	6,12

Facilitators		
4 Orientation materials	Accessed orientation materials	6,12
5 Utility of the tool in practice	Compared to before had the tool, able to find answers more often about: Diagnosis Treatment Procedure Device	6,12
6 Professional context	Clinician level: Most clinical colleagues use the tool Typical provider views tool use positively Use the tool in front of other clinicians	6,12
	Patient level: Typical patient views tool use positively Use the tool in front of patients	6,12

Factors 1 to 3 were measured as barriers to use. Factors 4 to 6 were measured as facilitators of use. Four types of clinical decisions were covered in the survey: treatments, diagnoses, devices, and procedures. We measured Factor 7, a sense of self-efficacy, with the 8-item New General Self Efficacy scale.[14] We added a contextualizing frame at the start of the scale: "When providing clinical care, how true are the following statements for you?"

We collapsed 34 categories of specialties into 8 groups (see Appendix A). Twelve prior donation recipients from 3 continents, ranging in age from 25 to 65, provided feedback on the survey's clarity, wording, response options, and acceptability. The survey was adapted accordingly.

We integrated the baseline survey and the UpToDate donation application. Following the application approval, survey links were then triggered to be sent by email for the 2-month survey (sent 60 days after approval), 4-month survey (120 days after), 6-month survey (180 days after), and 12-month final survey

(350 days after). We excluded survey answers that were completed more than 30 days after the survey link was sent.

The baseline, 6-, and 12-month surveys covered all topics; to reduce respondent burden, the 2- and 4-month surveys only measured self-efficacy and barriers to use. Participants automatically received a 6-month subscription extension for completing the 6-month survey and another 6-month extension for completing the 12-month survey. In addition, those completing the 12-month survey were entered into a drawing for 10 prizes of US$100. The survey was built and administered in RedCAP.[15]

Clickstream data

We measured the actual use of UpToDate (purple box in Figure 1) through the tool's clickstream data, a machine-generated record of each click from every user. The records identified which pages users visited and when, starting from the day the subscription link was sent out for 365 days, across all mobile and desktop applications as well as during offline use.

We linked the survey data to the clickstream data through a unique identifier. We qualified online use in two ways: first, we created a binary indicator of whether a user ever logged on through the donated link, called "ever-users" and, second, we calculated the total amount of time ever-users spent using UpToDate over the yearlong study period. We estimated the length of specific user sessions as a function of 1) the time between clicks, 2) the content or function clicked on, and 3) overall estimates of the amount of time spent reading content, navigating the site, and managing user accounts. These methods have been detailed elsewhere.[16]

Quantitative analysis

We grouped countries into the six geographic regions used by the World Health Organization. We determined the total number of donees in each respondent's country using historical administrative data from the donation program. We reported the percent distributions of all demographic characteristics of the study sample.

We then calculated the percent of each demographic subgroup who were ever-users, and among them, the median number of hours they spent using the tool over the year. We used median hours instead of means due to a highly logged distribution. We presented the proportion of users who experienced each barrier or facilitator once they had the subscription, at the 2-, 4-, 6-, or 12-month mark.

Next, we modeled the relationship between barriers, facilitators, and use of the tool. The first set of regression models predicted the use of the tool around the time of the survey. For each user, we first identified the date they completed the 2-, 4-, 6-, or 12-month survey, and summed up the amount of time they spent using the tool in the two weeks around that date (7 days before to 7 days after), using the clickstream data. We fit 21 statistical models, one for each barrier or facilitator we measured, of the form:

$$Y_{im} = \beta_0 + \beta_1 m + \beta_2 BF_{im} + \beta_x [X]_i + \varepsilon$$

Where: $\beta 0$ = intercept

Y_i = any use of the tool by subject i in the two weeks around survey month m (binary)

m = month of survey (encoded as a continuous variable with values 2,4,6, and 12)

BF_{im} = presence of barrier or facilitator for subject i at survey month m (binary)

X_i = vector of demographic characteristics for subject i.

These 21 generalized linear models used a binary link function to the outcome and accounted for repeated measures over each subject.

The second set of models included only ever-users of the tool and predicted the minutes spent using the tool around the time that a barrier or facilitator was reported to be present. Like the first set of models, these accounted for repeated measures over subjects. The dependent variable—the minutes of use around each survey—was logged to bring its distribution closer to normality, and no link function was applied.

To select demographic variables to include in the model, we tested each variable for the strength of its relationship to both outcomes and for collinearity with other demographic variables. This process

identified three controls to include in the model: age category, specialty, and the total number of UpToDate donation recipients in the user's country. In order to constrain the risks of multiple testing over the full set of (42) models, we set the alpha level for each coefficient at 0.0012, which is the standard alpha of 0.05 divided by 42. In line with this alpha threshold, we present 99.9% confidence intervals. All analyses were done in SAS 9.4 (Cary, NC: SAS Institute. Inc.).

Qualitative analysis

We imported the free-text responses from the surveys into NVivo 12 (QSR International Pty Ltd.) for coding and analysis. The coding scheme included high-level themes developed deductively from the research questions and sub-themes developed inductively based on the content of the responses. Responses tended to be brief, containing a single idea closely aligned with the theme, so codes were applied with little need for interpretation or subjectivity. We included a sample of 250 surveys for analysis, choosing at random from across the spectrum of tool use. Because of the nature of the responses, one person coded all the responses for consistency under supervision.

Results

We had 1,681 study enrollees and collected baseline data on all. Follow-up survey response rates were 67% at month 2, 60% at month 4, 54% at month 6, and 58% at month 12. Eighteen percent of respondents answered all four follow-up surveys, and 36% answered none. Based on the clickstream data, 249 (15%) of the enrollees never used the tool at all; although, 245 (98%) of these did respond to at least one follow-up survey.

Demographic characteristics

The vast majority (69%) of study enrollees were male, and most respondents (71%) were between 25 and 35 years old. As is typical, years of experience was highly correlated with age, and most respondents (55%) had four or fewer years of experience. Many subjects (42%) were general practitioners, with 22%

in a medical subspecialty. Surgery, pediatrics, and other specialties each had under 10% of respondents. Nearly two-thirds of the sample (61%) was in full-time paid work. Patient load fell into rough quartiles: 20% saw under 50 patients per week, 25% saw 50 to 99 patients, 29% saw 100 to 199 patients, and the remaining 26% saw 200 or more patients. Most subjects (57%) were in urban settings, with 26% in rural settings, and the remainder in mixed areas (Figure 2).

Two-thirds of our sample came from countries with 200 or more other donation recipients. A quarter of respondents came from countries with 50–199 donation recipients, and the remaining 9%, from countries with only 1–49 other donation recipients. Eighteen study participants were the first and sole donation recipients in their entire country. Finally, the study sample included clinicians from all six geographic regions, mainly from Southeast Asia (35%) and sub-Saharan Africa (33%).

Variation in use by demographic characteristics

While 85% of the sample used the tool at least once, percent of ever-users ranged from 77% to 89% depending on the demographic group (Figure 2).

Among ever-users of the tool (N = 1,432), median time spent with the tool was 5.0 hours over the course of the study year. However, time varied strongly by some demographic groups (Figure 2). Variation by specialty was marked, ranging from 1.9 hours for surgical subspecialists to 7.3 hours for medical practitioners. Similarly, variation by geographic region was large, from 3.3 hours in Sub-Saharan Africa to 7.2 hours in Europe.

As for age, the middle age group (25 to 35 years) used the tool for 5.8 median hours, while the younger users (under 25) used it for 4.2 hours, and the older users (over age 35) used it for 3.2 hours. The lower use among older users was also reflected in the results by years of experience: those with seven or more years of experience used the tool for less time than others (3.9 hours vs. 5.4 or more hours).

Those with the highest patient load (200 or more patients per week) used the tool for comparatively longer over the year, 6.2 median hours, compared to the median across other groups, 4.5 to 4.8 hours. Users in countries with many donation recipients (200 or more) used the tool for 5.6 median hours over the year, while those from countries with fewer than 200 recipients used it less, for 3.8 to 4.0 median hours. There was very little variation in median hours of use by gender, employment type, or urban/rural setting.

Prevalence of barriers and facilitators to use of UpToDate in clinical practice

The least common technical barrier (Figure 3, Factor 1) was lack of a device (6% or less at all time points), and the most common barrier was slow internet speed (reported by about 33% of users at months 6 and 12). The percent of users reporting difficulties with access to the internet declined over time, from 31% at month 2 to 16% at month 12 (Figure 3, Factor 1).

Few users reported barriers to navigating the tool (Figure 3, Factor 2). In each follow-up survey in which these questions were asked, 9% or fewer respondents reported that they faced barriers either in knowing what was available or in finding the information they needed in the tool.

Fewer than 20% of users at any time point faced the barriers of lack of time, understanding the medical content, or finding it difficult to fit into their workflow. One clinician mentioned in a free-text response, “Even though I don't speak English fluently, I can understand easily because the terms they use are not complicated...it's very easy when you want to find out something...you get it quickly.” However, enrollees also explained workflow concerns: "Patient flow is way too high. So I don't get time to open UpToDate at that time..." and "[It's] tough opening UpToDate and checking patients in a crowded and hurr[ied] situation.” Regarding having what was needed to apply the information learned from the tool in practice, the percentage of users reporting this barrier rose from 13% at month 2 to 32% at month 12 (Figure 3, Factor 3).

As for facilitators, approximately 40% of respondents at months 6 and 12 reported that they had ever referred to the orientation materials (Figure 3, Factor 4). The utility of the tool in practice, measured as the percentage of users who reported being able to find answers to questions more readily as compared to before they had the tool, was stable across months 6 and 12:47% of respondents were better able to find answers to treatment questions, 43% to find answers to diagnostic questions, 34% to procedure questions, and 33% to device questions (Figure 3, Factor 5). Clinicians shared examples of using the tool:

> "Let me exemplify a case of pneumothorax. There was a lot of debate regarding the tube thoracostomy. One of the residents read out the contents of UpToDate, and thence the tube thoracostomy was planned."

> "I have been using UpToDate to make management plans for my patients and to optimize their care. Whenever I am having a problem getting a diagnosis for a patient, I go to UpToDate and read around the topic."

The professional context results were fairly consistent across months 6 and 12. Approximately 80% of respondents reported that clinicians typically viewed the use of a digital tool like UpToDate positively, and roughly 70% said that most of their clinical colleagues used such tools. About 65% reported using the tools often or very often in front of other clinicians (Figure 3, Factor 6). Open text answers related to this factor include responses such as "Senior [attendings] recommend it" and "It is commonly known and most colleagues use it." One clinician explained, "I came to know about the subscription of UpToDate through my colleague. There was an incident when I was working late night duty. I was confused about the latest recommendation, and my colleague helped me with the help of UpToDate."

Clinicians did not feel patients were as supportive of tool use. Only 30% of subjects reported that they believed their typical patient viewed the use of a tool like UpToDate during care positively, and about a quarter used the tool often or very often in front of patients during clinical care (Figure 3, Factor 6).

Self-efficacy

The self-efficacy results were problematic, including ceiling effects and evidence of straightlining (24% of all administrations of the scale had the same response for all eight questions). Moreover, we found almost no group-level variation where it might be expected: across age, years of experience, specialty, geographic region, or any other demographic group. Self-efficacy scores showed no consistent or notable increase or decrease over time, either on the group level or the individual level. By comparison, other survey questions did exhibit these basic features of item validity and functioning. Given it is implausible that the self-efficacy of all clinicians was identical and unchanging, we concluded that the psychometrics of the self-efficacy scale did not function properly in this study. For this reason, we dropped self-efficacy (Factor 7) from our presentation of results.

Relationship between barriers, facilitators, and UpToDate use.

Results of the statistical models are presented in Figure 4. Panel A shows the estimated odds ratios of using the tool around the time when a barrier or facilitator was present compared to when it was not present, adjusted for age, specialty, and number of donation recipients in the subject's country. For the 11 barriers, most estimates were less than 1, suggesting that the odds of using the tool was lower when the barrier was present. However, only one of these relationships rose to statistical significance under the multiplicity adjusted alpha threshold: when clinicians reported that it was difficult to fit the tool into their workflow, they were 42% less likely to use it (OR 0.56, $p = 0.0003$).

For facilitators, most odds ratios were near or above 1, suggesting that the odds of using the tool may have been higher when the facilitator was present. Of the 10 facilitators, two were statistically significant. First, users were 1.5 times more likely to log on if they reported that using UpToDate increased their ability to find answers to their clinical questions about treatments (OR 1.5, $p = 0.0001$). Second, users were 1.7 times more likely to log on to the tool if their professional context supported using the tool in front of other clinicians (OR 1.7, $p < 0.0001$).

Panel B shows the estimated ratio of minutes using the tool around the time that the barrier or facilitator was present. For the 11 barriers, none of these coefficients were statistically significant, although most were below 1, which was in the expected direction. Among the 10 facilitators, most were above 1, suggesting longer use of the tool at the time that the facilitator was present. One coefficient reached statistical significance: when users felt that they could more easily find answers to questions about diagnoses, they spent 1.4 times as many minutes using the tool, compared to when they did not feel they could answer more questions (ratio of minutes 1.4, p = 0.0004).

Discussion

Our results drew attention to three factors relating to clinicians' uptake and usage of UpToDate. The first factor (Factor 3) highlighted the ability to integrate the digital tool into practice. Of statistical significance, when clinicians reported difficulty fitting the tool into their daily workflow, they were only about half as likely to log on to the tool as when they did not face that difficulty. Although under 20% of clinicians reported lack of time, difficulty fitting the tool into their workflow, or problems understanding the medical content, and not all had statistically significant findings, clinicians who faced such barriers did appear to use the tool less. Interestingly, over the study year, the prevalence of not having what was needed to apply the information in UpToDate (Factor 3) rose from 14% to 33%. This increase over time could demonstrate decreasing resource levels for clinicians or clinicians' increased knowledge of the resources they lack. In other words, clinicians may have been more aware than previously of newer supplies and tests that were unavailable to them after a year of using UpToDate. Regardless, the presence of this barrier did not deter use: it was not associated with how likely users were to log in to UpToDate nor the number of minutes they spent using the tool.

Second, the facilitator of perceived utility of the tool (Factor 5) seemed to matter for uptake. For example, the percentage of subjects reporting an improved ability to find answers to questions about treatments and diagnoses (as compared to before having access to the tool) was consistently above 40%. Moreover,

though not all correlations were statistically significant at the multiplicity adjusted threshold, donees recognizing the tool's utility for treatment and diagnostic decision making were more likely to log in to the tool and spent more minutes on the tool than those who did not report increased ability to find answers with the tool. In other words, positive perceptions of the tool's utility for diagnoses and treatment correlated with more use of the tool.

Third, a positive professional context (Factor 6) also seemed to facilitate tool use. Measures of professional context (the belief that colleagues viewed the use of the tool positively, most clinical colleagues used the tool, and used the tool in front of other clinicians) were all consistently reported by more than 60% of participants. When subjects reported feeling comfortable using the tool in front of other clinicians, they were approximately 70% more likely to log in (statistically significant) and spent 30% more minutes on the tool (not statistically significant at multiplicity adjusted threshold). Study participants in countries with 200 or more donation recipients used the tool for longer over the year compared to those in countries with fewer donation recipients. A professional context in which more clinicians had access to the tool and felt comfortable using it in front of other clinicians was associated with more use of the tool.

Other barriers and facilitators we tested did not show these kinds of relationships. For example, facing technical access barriers did not significantly change the odds of using the tool or of the amount of time spent using it. This result may seem counterintuitive but likely points toward the determination of these motivated users. For example, at months 2 and 4, about a third of users reported that access to the internet was a barrier for them, but this proportion fell to about 20% at months 6 and 12, and limited access to the internet was not related to the likelihood of logging on or how long was spent using the tool. This could have resulted from differential dropout—those with worse internet access stopped responding to surveys—or the users may have learned how to download and use the tool offline or secured better internet connections. These technical considerations were not the barriers to use that we might have expected. Similarly, users did not report high levels of difficulty navigating the tool or finding

information on it. About 40% of clinicians reported using the orientation materials, but reading those materials was not a significant facilitator of tool use.

One final factor related to usage was age. Only 7% of study participants were in the youngest age group (< 25), likely due to the fact that most people do not start practicing medicine until later. Those aged 25–29 represented 42% of all applicants, and, along with those aged 30–34, used the tool more than the oldest participants (35+). This suggests there is a stronger interest in technology among the newest generation of clinicians and provides hope that uptake and use of digital clinical decision support tools may increase with time.

Our study had several limitations. First, while our sample of clinicians was large and diverse, it was non-representative across countries and types of clinicians; we accepted all clinicians who applied and met eligibility criteria for the donation program during the study period. Eligibility criteria required that clinicians be able to complete the application in English and be working in a limited-resource setting. The sample included only clinicians motivated to apply to the program, who self-selected to try to improve their practice, making it non-representative of the general clinician population. Thus, external validity and the generalizability of our conclusions may be limited. Second, any of the factors we explored can be framed and measured as either barriers or facilitators; we measured some as barriers and others as facilitators, which may have impacted how participants answered the questions. Finally, we were able to integrate the baseline survey into our application process in order to not alter the application experience dramatically; however, other surveys may have influenced tool use by reminding users about the tool when they normally would receive no such reminder.

Globally, the healthcare workforce faces scarce time and attention, high demand for services, varied patient populations, and ever-growing medical literature. As a result, clinicians must remember, apply, and integrate a massive volume of information under difficult circumstances. Digital tools can help, but only if clinicians can and do use them in clinical care. We believe that the patterns suggested here can

serve as the basis for further implementation work and research to better understand how to best reach diverse, both more and less motivated populations of clinicians.

Conclusion

This study can inform the implementation of digital clinical decision support tools in the future. Findings suggest implementing the use of digital clinical decision support tools like UpToDate in cohorts of clinicians to generate supportive professional contexts, encouraging the use of such tools over time to increase exposure and help clinicians realize the utility of them, and working with health systems to promote the use of clinical decision support tools in workflows to promote use.

There is great potential for digital tools to help ensure effective and high-quality care. By learning how to better facilitate use and minimize barriers among clinicians around the globe, we can take an important step toward more effective diagnostic and clinical management leading to better, more equitable health outcomes.

Declarations

Author contributions:

JR conceived the design of the work, contributed to survey design and data collection, to data analysis and interpretation, to drafting and critical revision of the article, and to final approval of the version to be published. KM contributed to the design of the work, survey design, data analysis and interpretation, drafting and critical revision of the article and final approval of the version to be published. OP contributed to data collection, data analysis and interpretation, and final approval of the version of the article to be published. NH contributed to survey design and data collection, to data analysis and interpretation, and to revision and approval of the final version of the article to be published. AK contributed to drafting the article, critical revision, and final approval of the version to be published. RW

conceived of the design of the work, contributed to survey design, to data analysis and interpretation, critical revision of the article and final approval of the version to be published.

Competing interests: The authors declare that they have no competing interests.

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Data Sharing: Restrictions apply to the availability of study data, which were used under a data use agreement for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of UpToDate.

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Ethics Approval:

This study received ethical approval from the Partners Human Research Committee (now called Mass General Brigham Institutional Review Board) under protocol 2018P001183. The Harvard T. H. Chan School of Public Health institutional review board ceded review to the Partners Human Research Committee. All participants provided informed consent. The informed consent addressed the collection of both the survey and clickstream data.

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Figure Legends

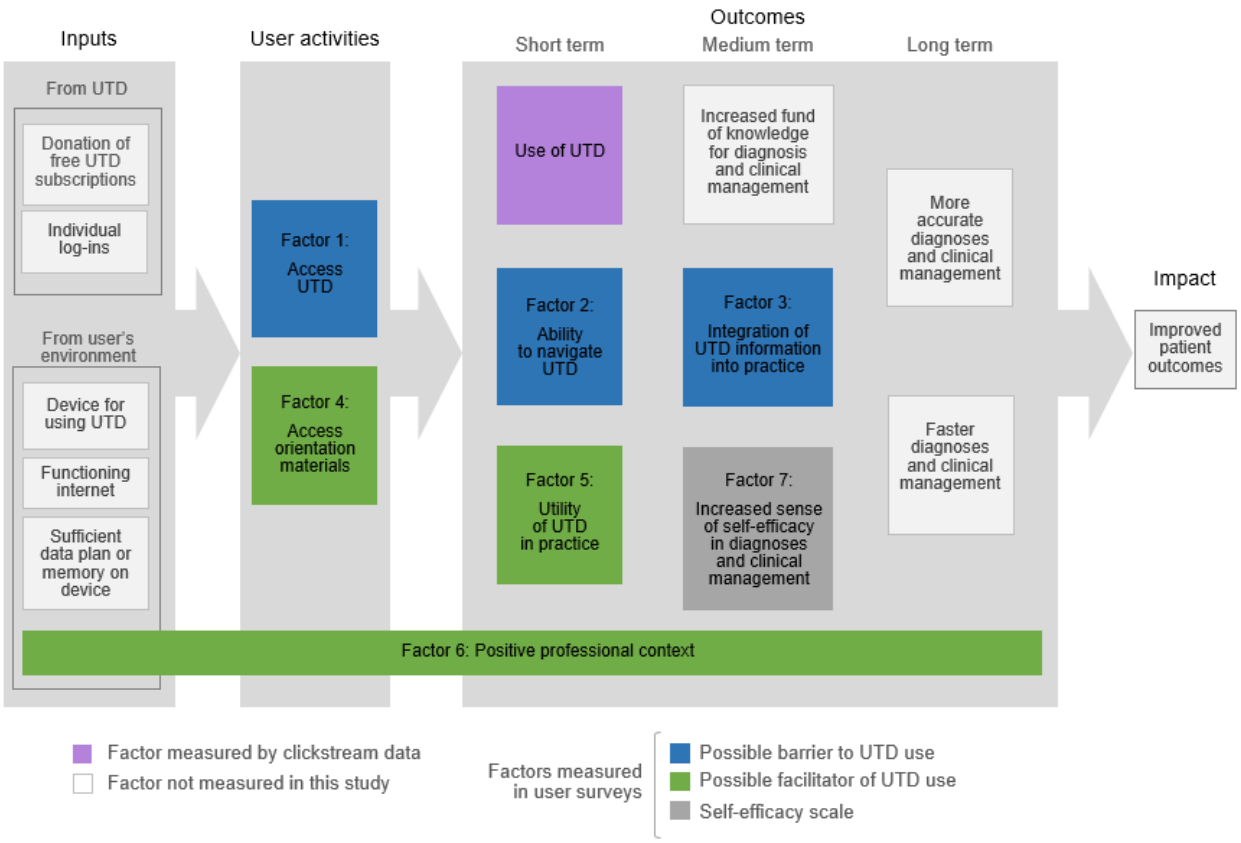
Figure 1: Logic model showing how UpToDate use among clinicians can impact patient outcomes; UTD = UpToDate

Figure 2: Population demographics and use of the tool

Figure 3: Percent of users reporting presence of each barrier or facilitator by survey month

Figure 4: Relationship between barriers, facilitators, and use of the tool around the time of the survey

Figure 1: Logic model showing how UpToDate use among clinicians can impact patient outcomes



UTD = UpToDate

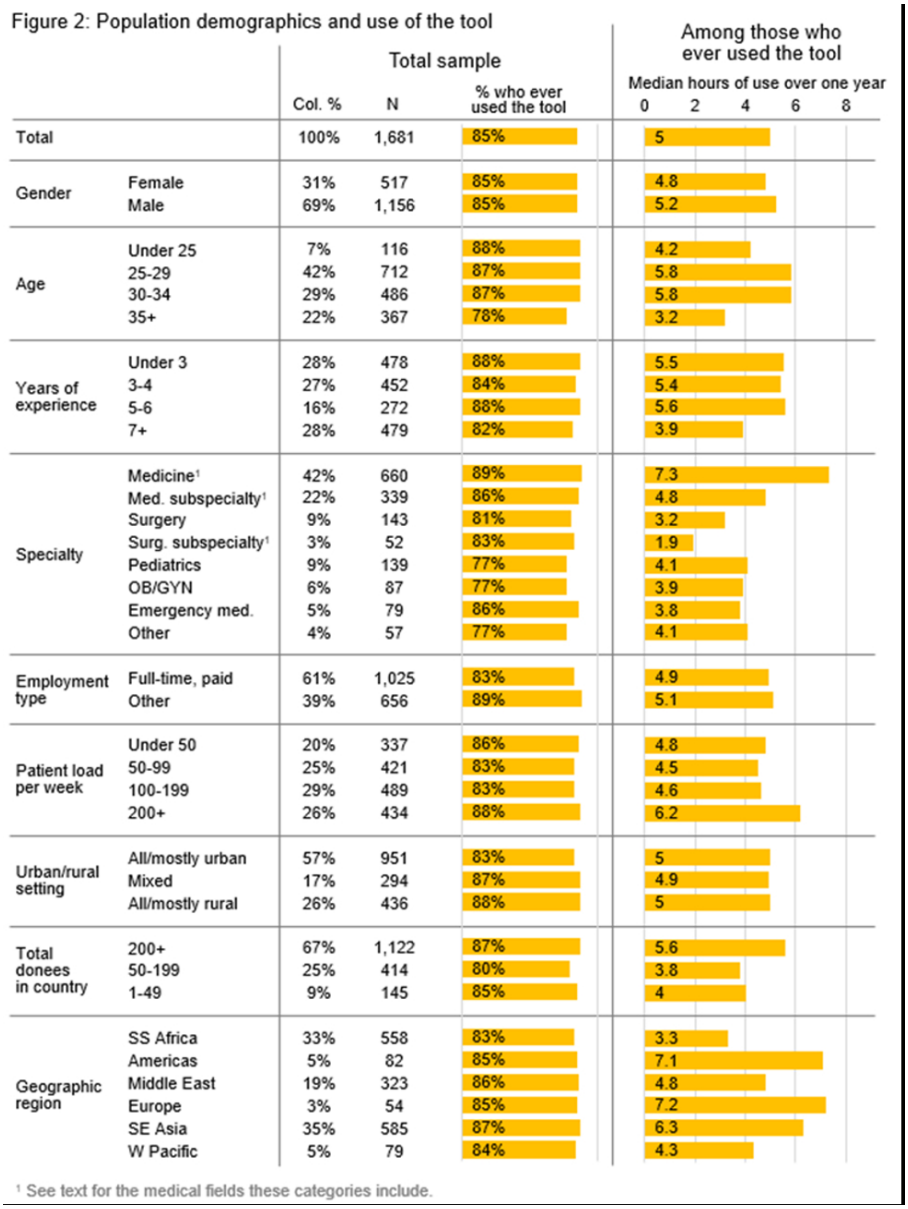


Figure 2: Population Demographics and Use of the Tool

165x220mm (150 x 150 DPI)

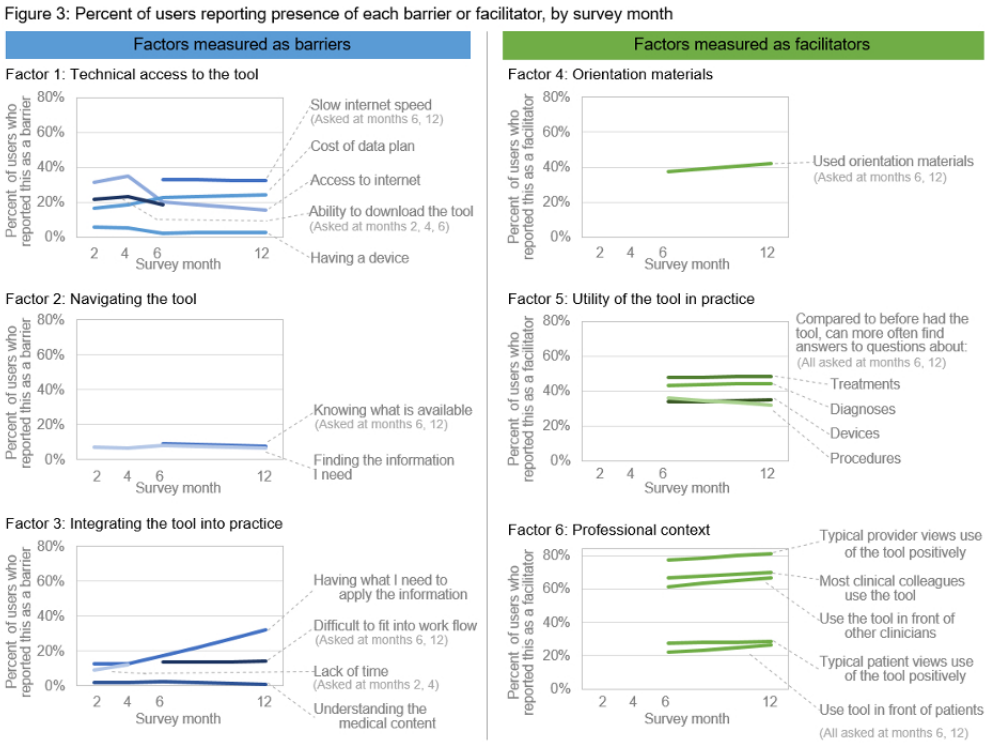


Figure 3: Percent of users reporting presence of each barrier or facilitator by survey month

165x123mm (144 x 144 DPI)

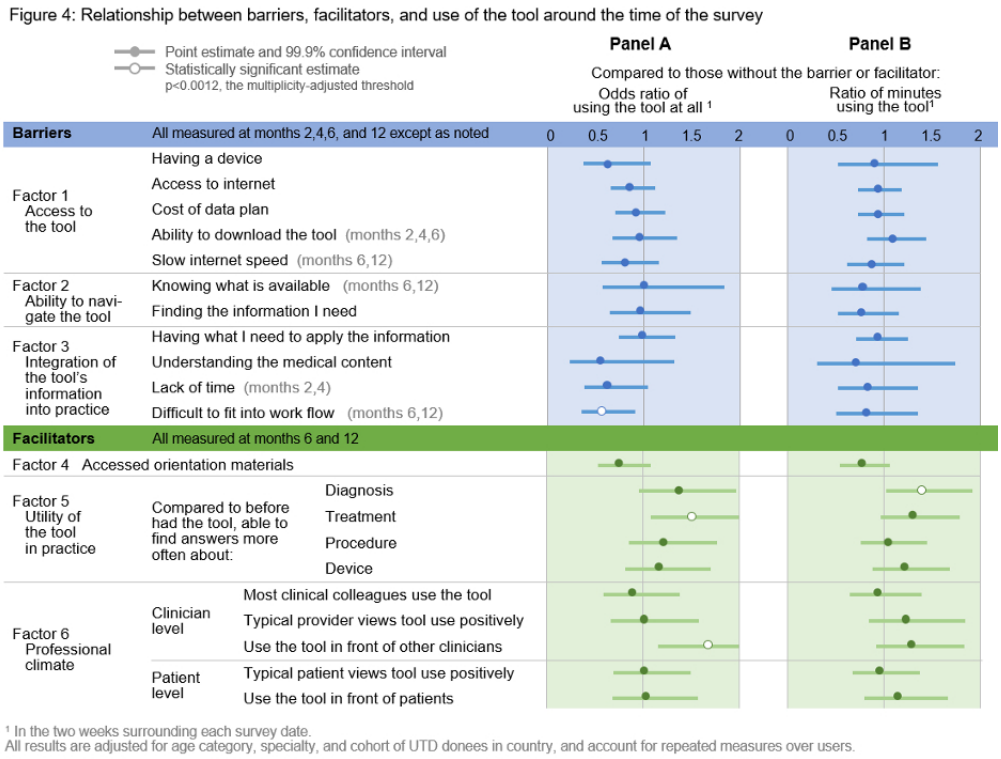


Figure 4: Relationship between barriers, facilitators and use of the tool around the time of the survey

165x125mm (144 x 144 DPI)

Appendix A

The 34 categories of medical specialties were collapsed into 8 groups as follows:

1. Medicine: family medicine, general practice, and internal medicine
2. Medical subspecialty: allergy and immunology, anesthesiology, cardiology, dermatology, endocrinology, gastroenterology, geriatrics, hematology, hospital medicine, infectious disease, nephrology, neurology, oncology, psychiatry, pulmonary, rheumatology, sports medicine, and women's health
3. Surgical subspecialty: ophthalmology, orthopedic surgery, otorhinolaryngology, and urology.
4. Other specialty: pathology, radiology, and other
5. Emergency medicine: no subgroups
6. OB/GYN: no subgroups
7. Pediatrics: no subgroups
8. Surgery: no subgroups

UpToDate-GHD Donation Application

* Required

Terms and conditions

Grant Privacy Policy, Requirements and Termination Clause
http://www.globalhealthdelivery.org/files/ghd/files/grant-privacy-policy-requirements-termination-clause.pdf

UpToDate, Inc. Subscription and License Agreement
http://www.globalhealthdelivery.org/files/ghd/files/uptodate-license-agreement.pdf

Note: Some UpToDate donations have subsequently led to paid subscription accounts; in some circumstances, applicants may be contacted by UpToDate sales representatives to facilitate such arrangements.

1. **I agree to the terms and conditions** *
   Mark only one oval.

   ◯ Yes

Tell us about yourself

2. **First name / given name** *

3. **Last name / family name** *

4. **Suffix** *
Check all that apply.

- [ ] MD
- [ ] DO
- [ ] RN
- [ ] MBBS
- [ ] PhD
- [ ] MPH
- [ ] MBA
- [ ] N/A
- [ ] Other: _____

5. **What is your age?** *

_____

6. **If you are a clinician, please tell us where and when you received your highest level of training.**

_____

7. **How many years of clinical experience do you have?** *

_____

8. **Preferred email address** *

_____

9. **Preferred email address (please re-type)** *

_____

10. **Preferred phone number (please do not include any special characters)** *

_____

Tell us about your work

11. **Name of your organization** *

12. **Organization mailing address** *

13. **City where you work with the organization** *

14. **Country where you work with the organization** *

15. **Your organization is:** *
Check all that apply.

- [ ] A government agency
- [ ] A university, college, or other education
- [ ] A non-governmental organization (NGO)
- [ ] A public hospital
- [ ] A mission hospital
- [ ] A physician solo practice
- [ ] A group/family practice
- [ ] Other: _____

16. **Where does funding/revenue for your organization's services come from?** *
Check all that apply.

- [ ] Government
- [ ] International donors (PEPFAR, USAID, DFID, Global Fund, etc.)
- [ ] Patients' insurance
- [ ] Patients' payments and fees
- [ ] Private philanthropy
- [ ] Other: _____

17. **Is your organization in a rural or urban setting?** *
Mark only one oval.

- ◯ Mostly urban
- ◯ Mostly rural
- ◯ All rural
- ◯ All urban
- ◯ 50/50

18. **What is your status with this organization?** *
Mark only one oval.

- ◯ Full-time paid employee
- ◯ Part-time paid employee
- ◯ Volunteer
- ◯ Contractor
- ◯ Consultant
- ◯ Invited guest
- ◯ Other: _____

19. **What is your role/profession?** *
Mark only one oval.

- ◯ Physician
- ◯ Physician assistant
- ◯ Nurse
- ◯ Nurse practitioner
- ◯ Pharmacist
- ◯ Corporate
- ◯ Medical librarian
- ◯ Medical student
- ◯ Resident
- ◯ Other: _____

20. **What is your medical specialty?**
Mark only one oval.

- ◯ Allergy and immunology
- ◯ Anesthesiology
- ◯ Cardiology

- [ ] Dermatology
- [ ] Emergency medicine
- [ ] Endocrinology
- [ ] Family medicine
- [ ] Gastroenterology
- [ ] General practice
- [ ] Geriatrics
- [ ] Hematology
- [ ] Hospital medicine
- [ ] Infectious disease
- [ ] Internal medicine
- [ ] Nephrology
- [ ] Neurology
- [ ] OB/GYN
- [ ] Oncology
- [ ] Ophthalmology
- [ ] Orthopedic surgery
- [ ] Otorhinolaryngology
- [ ] Palliative care
- [ ] Pathology
- [ ] Pediatrics
- [ ] Psychiatry
- [ ] Pulmonary
- [ ] Radiology
- [ ] Rheumatology
- [ ] Sleep medicine
- [ ] Sports medicine
- [ ] Surgery
- [ ] Urology
- [ ] Women's health
- [ ] Other: _____

Tell us why you need a donated subscription

21. **In a short paragraph, please tell us more about your work:** *
Please describe the mission of your organization, why and when you got involved, and what you work on.

22. **In a short paragraph, please tell us why you should receive a donated UpToDate subscription and its potential impact on the community you serve.** *

UpToDate features

23. **Please check the offline features you will need with your subscription.** *
Check all that apply.

☐ MobileComplete: An application that enables offline access on a smartphone or tablet after an initial Internet-powered install for Apple and Android devices

☐ Downloadable Desktop: An application that enables offline access on a desktop computer or laptop after an initial Internet-powered download.

Baseline Survey (Pre-donation)

1. Which of the following are important when you are deciding whether or not to look up clinical information online? (Select all that are apply.)

    a. Having ready access to a device to use, such as a smart phone or computer
    b. Access to internet
    c. Cost of data access plan
    d. Anticipated ease of finding the information I need
    e. Likelihood of having the tests or medicines I need to apply the information in clinical practice
    f. The potential of the content to improve the care I provide
    g. The ability to use it in my usual workflow

2.

	Never	Rarely	Sometimes		Often	
a. How often do you look for information online when a patient presents with a condition you treat frequently?	1	2	3	4	5	6
b. How often do you look for information online when a patient presents with a condition you have not treated before?	1	2	3	4	5	6

3. Why did you decide to apply for an UpToDate subscription? (Select all that apply)

    a. I saw other practitioners using it.
    b. It was recommended to me.
    c. I received a promotional email.
    d. It seemed like a good deal (free).
    e. I want to improve my clinical practice.
    f. Other (please describe)

    g. If other: Please describe the reason. [open text]

4. How often do you have access to a smartphone, tablet or computer while providing clinical care?

    a. Never
    b. Rarely
    c. Sometimes
    d. Often
    e. Almost always
    f. Always

5. Approximately how many of the clinical care providers that you work with use UpToDate? (Select one)

a. 100%
b. 75%
c. 50%
d. 25%
e. 0%
f. I don't know
g. N/A (I don't work with other clinical providers.)

6.	Negatively		Neutrally	Positively	It's highly variable	I don't know
a. How do you think clinicians in your area would view the use of an online tool like UpToDate for clinical care?	1	2	3	4	5	
b. How do you think your patients would view the use of an online tool like UpToDate during clinical care?	1	2	3	4	5	

7.	Never	Rarely	Sometimes	Often	Almost always	Always	N/A
a. In the last month, when you've had diagnostic questions, how often have you been able to find the answers?	1	2	3	4	5	6	7
b. In the last month, when you've had questions about creating a treatment plan, how often have you been able to find the answers?	1	2	3	4	5	6	7
c. In the last month, when you've had questions about using a medical device, how often have you been able to find the answers?	1	2	3	4	5	6	7
d. In the last month, when you've had questions about preparing for a procedure, how often have you been able to find the answers?	1	2	3	4	5	6	7

8. Approximately how often do you learn useful information from the following sources?

	Never	A few times per year	Monthly	Weekly	Daily

a. Colleagues	1	2	3	4	5
b. UpToDate	1	2	3	4	5
c. Other online resources	1	2	3	4	5
d. Textbooks	1	2	3	4	5
e. WHO protocols	1	2	3	4	5
f. In-person lectures or trainings	1	2	3	4	5

9. When providing clinical care, how true are the following statements for you?

	Not at all true	Hardly true	Moderately true	Exactly true
a. I will be able to achieve most of the goals that I have set for myself.	1	2	3	4
b. When facing difficult tasks, I am certain that I will accomplish them.	1	2	3	4
c. In general, I think that I can obtain outcomes that are important to me.	1	2	3	4
d. I believe I can succeed at most any endeavor to which I set my mind.	1	2	3	4
e. I will be able to successfully overcome many challenges.	1	2	3	4
f. I am confident that I can perform effectively on many different tasks.	1	2	3	4
g. Compared to other people, I can do most tasks very well.	1	2	3	4
h. Even when things are tough, I can perform well.	1	2	3	4

12 month survey

Thank you for your interest in helping us improve our impact by completing this brief survey. In exchange for your participation, you will get an additional 6 months of UpToDate access added to your subscription.

Filling out this survey serves as a statement of informed consent from you, meaning that you agree to participate in the study. Participation in this study is completely voluntary, and refusal to participate will not affect your future eligibility for free access to UpToDate or for any other benefits to which you may be entitled. You may discontinue your participation in this study at any time. We anticipate enrolling approximately 1,600 participants.

How: The following survey will ask you about your thoughts on UpToDate and your experiences using it as well as your clinical confidence. The survey should take approximately 20 minutes. We will also review your activity on UpToDate using your username to understand how frequently you log on, what you search for, and what topics you view.

Benefits: By opting in to the study extension and completing the final survey, participants will receive an additional six months for a total of a 24-month subscription and will be eligible to renew their subscriptions and continue receiving access. You may use UpToDate from any device or network. Currently, a year of subscription to UpToDate for an individual medical professional in the US costs $495 US Dollars. You will not receive any monetary compensation for your participation.

Privacy: Your data (survey responses, UpToDate usage) will be linked to your email but will be kept fully confidential in password-protected computers. Your personal information, individual responses, and data use will not be shared with anyone beyond our research team, but study results in aggregate may be published.

Questions: If you have any questions about the research, please email Julie@globalhealthdelivery.org.

If you would like to speak to someone not involved in this research about your rights as a human research subject, or any concerns or complaints you may have about the research, please contact the Partners Human Research Committee at 857-282-1900.

UpToDate, Inc. Subscription and License Agreement:
http://www.globalhealthdelivery.org/files/ghd/files/uptodate-license-agreement.pdf

Note: Some UpToDate donations have subsequently led to paid subscription accounts; in some circumstances, applicants may be contacted by UpToDate sales representatives to facilitate such arrangements.

I agree to the terms and conditions

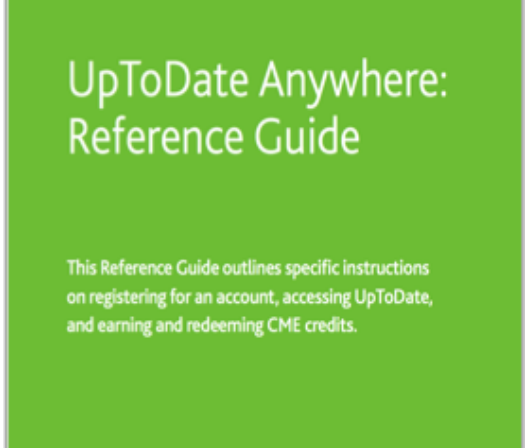
◯ Yes
◯ No

Did you use the quick reference guide or online trainings in UpToDate's Training Resource Center shown below in the past 6 months?

◯ Yes
◯ No
◯ I don't know

Please tell us why you did not use the quick reference guide or online trainings in UpToDate's Training Resource Center.

_____



Have you had these problems accessing UpToDate? (Select all that apply)

	This has never been a problem	This was a problem in the past but not anymore	This is a problem now
Not having a device to use	☐	☐	☐
Accessing the internet	☐	☐	☐
Cost of the data plan	☐	☐	☐
Slow internet speed	☐	☐	☐
Other	☐	☐	☐

Not having a device to use: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

Accessing the internet: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

Cost of the data plan: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

Slow internet speed: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

Other: please describe the problem you experienced.

_____

Have you had problems using and applying UpToDate? (Select all that apply)

	This has never been a problem	This was a problem in the past but not anymore	This is a problem now
Understanding the medical content in UpToDate	☐	☐	☐
Understanding UpToDate because it is written in English	☐	☐	☐
Finding the information I need	☐	☐	☐
Knowing what is available in UpToDate, such as tables or dosage calculators	☐	☐	☐
Not having the tests, data, or medicines recommended by UpToDate	☐	☐	☐
Other	☐	☐	☐

If other, please describe the problem and when it started.

_____

Understanding the medical content in UpToDate: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

Understanding UpToDate because it is written in English: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

Finding the information I need: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

Knowing what is available in UpToDate, such as tables or dosage calculators: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

Not having the tests, data, or medicines recommended by UpToDate: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

When you do not have the tests, data, or medicines recommended by UpToDate, what do you typically do?

_____

Do you have advice for dealing with this challenge?

_____

How often do you use UpToDate for...?

	Never	Rarely	Sometimes	Often	Almost Always	Always	N/A
Determining a diagnosis	○	○	○	○	○	○	○
Developing a treatment plan	○	○	○	○	○	○	○
Using a medical device	○	○	○	○	○	○	○
Preparing for a procedure	○	○	○	○	○	○	○
Earning continuing medical education credit (CME credit)	○	○	○	○	○	○	○
General learning (not patient-specific)	○	○	○	○	○	○	○
Teaching students/colleagues	○	○	○	○	○	○	○
Educating patients	○	○	○	○	○	○	○
Other	○	○	○	○	○	○	○

Please describe the other ways you use UpToDate and how often you use it that way.

_____

	Never	Rarely	Sometimes	Often	Almost Always	Always	N/A
How often do you look for information online when a patient presents with a condition you treat infrequently?	○	○	○	○	○	○	○
How often do you look for information online when a patient presents with a condition you have not treated before?	○	○	○	○	○	○	○

Approximately how often do you learn useful information from these sources?

	Never	A few times per year	Monthly	Weekly	Daily
Colleagues	◯	◯	◯	◯	◯
UpToDate	◯	◯	◯	◯	◯
Other online resources	◯	◯	◯	◯	◯
Textbooks	◯	◯	◯	◯	◯
WHO protocols	◯	◯	◯	◯	◯
In-person lectures or trainings	◯	◯	◯	◯	◯

How easy or difficult is it for you to use UpToDate in your usual workflow?

◯ Very easy
◯ Somewhat easy
◯ Somewhat difficult
◯ Very difficult
◯ N/A

What makes UpToDate easy to use in your usual workflow?

_____

What makes UpToDate difficult to use in your usual workflow?

_____

Do you use UpToDate's offline mode (MobileComplete or Downloadable Desktop)?

◯ Yes
◯ No

If no, why not?

_____

Approximately how many of the clinical care providers that you work with use UpToDate?

◯ 100%
◯ 75%
◯ 50%
◯ 25%
◯ 0%
◯ I don't know
◯ N/A (I don't work with other clinical providers)

How often do you refer to UpToDate with patients during clinical care so that they can see you using it?

◯ Never
◯ Rarely
◯ Sometimes
◯ Often
◯ Very often

If you did use UpToDate during clinical care, how do you think the typical patient would view your use?

◯ Negatively
◯ Neutrally
◯ Positively
◯ It's highly variable
◯ I don't know

How do you think the typical patient views your use of UpToDate during clinical care?

◯ Negatively
◯ Neutrally
◯ Positively
◯ It's highly variable
◯ I don't know

How often do you refer to UpToDate in the presence of other clinical care providers?

◯ Never
◯ Rarely
◯ Sometimes
◯ Often
◯ Very often

If you did use UpToDate in the presence of other clinical care providers, how do you think the typical provider would view your use?

◯ Negatively
◯ Neutrally
◯ Positively
◯ It's highly variable
◯ I don't know

How do you think the typical provider views your use of UpToDate?

◯ Negatively
◯ Neutrally
◯ Positively
◯ It's highly variable
◯ I don't know

In the past month, how often have you been able to find answers...?

	Never	Rarely	Sometimes	Often	Almost Always	Always	N/A
When you have had diagnostic questions	○	○	○	○	○	○	○
When you have had questions about creating a treatment plan	○	○	○	○	○	○	○
When you have had questions about using a medical device	○	○	○	○	○	○	○
When you have had questions about preparing for a procedure	○	○	○	○	○	○	○

Before you had this UpToDate subscription, how often were you able to find answers...?

	Never	Rarely	Sometimes	Often	Almost Always	Always	N/A
When you have had diagnostic questions	◯	◯	◯	◯	◯	◯	◯
When you have had questions about creating a treatment plan	◯	◯	◯	◯	◯	◯	◯
When you have had questions about using a medical device	◯	◯	◯	◯	◯	◯	◯
When you have had questions about preparing for a procedure	◯	◯	◯	◯	◯	◯	◯

How likely are you to recommend the Better Evidence UpToDate donation program to a friend or a colleague?

Please rate on a scale of 1 to 10, with 1 meaning "not likely to recommend" and 10 meaning "extremely likely to recommend."

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ 10

Now please answer in words:
How likely are you to recommend the Better Evidence UpToDate donation program to a friend or a colleague?

◯ Highly unlikely
◯ Somewhat unlikely
◯ Undecided (neither likely nor unlikely)
◯ Somewhat likely
◯ Highly likely

In the past 6 months, have you noticed changes in the way you use UpToDate, such as what you use it for, how often you use it, or when you use it?

◯ Yes
◯ No

Please describe these changes and what caused them.

_____

How has UpToDate changed your confidence in your clinical decisions?

◯ I am much less confident
◯ I am a little less confident
◯ No change in confidence due to UpToDate
◯ I am a little more confident
◯ I am much more confident

In the last 6 months, I feel that using UpToDate CAUSED me to at least once: (select all that apply)

☐ Make a diagnostic error
☐ Make an inaccurate treatment plan
☐ Over use resources (e.g., tests, consultations)
☐ Spend too much time searching or reading UpToDate when unsure about a diagnosis or treatment option
☐ None of the above

In the last 6 months, I feel that using UpToDate HELPED me to at least once: (select all that apply)

☐ Make an accurate diagnosis that I otherwise would not have made
☐ Make a more accurate treatment plan than I would have without UpToDate
☐ More efficiently use resources (e.g., tests, consultations)
☐ Save time by searching or reading UpToDate when unsure about a diagnosis or treatment option
☐ None of the above

When providing clinical care, how true are the following statements for you?

	Not true at all	Hardly true	Moderately true	Exactly true
I will be able to achieve most of the goals that I have set for myself.	◯	◯	◯	◯
When facing difficult tasks, I am certain that I will accomplish them.	◯	◯	◯	◯
In general, I think that I can obtain outcomes that are important to me.	◯	◯	◯	◯
I believe I can succeed at most any endeavor to which I set my mind.	◯	◯	◯	◯
I will be able to successfully overcome many challenges.	◯	◯	◯	◯
I am confident that I can perform effectively on many different tasks.	◯	◯	◯	◯
Compared to other people, I can do most tasks very well.	◯	◯	◯	◯
Even when things are tough, I can perform well.	◯	◯	◯	◯

Is there a topic that UpToDate did not cover or do you have any other comments? Please explain.

_____

Would you be willing to be contacted in the future about your experience with the Better Evidence Donation Program?

◯ Yes
◯ No

What are the barriers to using UTD? Please check all that apply.

a. Having a device to use

b. Access to internet

c. Cost of data access plan

d. Ability to find the information I need

e. Ability to download UpToDate/MobileComplete

f. Relevancy of the information--having the tests or medicines I need to apply the information in clinical practice

g. Understanding the medical content in UpToDate

h. Colleagues—I don't want to use it in their presence and don't have privacy

i. Lack of time

j. Language-- Understanding UpToDate because it is written in English

a. Other (describe below)

b. No barriers

If other: Please describe. [open text]

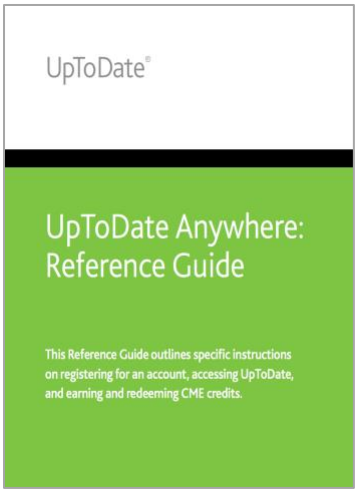
When providing clinical care, how true are the following statements for you?

	Not at all true	Hardly true	Moderately true	Exactly true
a. I will be able to achieve most of the goals that I have set for myself.	1	2	3	4
b. When facing difficult tasks, I am certain that I will accomplish them.	1	2	3	4
c. In general, I think that I can obtain outcomes that are important to me.	1	2	3	4
d. I believe I can succeed at most any endeavor to which I set my mind.	1	2	3	4
e. I will be able to successfully overcome many challenges.	1	2	3	4
f. I am confident that I can perform effectively on many different tasks.	1	2	3	4
g. Compared to other people, I can do most tasks very well.	1	2	3	4
h. Even when things are tough, I can perform well.	1	2	3	4

Follow-up at 6 months

1. Did you use the quick reference guide or online trainings in UpToDate's Training Resource Center shown below? (Select one)

    a. Yes
    b. No (describe below)
    c. I don't know
    d. Please tell us why you did not use the quick reference guide or online trainings in UpToDate's Training Resource Center. [open text]



2. Do you have any problems with **accessing** UpToDate? (Select yes or no for each row and column)

	This was a problem in the beginning	This is an ongoing problem
a. Not having a device to use	yes/no	yes/no
b. Accessing the internet	yes/no	yes/no
c. Cost of the data plan	yes/no	yes/no
d. Downloading UpToDate	yes/no	yes/no
e. Slow internet speed	yes/no	yes/no
f. Other (describe below)	yes/no	yes/no

g. If other: Please describe the problem you experience in the beginning and when it started. [open text]
h. If other: Please describe the ongoing problem and when it started. [open text]

3. Do you have any problems with **using and applying** UpToDate? (Select yes or no for each row and column)

	This was a problem in the beginning	This is an ongoing problem
a. Understanding the medical content in UpToDate	yes/no	yes/no
b. Understanding UpToDate because it is written in English	yes/no	yes/no
c. Finding the information I need	yes/no	yes/no
d. Knowing what is available in UpToDate, such as tables or dosage calculators	yes/no	yes/no
e. Not having the tests, data, or medicines recommended by UpToDate	yes/no	yes/no
f. Other (describe below)	yes/no	yes/no

g. If other: Please describe the problem you experienced in the beginning and when it started. [open text]
h. If other: Please describe the ongoing problem and when it started. [open text]

(If 3e is no in both columns, skip to 5)

4.

a. When you do not have the tests, data, or medicines recommended by UpToDate, what do you typically do? [open text]
b. Do you have advice for dealing with this challenge? [open text]

5. How often do you use UpToDate for ...?

	Never	Rarely	Some-times	Often	Almost always	Always	N/A
a. Determining a diagnosis	1	2	3	4	5	6	7
b. Developing a treatment plan	1	2	3	4	5	6	7
c. Using a medical device	1	2	3	4	5	6	7
d. Preparing for a procedure	1	2	3	4	5	6	7
e. Earning continuing medical education credit (CME credit)	1	2	3	4	5	6	7
f. General learning (not patient-specific)	1	2	3	4	5	6	7
g. Teaching students/colleagues	1	2	3	4	5	6	7
h. Educating patients	1	2	3	4	5	6	7
i. Other (describe below)	1	2	3	4	5	6	7

j. If other, please describe the other ways you use UpToDate and how often you use it that way. [open text]

6.	Never	Rarely	Sometimes	Often	Almost Always	Always
a. How often do you look for information online when a patient presents with a condition you treat frequently?	1	2	3	4	5	6
b. How often do you look for information online when a patient presents with a condition you have not treated before?	1	2	3	4	5	6

7. Approximately how often do you learn useful information from these sources?

	Never	A few times per year	Monthly	Weekly	Daily
c. Colleagues	1	2	3	4	5
d. UpToDate	1	2	3	4	5
e. Other online resources	1	2	3	4	5
f. Textbooks	1	2	3	4	5
g. WHO protocols	1	2	3	4	5
h. In-person lectures or trainings	1	2	3	4	5

8. How easy or difficult is it for you to use UpToDate in your usual workflow? (Select one)

a. Very easy
b. Somewhat easy
c. Somewhat difficult (Skip to 10)
d. Very difficult (Skip to 10)
e. N/A (Skip to 11)

9. What makes it easy to fit UpToDate into your usual workflow? [open text]
(Skip to 11)

10. What makes it difficult to fit UpToDate into your usual workflow? [open text]

11. Approximately how many of the clinical care providers that you work with use UpToDate? (Select one)

a. 100%
b. 75%
c. 50%
d. 25%
e. 0%
f. I don't know
g. N/A (I don't work with other clinical providers.)

12. How often do you refer to UpToDate **with patients during clinical care**, so that they can see you using it? (Select one)

a. Never
b. Rarely (Skip to 14)
c. Sometimes (Skip to 14)
d. Often (Skip to 14)
e. Very often (Skip to 14)

13. If you did use UpToDate during clinical care, how do you think the typical **patient** would view your use? (Select one)

a. Negatively
b. Neutrally
c. Positively
d. It's highly variable
e. I don't know
(Skip to 15)

14. How do you think your typical **patient** views your use of UpToDate during clinical care? (Select one)

a. Negatively
b. Neutrally
c. Positively
d. It's highly variable
e. I don't know

15. How often do you refer to UpToDate **in the presence of other clinical care providers**? (Select one)

a. Never
b. Rarely (Skip to 17)
c. Sometimes (Skip to 17)
d. Often (Skip to 17)
e. Always (Skip to 17)

16. If you did use UpToDate in the presence of other clinical care providers, how do you think the typical **provider** would view your use? (Select one)

a. Negatively
b. Neutrally
c. Positively
d. It's highly variable
e. I don't know (Skip to 18)

17. How do you think the typical **provider** would view your use of UpToDate? (Select one)

a. Negatively
b. Neutrally
c. Positively

d. It's highly variable
e. I don't know

18.	Never	Rarely	Sometimes	Often	Almost always	Always	N/A
a. In the last month, when you've had diagnostic questions, how often have you been able to find the answers?	1	2	3	4	5	6	7
b. In the last month, when you've had questions about creating a treatment plan, how often have you been able to find the answers?	1	2	3	4	5	6	7
c. In the last month, when you've had questions about using a medical device, how often have you been able to find the answers?	1	2	3	4	5	6	7
d. In the last month, when you've had questions about preparing for a procedure, how often have you been able to find the answers?	1	2	3	4	5	6	7
e. Before you had this UpToDate subscription, when you had diagnostic questions, how often were you able to find the answers?	1	2	3	4	5	6	7
f. Before you had this UpToDate subscription, when you had questions about creating a treatment plan, how often were you able to find the answers?	1	2	3	4	5	6	7
g. Before you had this UpToDate subscription, when you had questions about using a medical device, how often were you able to find the answers?	1	2	3	4	5	6	7
h. Before you had this UpToDate subscription, when you had questions about preparing for a procedure, how often were you able to find the answers?	1	2	3	4	5	6	7

19. How likely are you to recommend the GHD-UpToDate donation program to a colleague?

a. Highly unlikely
b. Somewhat unlikely
c. Undecided (neither likely nor unlikely)
d. Somewhat likely
e. Highly likely

20. In the past 6 months, have you noticed changes in the way you use UpToDate, such as what you use it for, how often you use it, or when you use it? (Select one)

    a. Yes
    b. No (Skip to 22)

21. Please describe these changes and what caused them. [open text]

22. How has UptoDate changed your confidence in your clinical decisions?

    a. I am much less confident
    b. I am a little less confident
    c. No change in confidence due to UpToDate
    d. I am a little more confident
    e. I am much more confident

23. In the last 6 months, I feel that using UpToDate **caused** me to at least once: (select all that apply)
    a. Make a diagnostic error
    b. Make an inaccurate treatment plan
    c. Over use resources (e.g., tests, consultations)
    d. Spend too much time searching or reading UpToDate when unsure about a diagnosis or treatment option
    e. None of the above

24. In the last 6 months, I feel that using UpToDate **helped** me to at least once: (select all that apply)
    a. Make an accurate diagnosis that I otherwise would not have made
    b. Make a more accurate treatment plan than I would have without UpToDate
    c. More efficiently use resources (e.g., tests, consultations)
    d. Save time by searching or reading UpToDate when unsure about a diagnosis or treatment option
    e. None of the above

25. When providing clinical care, how true are the following statements for you?

	Not at all true	Hardly true	Moderately true	Exactly true
a. I will be able to achieve most of the goals that I have set for myself.	1	2	3	4
b. When facing difficult tasks, I am certain that I will accomplish them.	1	2	3	4
c. In general, I think that I can obtain outcomes that are important to me.	1	2	3	4
d. I believe I can succeed at most any endeavor to which I set my mind.	1	2	3	4
e. I will be able to successfully overcome many challenges.	1	2	3	4
f. I am confident that I can perform effectively on many different tasks.	1	2	3	4
g. Compared to other people, I can do most tasks very well.	1	2	3	4
h. Even when things are tough, I can perform well.	1	2	3	4

26. Any other comments? [open text]

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-9
Bias	9	Describe any efforts to address potential sources of bias	12-13 (self-efficacy scale)
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8-11
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11-12
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11-13
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) Summarise follow-up time (eg, average and total amount)	

Outcome data	15*	Report numbers of outcome events or summary measures over time	11-16

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (*b*) Report category boundaries when continuous variables were categorized (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	15-16
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	16-17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	18
Generalisability	21	Discuss the generalisability (external validity) of the study results	18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	20

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

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Barriers and Facilitators to Use of a Digital Clinical Decision Support Tool: A cohort study combining clickstream and survey data

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Barriers and Facilitators to Use of a Digital Clinical Decision Support Tool: A cohort study combining clickstream and survey data

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Abstract

Objectives: This research aimed to understand the barriers and facilitators clinicians face in using a digital clinical decision support tool —UpToDate — around the globe.

Design: We used a mixed-methods cohort study design that enrolled 1,681 clinicians (physicians, surgeons, or physician's assistants) who applied for free access to UpToDate through our established donation program during a 9-week study enrollment period. Eligibility included working outside of the United States for a public or non-profit health facility serving vulnerable populations, having at least

intermittent internet access, completing the application in English; and not being otherwise able to afford the subscription.

Interventions: After consenting to study participation, clinicians received a one-year subscription to UpToDate. They completed a series of surveys over the year, and we collected clickstream data tracking their use of the tool.

Primary and secondary outcome measures:

1) the variation in use by demographic

2) the prevalence of barriers and facilitators of use

3) the relationship between barriers, facilitators, and use

Results:

Of 1,681 study enrollees, 69% were male and 71% were between 25 and 35 years old, with the plurality practicing general medicine and the majority in sub-Saharan Africa or Southeast Asia. Of the 11 barriers we assessed, fitting the tool into the workflow was a statistically significant barrier, making clinicians 50% less likely to use it. Of the 10 facilitators, a supportive professional context and utility were significant drivers of use.

Conclusions:

There are several clear barriers and facilitators to promoting the use of digital clinical decision support tools in practice. We recommend tools like UpToDate be implemented with complementary services. These include generating a supportive professional context, helping clinicians realize the tools' utility, and working with health systems to better integrate digital, clinical decision support tools into workflows.

Strengths and limitations:

- This study combines surveys with clickstream data from the digital tool—data that clinicians directly generate in using the tool—which provides precise, robust data.

- We only included clinicians who applied and met criteria for a donated subscription; this included those who were able to complete the application in English and those working in limited-resource settings, limiting generalizability.

- Due to time and resource constraints, we could not measure all components of the logic model we built relating the use of UpToDate to patient outcomes.

- While we hypothesized that access to UpToDate can improve clinicians' sense of self-efficacy, the psychometrics of the self-efficacy scale we instituted did not function properly in this study and resulted in null results.

Background

Diagnostic and treatment errors account for a significant amount of harm across high-, middle-, and low-income settings and represent a serious public health problem. Most people will likely experience a diagnostic error in their lifetime.[1] In a high-income country in an outpatient setting, one study found that 5% of adults experienced diagnostic errors each year. Over half of these errors had the potential for severe harm. The researchers suggested that their findings were likely an underestimate and that the rate of diagnostic errors in low-income countries may be much higher. Other studies analyzing mortality data from autopsies have shown that 10– 15% of deaths are due to missed diagnoses.[2] Even in cases that are ultimately correctly diagnosed and treated, errors leading to delay may result in poor quality of care, patient safety risks, increased costs, and, in some cases, malpractice litigation.[3]

Diagnostic and treatment errors can happen at any point in the care process, including initial assessment, performing and interpreting diagnostic tests, determining treatment, follow-up visits and tracking. These errors involve the failure to provide a timely, accurate determination of a patient's health condition or

treatment option and/or to communicate necessary, accurate, timely information to a patient.[4] They represent missed opportunities to provide quality, effective care based on the best available clinical evidence.

More than half of the cases of diagnostic error are due to cognitive errors. Frontline healthcare workers face a demanding cognitive load. They need to keep up with new evidence and incorporate it into care decisions; more than 950,000 new publications are indexed in MEDLINE every year.[5] The coronavirus pandemic has further increased the speed and volume of clinical evidence, exacerbating the challenges.[6] Health information technology or digital tools used at the point of care–clinical decision support tools–can reduce diagnostic errors. In 2019, the World Health Organization acknowledged digital tools as important levers for ensuring effective, high-quality, equitable care.[7] They can support clinicians' decision making, enabling quick, better informed decisions that lead to better health outcomes.[8] Such tools include computerized alerts or reminders; clinical guidelines; focused patient data reports and analyses, and contextually relevant reference information, among other offerings.[8]

Clinical decision support tools like Merck Manuals, epocrates, UpToDate, DynaMed, and VisualDx are apps and websites that bring the most recent medical evidence to the clinician at the bedside. Editors working behind the scenes review scientific literature and integrate it into relevant clinical guidance. At UpToDate, for example, more than 7,400 subject matter experts review emerging research related to their topic areas and update the tool's guidance as relevant to make sure clinicians can easily access the most current evidence when caring for patients. Clinical decision support tools can suggest key follow up questions or tests to consider, support in weighing diagnostic probabilities, show visual images to help with identification of disease or rashes, and more. Previous research has demonstrated a positive connection between evidence-based clinical decision support tools and clinician capacity; the use of

UpToDate, for example, was shown to increase performance on standardized exams among US clinicians[5] and, most importantly, to reduce risk-adjusted mortality rates at non-teaching hospitals.[6]

Despite these proven benefits, uptake and use of digital tools among clinicians around the globe remain inconsistent.[9–11] In fact, the World Medical Association recently acknowledged that lack of access to timely, current, evidence-based healthcare information—which such digital tools can provide—is a major contributor to morbidity and mortality in resource-limited settings.[12] For some, the cost of a subscription, which can be up to $580 for an individual, limits access.

In 2009, we started a program that removed the cost barrier by offering free access to UpToDate for clinicians serving vulnerable communities at resource-limited health facilities, with the goal of improving patient outcomes and health equity. Eliminating the UpToDate subscription cost led to increased use of the tool; however, we observed wide discrepancies in use patterns, suggesting that other barriers to use persisted.[13] In order to better leverage the potential impact of evidence-based clinical decision support tools s in limited-resource settings, it is important to understand what factors affect their uptake and use.

Using data from a global sample of clinicians who received UpToDate subscriptions through our online donation program, we conducted a mixed-methods cohort study. The general objective was to describe and explain the barriers and facilitators to use of the tool. Specifically, we aimed to describe:

1) the variation in UpToDate use by demographic characteristics of users,
2) the prevalence of barriers to and facilitators of UpToDate use in clinical practice, and
3) the relationship between barriers, facilitators, and UpToDate use.

Study participants reported barriers and facilitators in repeated surveys over one year, and actual use of the tool was measured through clickstream data gathered from Wolters Kluwer/UpToDate.

Methods

Study sample

All clinicians who went to the online donation program during our 9-week enrollment period (March 1, 2018 to May 4, 2018) were invited to participate in and consent to the study electronically before applying. Informed consent covered the collection of the application, survey, and clickstream data.

Eligibility criteria for the donation program included being a physician, surgeon, or physician's assistant outside of the United States; working for a public or non-profit limited-resource health facility; having at least intermittent internet access; being able to complete the application in English; attesting they are serving vulnerable populations (patients with limited-resources); and attesting they are not otherwise able to afford the subscription. Team members looked up health facilities and verified consistency in application information to confirm eligibility. Recruitment for the donation program relies primarily on word of mouth and occasional communications to beneficiaries suggesting they invite their colleagues to join. No additional recruitment efforts were undertaken for study purposes.[1] The decision to limit participation to those able to complete the application in English stems from the fact that the content within UpToDate is only available in English. We acknowledge that language is a barrier to access and did not feel it was necessary to test this hypothesis at the time.

Patient and public involvement

No patients involved.

Logic model

We built a logic model detailing how access to UpToDate could eventually affect patient outcomes (Figure 1). In this model, the inputs were the donation itself and technical supports such as a functioning internet connection. These enabled users to login to UpToDate and learn about it through the included orientation materials. These activities would then enable several short-term outcomes, including actual use of UpToDate, ability to navigate the tool, and perceived utility of the tool in practice. Medium-term

[1] Application and eligibility criteria are available at www.better-evidence.org.

outcomes included increased medical knowledge, integration of that knowledge into practice, and increased self-efficacy. In the longer term, these elements could lead to faster and more accurate diagnoses and clinical management, which would eventually translate to improved patient outcomes. This overall process would be facilitated by a professional context that supported the use of digital clinical decision support tools in practice.

Due to time and resource constraints, we could not measure all components of this logic model, but we measured several elements through two data streams: surveys and clickstream data.

Surveys

The survey included demographic, quantitative, and open-text response fields. We captured respondents' gender, age, years of experience, country of practice, urban/rural setting, patient load per week, and employment type (full-time paid vs. other).

We developed survey questions based on seven factors in the logic model downstream of the inputs as delineated in Table 1 [see Supplementary Materials for survey questions].

Table 1: Barriers and facilitators measured in surveys

Factor	Measure	Surveyed at months
Barriers		
1 Access to the tool	Having a device	2,4,6,12
	Access to internet	2,4,6,12
	Cost of data plan	2,4,6,12
	Ability to download the tool	2,4,6
	Slow internet speed	6,12
2 Ability to navigate the tool	Knowing what is available	6,12
	Finding the information I need	2,4,6,12
3 Integration of the tool's information into practice	Having what I need to apply the information	2,4,6,12
	Understanding the medical content	2,4,6,12
	Lack of time	2,4
	Difficult to fit into work flow	6,12

Facilitators		
4 Orientation materials	Accessed orientation materials	6,12
5 Utility of the tool in practice	Compared to before had the tool, able to find answers more often about: Diagnosis Treatment Procedure Device	6,12
6 Professional context	Clinician level: Most clinical colleagues use the tool Typical provider views tool use positively Use the tool in front of other clinicians	6,12
	Patient level: Typical patient views tool use positively Use the tool in front of patients	6,12

Factors 1 to 3 were measured as barriers to use. Factors 4 to 6 were measured as facilitators of use. Four types of clinical decisions were covered in the survey: treatments, diagnoses, devices, and procedures. We measured Factor 7, a sense of self-efficacy, with the 8-item New General Self Efficacy scale.[14] We added a contextualizing frame at the start of the scale: "When providing clinical care, how true are the following statements for you?"

Twelve prior donation recipients from 3 continents, ranging in age from 25 to 65, provided feedback on the survey's clarity, wording, response options, and acceptability. The survey was shortened, language was updated, and feedback was incorporated after several reviews and circulated to remaining reviewers for further review and refinement.

We integrated the baseline survey and the UpToDate donation application. Following the application approval, survey links were then triggered to be sent by email for the 2-month survey (sent 60 days after

approval), 4-month survey (120 days after), 6-month survey (180 days after), and 12-month final survey (350 days after). We excluded survey answers that were completed more than 30 days after the survey link was sent.

The baseline, 6-, and 12-month surveys covered all topics; to reduce respondent burden, the 2- and 4-month surveys only measured self-efficacy and barriers to use. Participants automatically received a 6-month subscription extension for completing the 6-month survey and another 6-month extension for completing the 12-month survey. In addition, those completing the 12-month survey were entered into a drawing for 10 prizes of US$100. The survey was built and administered in RedCAP.[15]

Clickstream data

We measured the actual use of UpToDate (purple box in Figure 1) through the tool's clickstream data, a machine-generated record of each click from every user. The records identified which pages users visited and when, starting from the day the subscription link was sent out for 365 days, across all mobile and desktop applications as well as during offline use.

We linked the survey data to the clickstream data through a unique identifier. We qualified online use in two ways: first, we created a binary indicator of whether a user ever logged on through the donated link, called "ever-users" and, second, we calculated the total amount of time ever-users spent using UpToDate over the yearlong study period. We estimated the length of specific user sessions as a function of 1) the time between clicks, 2) the content or function clicked on, and 3) overall estimates of the amount of time spent reading content, navigating the site, and managing user accounts. These methods have been detailed elsewhere.[16]

Quantitative analysis

We grouped countries into the six geographic regions used by the World Health Organization. We determined the total number of donees in each respondent's country using historical administrative data

from the donation program. We reported the percent distributions of all demographic characteristics of the study sample. We collapsed 34 categories of specialties into 8 groups (see Appendix A).

We then calculated the percent of each demographic subgroup who were ever-users, and among them, the median number of hours they spent using the tool over the year. We used median hours instead of means due to a highly logged distribution. We presented the proportion of users who experienced each barrier or facilitator once they had the subscription, at the 2-, 4-, 6-, or 12-month mark.

Next, we modeled the relationship between barriers, facilitators, and use of the tool. The first set of regression models predicted the use of the tool around the time of the survey. For each user, we first identified the date they completed the 2-, 4-, 6-, or 12-month survey, and summed up the amount of time they spent using the tool in the two weeks around that date (7 days before to 7 days after), using the clickstream data. We fit 21 statistical models, one for each barrier or facilitator we measured, of the form:

$$Y_{im} = \beta_0 + \beta_1 m + \beta_2 BF_{im} + \beta_x [X]_i + \varepsilon$$

Where: $\beta 0$ = intercept

Y_i = any use of the tool by subject i in the two weeks around survey month m (binary)

m = month of survey (encoded as a continuous variable with values 2,4,6, and 12)

BF_{im} = presence of barrier or facilitator for subject i at survey month m (binary)

X_i = vector of demographic characteristics for subject i.

These 21 generalized linear models used a binary link function to the outcome and accounted for repeated measures over each subject.

The second set of models included only ever-users of the tool and predicted the minutes spent using the tool around the time that a barrier or facilitator was reported to be present. Like the first set of models, these accounted for repeated measures over subjects. The dependent variable—the minutes of use around each survey—was logged to bring its distribution closer to normality, and no link function was applied.

To select demographic variables to include in the model, we tested each variable for the strength of its relationship to both outcomes and for collinearity with other demographic variables. This process identified three controls to include in the model: age category, specialty, and the total number of UpToDate donation recipients in the user's country. In order to constrain the risks of multiple testing over the full set of (42) models, we set the alpha level for each coefficient at 0.0012, which is the standard alpha of 0.05 divided by 42. In line with this alpha threshold, we present 99.9% confidence intervals. All analyses were done in SAS 9.4 (Cary, NC: SAS Institute. Inc.).

Qualitative analysis

We imported the free-text responses from the surveys into NVivo 12 (QSR International Pty Ltd.) for coding and analysis. The coding scheme included high-level themes developed deductively from the research questions and sub-themes developed inductively based on the content of the responses. Responses tended to be brief, containing a single idea closely aligned with the theme, so codes were applied with little need for interpretation or subjectivity. We included a sample of 250 surveys for analysis, choosing at random from across the spectrum of tool use. Because of the nature of the responses, one person coded all the responses for consistency under supervision.

Results

We had 1,681 study enrollees and collected baseline data on all. Follow-up survey response rates were 67% at month 2, 60% at month 4, 54% at month 6, and 58% at month 12. Eighteen percent of respondents answered all four follow-up surveys, and 36% answered none. Based on the clickstream data, 249 (15%) of the enrollees never used the tool at all; although, 245 (98%) of these did respond to at least one follow-up survey.

Demographic characteristics

The vast majority (69%) of study enrollees were male, and most respondents (71%) were between 25 and 35 years old. As is typical, years of experience was highly correlated with age, and most respondents (55%) had four or fewer years of experience. Many subjects (42%) were general practitioners, with 22% in a medical subspecialty. Surgery, pediatrics, and other specialties each had under 10% of respondents. Nearly two-thirds of the sample (61%) was in full-time paid work. Patient load fell into rough quartiles: 20% saw under 50 patients per week, 25% saw 50 to 99 patients, 29% saw 100 to 199 patients, and the remaining 26% saw 200 or more patients. Most subjects (57%) were in urban settings, with 26% in rural settings, and the remainder in mixed areas (Figure 2).

Two-thirds of our sample came from countries with 200 or more other donation recipients. A quarter of respondents came from countries with 50–199 donation recipients, and the remaining 9%, from countries with only 1–49 other donation recipients. Eighteen study participants were the first and sole donation recipients in their entire country. Finally, the study sample included clinicians from all six geographic regions, mainly from Southeast Asia (35%) and sub-Saharan Africa (33%).

Variation in use by demographic characteristics

While 85% of the sample used the tool at least once, percent of ever-users ranged from 77% to 89% depending on the demographic group (Figure 2).

Among ever-users of the tool (N = 1,432), median time spent with the tool was 5.0 hours over the course of the study year. However, time varied strongly by some demographic groups (Figure 2). Variation by specialty was marked, ranging from 1.9 hours for surgical subspecialists to 7.3 hours for medical practitioners. Similarly, variation by geographic region was large, from 3.3 hours in Sub-Saharan Africa to 7.2 hours in Europe.

As for age, the middle age group (25 to 35 years) used the tool for 5.8 median hours, while the younger users (under 25) used it for 4.2 hours, and the older users (over age 35) used it for 3.2 hours. The lower

use among older users was also reflected in the results by years of experience: those with seven or more years of experience used the tool for less time than others (3.9 hours vs. 5.4 or more hours).

Those with the highest patient load (200 or more patients per week) used the tool for comparatively longer over the year, 6.2 median hours, compared to the median across other groups, 4.5 to 4.8 hours. Users in countries with many donation recipients (200 or more) used the tool for 5.6 median hours over the year, while those from countries with fewer than 200 recipients used it less, for 3.8 to 4.0 median hours. There was very little variation in median hours of use by gender, employment type, or urban/rural setting.

Prevalence of barriers and facilitators to use of UpToDate in clinical practice

The least common technical barrier (Figure 3, Factor 1) was lack of a device (6% or less at all time points), and the most common barrier was slow internet speed (reported by about 33% of users at months 6 and 12). The percent of users reporting difficulties with access to the internet declined over time, from 31% at month 2 to 16% at month 12 (Figure 3, Factor 1).

Few users reported barriers to navigating the tool (Figure 3, Factor 2). In each follow-up survey in which these questions were asked, 9% or fewer respondents reported that they faced barriers either in knowing what was available or in finding the information they needed in the tool.

Fewer than 20% of users at any time point faced the barriers of lack of time, understanding the medical content, or finding it difficult to fit into their workflow. One clinician mentioned in a free-text response, “Even though I don't speak English fluently, I can understand easily because the terms they use are not complicated...it's very easy when you want to find out something...you get it quickly.” However, enrollees also explained workflow concerns: "Patient flow is way too high. So I don't get time to open UpToDate at that time..." and "[It's] tough opening UpToDate and checking patients in a crowded and hurr[ied] situation.” Regarding having what was needed to apply the information learned from the tool in practice,

the percentage of users reporting this barrier rose from 13% at month 2 to 32% at month 12 (Figure 3, Factor 3).

As for facilitators, approximately 40% of respondents at months 6 and 12 reported that they had ever referred to the orientation materials (Figure 3, Factor 4). The utility of the tool in practice, measured as the percentage of users who reported being able to find answers to questions more readily as compared to before they had the tool, was stable across months 6 and 12:47% of respondents were better able to find answers to treatment questions, 43% to find answers to diagnostic questions, 34% to procedure questions, and 33% to device questions (Figure 3, Factor 5). Clinicians shared examples of using the tool:

> "Let me exemplify a case of pneumothorax. There was a lot of debate regarding the tube thoracostomy. One of the residents read out the contents of UpToDate, and thence the tube thoracostomy was planned."

> "I have been using UpToDate to make management plans for my patients and to optimize their care. Whenever I am having a problem getting a diagnosis for a patient, I go to UpToDate and read around the topic."

The professional context results were fairly consistent across months 6 and 12. Approximately 80% of respondents reported that clinicians typically viewed the use of a digital tool like UpToDate positively, and roughly 70% said that most of their clinical colleagues used such tools. About 65% reported using the tools often or very often in front of other clinicians (Figure 3, Factor 6). Open text answers related to this factor include responses such as "Senior [attendings] recommend it" and "It is commonly known and most colleagues use it." One clinician explained, "I came to know about the subscription of UpToDate through my colleague. There was an incident when I was working late night duty. I was confused about the latest recommendation, and my colleague helped me with the help of UpToDate."

Clinicians did not feel patients were as supportive of tool use. Only 30% of subjects reported that they believed their typical patient viewed the use of a tool like UpToDate during care positively, and about a quarter used the tool often or very often in front of patients during clinical care (Figure 3, Factor 6).

Self-efficacy

The self-efficacy results were problematic, including ceiling effects and evidence of straightlining (24% of all administrations of the scale had the same response for all eight questions). Moreover, we found almost no group-level variation where it might be expected: across age, years of experience, specialty, geographic region, or any other demographic group. Self-efficacy scores showed no consistent or notable increase or decrease over time, either on the group level or the individual level. By comparison, other survey questions did exhibit these basic features of item validity and functioning. Given it is implausible that the self-efficacy of all clinicians was identical and unchanging, we concluded that the psychometrics of the self-efficacy scale did not function properly in this study. For this reason, we dropped self-efficacy (Factor 7) from our presentation of results.

Relationship between barriers, facilitators, and UpToDate use.

Results of the statistical models are presented in Figure 4. Panel A shows the estimated odds ratios of using the tool around the time when a barrier or facilitator was present compared to when it was not present, adjusted for age, specialty, and number of donation recipients in the subject's country. For the 11 barriers, most estimates were less than 1, suggesting that the odds of using the tool was lower when the barrier was present. However, only one of these relationships rose to statistical significance under the multiplicity adjusted alpha threshold: when clinicians reported that it was difficult to fit the tool into their workflow, they were 42% less likely to use it (OR 0.56, p = 0.0003).

For facilitators, most odds ratios were near or above 1, suggesting that the odds of using the tool may have been higher when the facilitator was present. Of the 10 facilitators, two were statistically significant.

First, users were 1.5 times more likely to log on if they reported that using UpToDate increased their ability to find answers to their clinical questions about treatments (OR 1.5, p = 0.0001). Second, users were 1.7 times more likely to log on to the tool if their professional context supported using the tool in front of other clinicians (OR 1.7, p < 0.0001).

Panel B shows the estimated ratio of minutes using the tool around the time that the barrier or facilitator was present. For the 11 barriers, none of these coefficients were statistically significant, although most were below 1, which was in the expected direction. Among the 10 facilitators, most were above 1, suggesting longer use of the tool at the time that the facilitator was present. One coefficient reached statistical significance: when users felt that they could more easily find answers to questions about diagnoses, they spent 1.4 times as many minutes using the tool, compared to when they did not feel they could answer more questions (ratio of minutes 1.4, p = 0.0004).

Discussion

Our results drew attention to three factors relating to clinicians' uptake and usage of UpToDate. The first factor (Factor 3) highlighted the ability to integrate the digital tool into practice. Of statistical significance, when clinicians reported difficulty fitting the tool into their daily workflow, they were only about half as likely to log on to the tool as when they did not face that difficulty. Although under 20% of clinicians reported lack of time, difficulty fitting the tool into their workflow, or problems understanding the medical content, and not all had statistically significant findings, clinicians who faced such barriers did appear to use the tool less. Interestingly, over the study year, the prevalence of not having what was needed to apply the information in UpToDate (Factor 3) rose from 14% to 33%. This increase over time could demonstrate decreasing resource levels for clinicians or clinicians' increased knowledge of the resources they lack. In other words, clinicians may have been more aware than previously of newer supplies and tests that were unavailable to them after a year of using UpToDate. Regardless, the presence

of this barrier did not deter use: it was not associated with how likely users were to log in to UpToDate nor the number of minutes they spent using the tool.

Second, the facilitator of perceived utility of the tool (Factor 5) seemed to matter for uptake. For example, the percentage of subjects reporting an improved ability to find answers to questions about treatments and diagnoses (as compared to before having access to the tool) was consistently above 40%. Moreover, though not all correlations were statistically significant at the multiplicity adjusted threshold, donees recognizing the tool's utility for treatment and diagnostic decision making were more likely to log in to the tool and spent more minutes on the tool than those who did not report increased ability to find answers with the tool. In other words, positive perceptions of the tool's utility for diagnoses and treatment correlated with more use of the tool.

Third, a positive professional context (Factor 6) also seemed to facilitate tool use. Measures of professional context (the belief that colleagues viewed the use of the tool positively, most clinical colleagues used the tool, and used the tool in front of other clinicians) were all consistently reported by more than 60% of participants. When subjects reported feeling comfortable using the tool in front of other clinicians, they were approximately 70% more likely to log in (statistically significant) and spent 30% more minutes on the tool (not statistically significant at multiplicity adjusted threshold). Study participants in countries with 200 or more donation recipients used the tool for longer over the year compared to those in countries with fewer donation recipients. A professional context in which more clinicians had access to the tool and felt comfortable using it in front of other clinicians was associated with more use of the tool.

Other barriers and facilitators we tested did not show these kinds of relationships. For example, facing technical access barriers did not significantly change the odds of using the tool or of the amount of time spent using it. This result may seem counterintuitive but likely points toward the determination of these motivated users. For example, at months 2 and 4, about a third of users reported that access to the internet

was a barrier for them, but this proportion fell to about 20% at months 6 and 12, and limited access to the internet was not related to the likelihood of logging on or how long was spent using the tool. This could have resulted from differential dropout—those with worse internet access stopped responding to surveys—or the users may have learned how to download and use the tool offline or secured better internet connections. These technical considerations were not the barriers to use that we might have expected. Similarly, users did not report high levels of difficulty navigating the tool or finding information on it. About 40% of clinicians reported using the orientation materials, but reading those materials was not a significant facilitator of tool use.

One final factor related to usage was age. Only 7% of study participants were in the youngest age group (< 25), likely due to the fact that most people do not start practicing medicine until later. Those aged 25–29 represented 42% of all applicants, and, along with those aged 30–34, used the tool more than the oldest participants (35+). This suggests there is a stronger interest in technology among the newest generation of clinicians and provides hope that uptake and use of digital clinical decision support tools may increase with time.

Our study had several limitations. First, while our sample of clinicians was large and diverse, it was non-representative across countries and types of clinicians; we accepted all clinicians who applied and met eligibility criteria for the donation program during the study period. Eligibility criteria required that clinicians be able to complete the application in English and be working in a limited-resource setting. The sample included only clinicians motivated to apply to the program, who self-selected to try to improve their practice, making it non-representative of the general clinician population. Thus, external validity and the generalizability of our conclusions may be limited. Second, any of the factors we explored can be framed and measured as either barriers or facilitators; we measured some as barriers and others as facilitators, which may have impacted how participants answered the questions. Finally, we were able to integrate the baseline survey into our application process in order to not alter the application experience

dramatically; however, other surveys may have influenced tool use by reminding users about the tool when they normally would receive no such reminder.

Globally, the healthcare workforce faces scarce time and attention, high demand for services, varied patient populations, and ever-growing medical literature. As a result, clinicians must remember, apply, and integrate a massive volume of information under difficult circumstances. Digital tools can help, but only if clinicians can and do use them in clinical care. We believe that the patterns suggested here can serve as the basis for further implementation work and research to better understand how to best reach diverse, both more and less motivated populations of clinicians.

Conclusion

This study can inform the implementation of digital clinical decision support tools in the future. Findings suggest implementing the use of digital clinical decision support tools like UpToDate in cohorts of clinicians to generate supportive professional contexts, encouraging the use of such tools over time to increase exposure and help clinicians realize the utility of them, and working with health systems to promote the use of clinical decision support tools in workflows to promote use.

There is great potential for digital tools to help ensure effective and high-quality care. By learning how to better facilitate use and minimize barriers among clinicians around the globe, we can take an important step toward more effective diagnostic and clinical management leading to better, more equitable health outcomes.

Declarations

Author contributions:

JR conceived the design of the work, contributed to survey design and data collection, to data analysis and interpretation, to drafting and critical revision of the article, and to final approval of the version to be

published. KM contributed to the design of the work, survey design, data analysis and interpretation, drafting and critical revision of the article and final approval of the version to be published. OP contributed to data collection, data analysis and interpretation, and final approval of the version of the article to be published. NH contributed to survey design and data collection, to data analysis and interpretation, and to revision and approval of the final version of the article to be published. AK contributed to drafting the article, critical revision, and final approval of the version to be published. RW conceived of the design of the work, contributed to survey design, to data analysis and interpretation, critical revision of the article and final approval of the version to be published.

Competing interests: The authors declare that they have no competing interests.

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Data Sharing: Restrictions apply to the availability of study data, which were used under a data use agreement for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of UpToDate.

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Ethics Approval:

This study received ethical approval from the Partners Human Research Committee (now called Mass General Brigham Institutional Review Board) under protocol 2018P001183. The Harvard T. H. Chan School of Public Health institutional review board ceded review to the Partners Human Research Committee. All participants provided informed consent. The informed consent addressed the collection of both the survey and clickstream data.

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Figure Legends

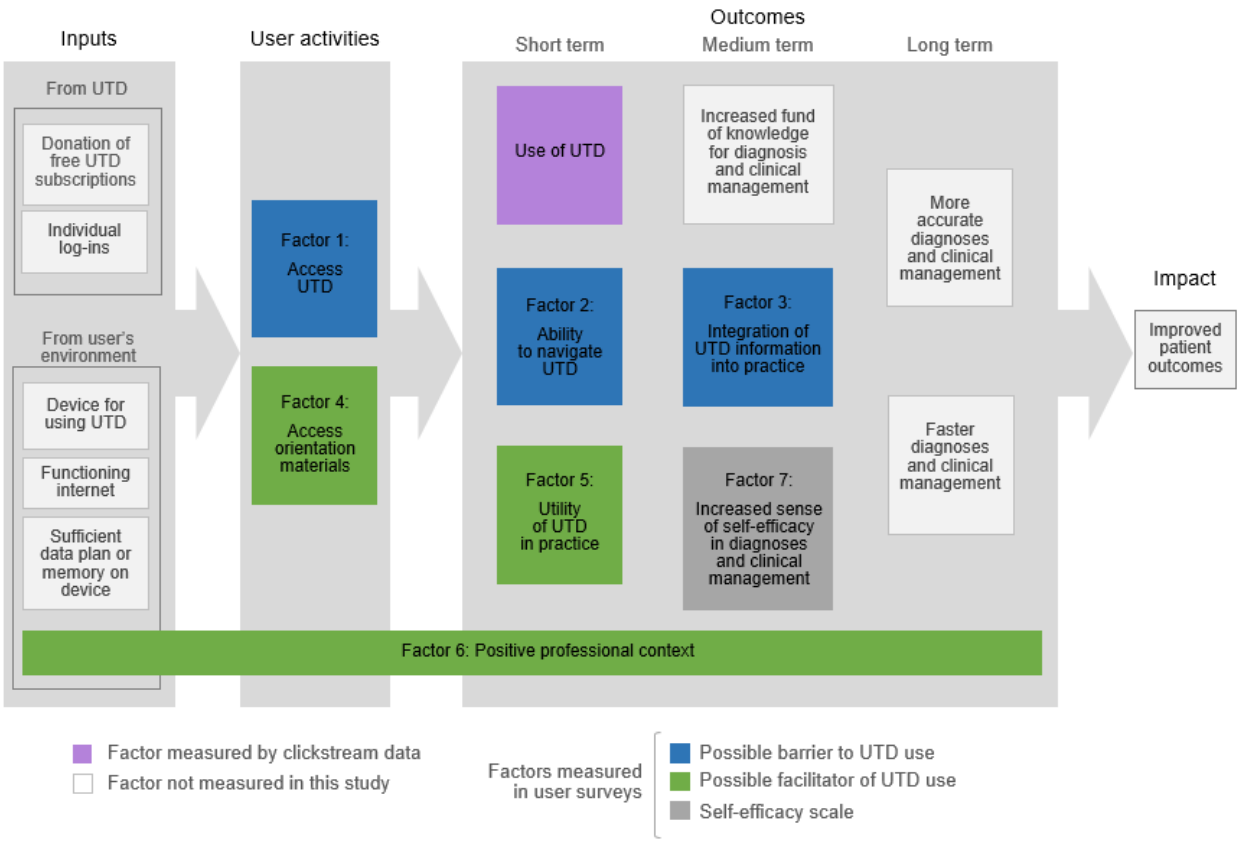
Figure 1: Logic model showing how UpToDate use among clinicians can impact patient outcomes; UTD = UpToDate

Figure 2: Population demographics and use of the tool

Figure 3: Percent of users reporting presence of each barrier or facilitator by survey month

Figure 4: Relationship between barriers, facilitators, and use of the tool around the time of the survey

Figure 1: Logic model showing how UpToDate use among clinicians can impact patient outcomes



UTD = UpToDate

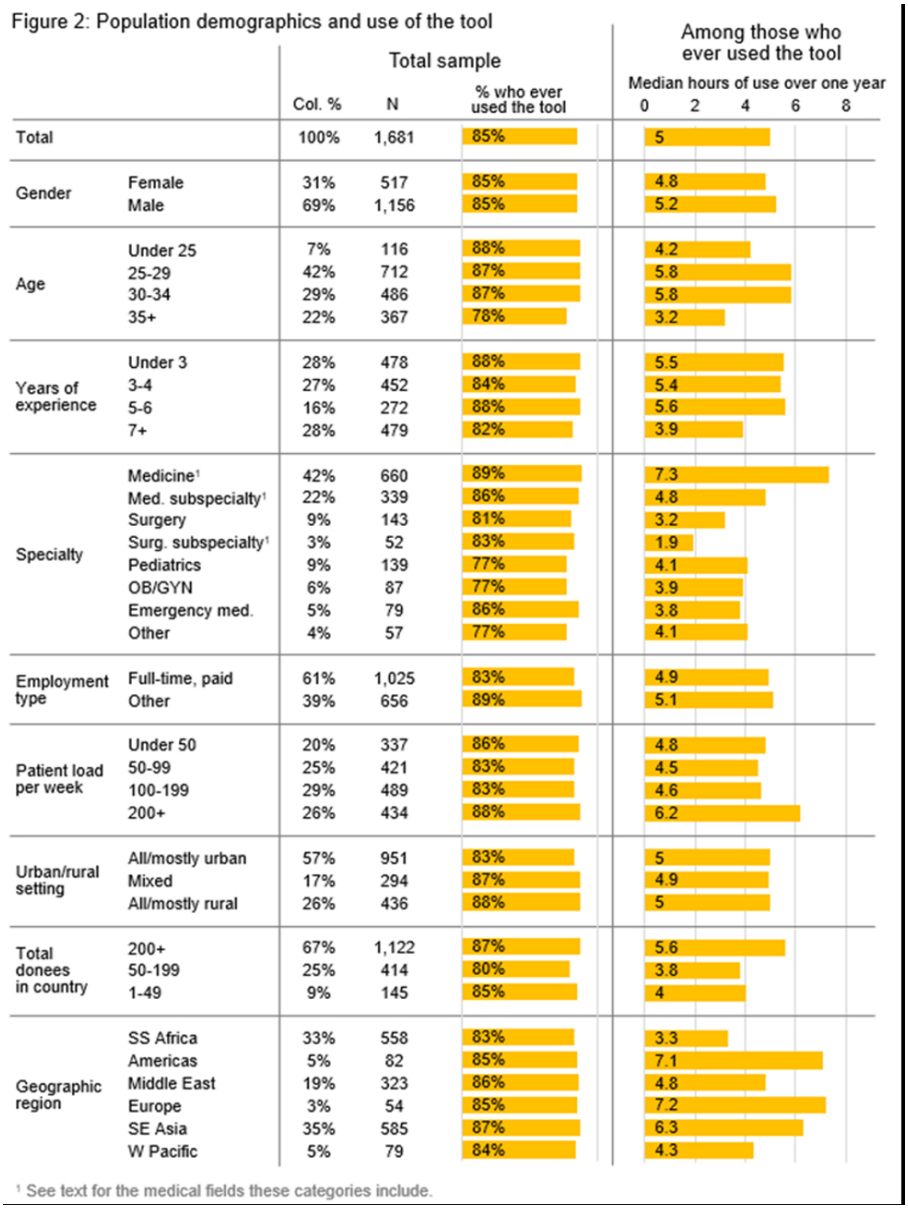


Figure 2: Population Demographics and Use of the Tool

165x220mm (150 x 150 DPI)

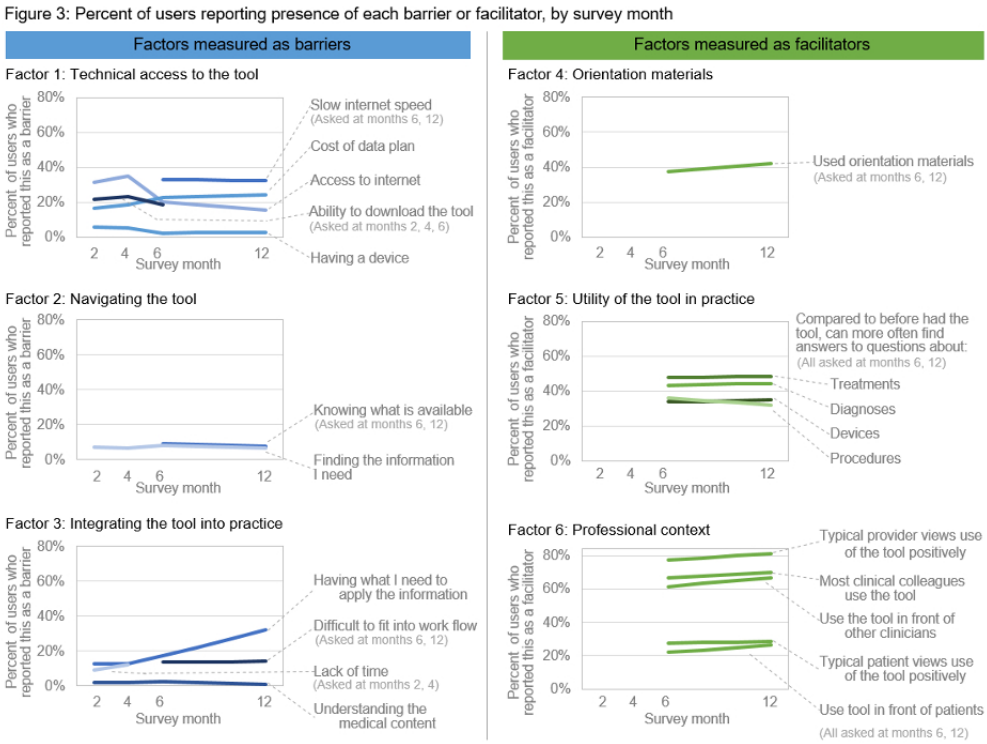


Figure 3: Percent of users reporting presence of each barrier or facilitator by survey month

165x123mm (144 x 144 DPI)

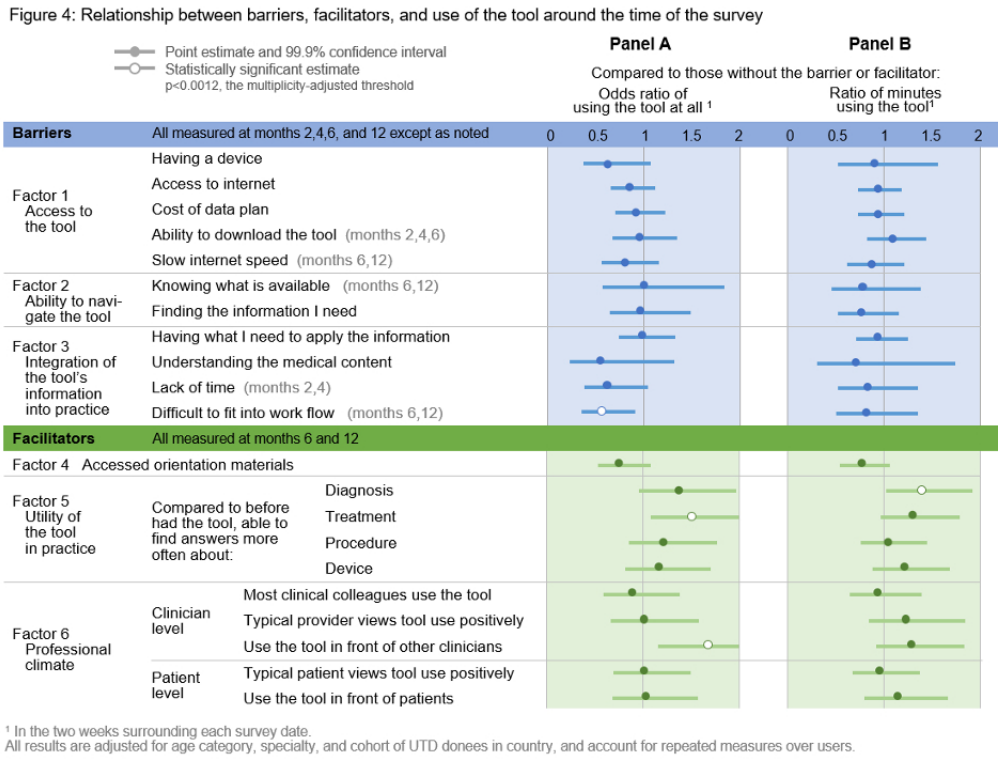


Figure 4: Relationship between barriers, facilitators and use of the tool around the time of the survey

165x125mm (144 x 144 DPI)

Appendix A

The 34 categories of medical specialties were collapsed into 8 groups as follows:

1. Medicine: family medicine, general practice, and internal medicine
2. Medical subspecialty: allergy and immunology, anesthesiology, cardiology, dermatology, endocrinology, gastroenterology, geriatrics, hematology, hospital medicine, infectious disease, nephrology, neurology, oncology, psychiatry, pulmonary, rheumatology, sports medicine, and women's health
3. Surgical subspecialty: ophthalmology, orthopedic surgery, otorhinolaryngology, and urology.
4. Other specialty: pathology, radiology, and other
5. Emergency medicine: no subgroups
6. OB/GYN: no subgroups
7. Pediatrics: no subgroups
8. Surgery: no subgroups

UpToDate-GHD Donation Application

* Required

Terms and conditions

Grant Privacy Policy, Requirements and Termination Clause
http://www.globalhealthdelivery.org/files/ghd/files/grant-privacy-policy-requirements-termination-clause.pdf

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Note: Some UpToDate donations have subsequently led to paid subscription accounts; in some circumstances, applicants may be contacted by UpToDate sales representatives to facilitate such arrangements.

1. **I agree to the terms and conditions** *
   Mark only one oval.

   ◯ Yes

Tell us about yourself

2. **First name / given name** *

3. **Last name / family name** *

4. **Suffix** *
Check all that apply.

- [ ] MD
- [ ] DO
- [ ] RN
- [ ] MBBS
- [ ] PhD
- [ ] MPH
- [ ] MBA
- [ ] N/A
- [ ] Other: _____

5. **What is your age?** *

_____

6. **If you are a clinician, please tell us where and when you received your highest level of training.**

_____

7. **How many years of clinical experience do you have?** *

_____

8. **Preferred email address** *

_____

9. **Preferred email address (please re-type)** *

_____

10. **Preferred phone number (please do not include any special characters)** *

_____

Tell us about your work

11. **Name of your organization** *

12. **Organization mailing address** *

13. **City where you work with the organization** *

14. **Country where you work with the organization** *

15. **Your organization is:** *
Check all that apply.

- [ ] A government agency
- [ ] A university, college, or other education
- [ ] A non-governmental organization (NGO)
- [ ] A public hospital
- [ ] A mission hospital
- [ ] A physician solo practice
- [ ] A group/family practice
- [ ] Other: _____

16. **Where does funding/revenue for your organization's services come from?** *
Check all that apply.

- [ ] Government
- [ ] International donors (PEPFAR, USAID, DFID, Global Fund, etc.)
- [ ] Patients' insurance
- [ ] Patients' payments and fees
- [ ] Private philanthropy
- [ ] Other: _____

17. **Is your organization in a rural or urban setting?** *
Mark only one oval.

- ◯ Mostly urban
- ◯ Mostly rural
- ◯ All rural
- ◯ All urban
- ◯ 50/50

18. **What is your status with this organization?** *
Mark only one oval.

- ◯ Full-time paid employee
- ◯ Part-time paid employee
- ◯ Volunteer
- ◯ Contractor
- ◯ Consultant
- ◯ Invited guest
- ◯ Other: _____

19. **What is your role/profession?** *
Mark only one oval.

- ◯ Physician
- ◯ Physician assistant
- ◯ Nurse
- ◯ Nurse practitioner
- ◯ Pharmacist
- ◯ Corporate
- ◯ Medical librarian
- ◯ Medical student
- ◯ Resident
- ◯ Other: _____

20. **What is your medical specialty?**
Mark only one oval.

- ◯ Allergy and immunology
- ◯ Anesthesiology
- ◯ Cardiology

- [ ] Dermatology
- [ ] Emergency medicine
- [ ] Endocrinology
- [ ] Family medicine
- [ ] Gastroenterology
- [ ] General practice
- [ ] Geriatrics
- [ ] Hematology
- [ ] Hospital medicine
- [ ] Infectious disease
- [ ] Internal medicine
- [ ] Nephrology
- [ ] Neurology
- [ ] OB/GYN
- [ ] Oncology
- [ ] Ophthalmology
- [ ] Orthopedic surgery
- [ ] Otorhinolaryngology
- [ ] Palliative care
- [ ] Pathology
- [ ] Pediatrics
- [ ] Psychiatry
- [ ] Pulmonary
- [ ] Radiology
- [ ] Rheumatology
- [ ] Sleep medicine
- [ ] Sports medicine
- [ ] Surgery
- [ ] Urology
- [ ] Women's health
- [ ] Other: _____

Tell us why you need a donated subscription

21. **In a short paragraph, please tell us more about your work:** *
Please describe the mission of your organization, why and when you got involved, and what you work on.

22. **In a short paragraph, please tell us why you should receive a donated UpToDate subscription and its potential impact on the community you serve.** *

UpToDate features

23. **Please check the offline features you will need with your subscription.** *
Check all that apply.

☐ MobileComplete: An application that enables offline access on a smartphone or tablet after an initial Internet-powered install for Apple and Android devices

☐ Downloadable Desktop: An application that enables offline access on a desktop computer or laptop after an initial Internet-powered download.

Baseline Survey (Pre-donation)

1. Which of the following are important when you are deciding whether or not to look up clinical information online? (Select all that are apply.)

    a. Having ready access to a device to use, such as a smart phone or computer
    b. Access to internet
    c. Cost of data access plan
    d. Anticipated ease of finding the information I need
    e. Likelihood of having the tests or medicines I need to apply the information in clinical practice
    f. The potential of the content to improve the care I provide
    g. The ability to use it in my usual workflow

2.

	Never	Rarely	Sometimes		Often	
a. How often do you look for information online when a patient presents with a condition you treat frequently?	1	2	3	4	5	6
b. How often do you look for information online when a patient presents with a condition you have not treated before?	1	2	3	4	5	6

3. Why did you decide to apply for an UpToDate subscription? (Select all that apply)

    a. I saw other practitioners using it.
    b. It was recommended to me.
    c. I received a promotional email.
    d. It seemed like a good deal (free).
    e. I want to improve my clinical practice.
    f. Other (please describe)

    g. If other: Please describe the reason. [open text]

4. How often do you have access to a smartphone, tablet or computer while providing clinical care?

    a. Never
    b. Rarely
    c. Sometimes
    d. Often
    e. Almost always
    f. Always

5. Approximately how many of the clinical care providers that you work with use UpToDate? (Select one)

a. 100%
b. 75%
c. 50%
d. 25%
e. 0%
f. I don't know
g. N/A (I don't work with other clinical providers.)

6.	Negatively		Neutrally	Positively	It's highly variable	I don't know
a. How do you think clinicians in your area would view the use of an online tool like UpToDate for clinical care?	1	2	3	4	5	
b. How do you think your patients would view the use of an online tool like UpToDate during clinical care?	1	2	3	4	5	

7.	Never	Rarely	Sometimes	Often	Almost always	Always	N/A
a. In the last month, when you've had diagnostic questions, how often have you been able to find the answers?	1	2	3	4	5	6	7
b. In the last month, when you've had questions about creating a treatment plan, how often have you been able to find the answers?	1	2	3	4	5	6	7
c. In the last month, when you've had questions about using a medical device, how often have you been able to find the answers?	1	2	3	4	5	6	7
d. In the last month, when you've had questions about preparing for a procedure, how often have you been able to find the answers?	1	2	3	4	5	6	7

8. Approximately how often do you learn useful information from the following sources?

	Never	A few times per year	Monthly	Weekly	Daily

a. Colleagues	1	2	3	4	5
b. UpToDate	1	2	3	4	5
c. Other online resources	1	2	3	4	5
d. Textbooks	1	2	3	4	5
e. WHO protocols	1	2	3	4	5
f. In-person lectures or trainings	1	2	3	4	5

9. When providing clinical care, how true are the following statements for you?

	Not at all true	Hardly true	Moderately true	Exactly true
a. I will be able to achieve most of the goals that I have set for myself.	1	2	3	4
b. When facing difficult tasks, I am certain that I will accomplish them.	1	2	3	4
c. In general, I think that I can obtain outcomes that are important to me.	1	2	3	4
d. I believe I can succeed at most any endeavor to which I set my mind.	1	2	3	4
e. I will be able to successfully overcome many challenges.	1	2	3	4
f. I am confident that I can perform effectively on many different tasks.	1	2	3	4
g. Compared to other people, I can do most tasks very well.	1	2	3	4
h. Even when things are tough, I can perform well.	1	2	3	4

12 month survey

Thank you for your interest in helping us improve our impact by completing this brief survey. In exchange for your participation, you will get an additional 6 months of UpToDate access added to your subscription.

Filling out this survey serves as a statement of informed consent from you, meaning that you agree to participate in the study. Participation in this study is completely voluntary, and refusal to participate will not affect your future eligibility for free access to UpToDate or for any other benefits to which you may be entitled. You may discontinue your participation in this study at any time. We anticipate enrolling approximately 1,600 participants.

How: The following survey will ask you about your thoughts on UpToDate and your experiences using it as well as your clinical confidence. The survey should take approximately 20 minutes. We will also review your activity on UpToDate using your username to understand how frequently you log on, what you search for, and what topics you view.

Benefits: By opting in to the study extension and completing the final survey, participants will receive an additional six months for a total of a 24-month subscription and will be eligible to renew their subscriptions and continue receiving access. You may use UpToDate from any device or network. Currently, a year of subscription to UpToDate for an individual medical professional in the US costs $495 US Dollars. You will not receive any monetary compensation for your participation.

Privacy: Your data (survey responses, UpToDate usage) will be linked to your email but will be kept fully confidential in password-protected computers. Your personal information, individual responses, and data use will not be shared with anyone beyond our research team, but study results in aggregate may be published.

Questions: If you have any questions about the research, please email Julie@globalhealthdelivery.org.

If you would like to speak to someone not involved in this research about your rights as a human research subject, or any concerns or complaints you may have about the research, please contact the Partners Human Research Committee at 857-282-1900.

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Note: Some UpToDate donations have subsequently led to paid subscription accounts; in some circumstances, applicants may be contacted by UpToDate sales representatives to facilitate such arrangements.

I agree to the terms and conditions

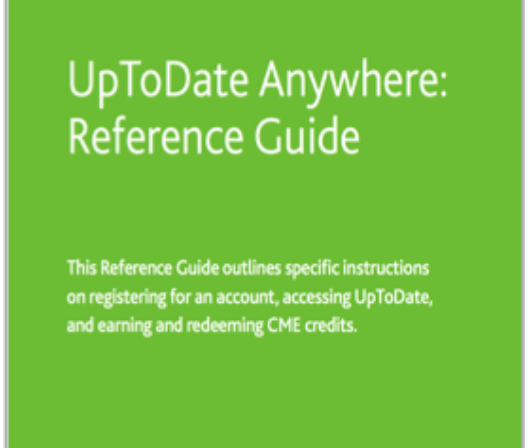
◯ Yes
◯ No

Did you use the quick reference guide or online trainings in UpToDate's Training Resource Center shown below in the past 6 months?

◯ Yes
◯ No
◯ I don't know

Please tell us why you did not use the quick reference guide or online trainings in UpToDate's Training Resource Center.

_____



Have you had these problems accessing UpToDate? (Select all that apply)

	This has never been a problem	This was a problem in the past but not anymore	This is a problem now
Not having a device to use	☐	☐	☐
Accessing the internet	☐	☐	☐
Cost of the data plan	☐	☐	☐
Slow internet speed	☐	☐	☐
Other	☐	☐	☐

Not having a device to use: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

Accessing the internet: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

Cost of the data plan: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

Slow internet speed: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

Other: please describe the problem you experienced.

_____

Have you had problems using and applying UpToDate? (Select all that apply)

	This has never been a problem	This was a problem in the past but not anymore	This is a problem now
Understanding the medical content in UpToDate	☐	☐	☐
Understanding UpToDate because it is written in English	☐	☐	☐
Finding the information I need	☐	☐	☐
Knowing what is available in UpToDate, such as tables or dosage calculators	☐	☐	☐
Not having the tests, data, or medicines recommended by UpToDate	☐	☐	☐
Other	☐	☐	☐

If other, please describe the problem and when it started.

_____

Understanding the medical content in UpToDate: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

Understanding UpToDate because it is written in English: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

Finding the information I need: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

Knowing what is available in UpToDate, such as tables or dosage calculators: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

Not having the tests, data, or medicines recommended by UpToDate: How would you describe the severity of this problem from 1 to 5, with 5 being the most severe?

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

When you do not have the tests, data, or medicines recommended by UpToDate, what do you typically do?

_____

Do you have advice for dealing with this challenge?

_____

How often do you use UpToDate for...?

	Never	Rarely	Sometimes	Often	Almost Always	Always	N/A
Determining a diagnosis	○	○	○	○	○	○	○
Developing a treatment plan	○	○	○	○	○	○	○
Using a medical device	○	○	○	○	○	○	○
Preparing for a procedure	○	○	○	○	○	○	○
Earning continuing medical education credit (CME credit)	○	○	○	○	○	○	○
General learning (not patient-specific)	○	○	○	○	○	○	○
Teaching students/colleagues	○	○	○	○	○	○	○
Educating patients	○	○	○	○	○	○	○
Other	○	○	○	○	○	○	○

Please describe the other ways you use UpToDate and how often you use it that way.

_____

	Never	Rarely	Sometimes	Often	Almost Always	Always	N/A
How often do you look for information online when a patient presents with a condition you treat infrequently?	○	○	○	○	○	○	○
How often do you look for information online when a patient presents with a condition you have not treated before?	○	○	○	○	○	○	○

Approximately how often do you learn useful information from these sources?

	Never	A few times per year	Monthly	Weekly	Daily
Colleagues	◯	◯	◯	◯	◯
UpToDate	◯	◯	◯	◯	◯
Other online resources	◯	◯	◯	◯	◯
Textbooks	◯	◯	◯	◯	◯
WHO protocols	◯	◯	◯	◯	◯
In-person lectures or trainings	◯	◯	◯	◯	◯

How easy or difficult is it for you to use UpToDate in your usual workflow?

◯ Very easy
◯ Somewhat easy
◯ Somewhat difficult
◯ Very difficult
◯ N/A

What makes UpToDate easy to use in your usual workflow?

_____

What makes UpToDate difficult to use in your usual workflow?

_____

Do you use UpToDate's offline mode (MobileComplete or Downloadable Desktop)?

◯ Yes
◯ No

If no, why not?

_____

Approximately how many of the clinical care providers that you work with use UpToDate?

◯ 100%
◯ 75%
◯ 50%
◯ 25%
◯ 0%
◯ I don't know
◯ N/A (I don't work with other clinical providers)

How often do you refer to UpToDate with patients during clinical care so that they can see you using it?

◯ Never
◯ Rarely
◯ Sometimes
◯ Often
◯ Very often

If you did use UpToDate during clinical care, how do you think the typical patient would view your use?

◯ Negatively
◯ Neutrally
◯ Positively
◯ It's highly variable
◯ I don't know

How do you think the typical patient views your use of UpToDate during clinical care?

◯ Negatively
◯ Neutrally
◯ Positively
◯ It's highly variable
◯ I don't know

How often do you refer to UpToDate in the presence of other clinical care providers?

◯ Never
◯ Rarely
◯ Sometimes
◯ Often
◯ Very often

If you did use UpToDate in the presence of other clinical care providers, how do you think the typical provider would view your use?

◯ Negatively
◯ Neutrally
◯ Positively
◯ It's highly variable
◯ I don't know

How do you think the typical provider views your use of UpToDate?

◯ Negatively
◯ Neutrally
◯ Positively
◯ It's highly variable
◯ I don't know

In the past month, how often have you been able to find answers...?

	Never	Rarely	Sometimes	Often	Almost Always	Always	N/A
When you have had diagnostic questions	○	○	○	○	○	○	○
When you have had questions about creating a treatment plan	○	○	○	○	○	○	○
When you have had questions about using a medical device	○	○	○	○	○	○	○
When you have had questions about preparing for a procedure	○	○	○	○	○	○	○

Before you had this UpToDate subscription, how often were you able to find answers...?

	Never	Rarely	Sometimes	Often	Almost Always	Always	N/A
When you have had diagnostic questions	◯	◯	◯	◯	◯	◯	◯
When you have had questions about creating a treatment plan	◯	◯	◯	◯	◯	◯	◯
When you have had questions about using a medical device	◯	◯	◯	◯	◯	◯	◯
When you have had questions about preparing for a procedure	◯	◯	◯	◯	◯	◯	◯

How likely are you to recommend the Better Evidence UpToDate donation program to a friend or a colleague?

Please rate on a scale of 1 to 10, with 1 meaning "not likely to recommend" and 10 meaning "extremely likely to recommend."

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ 10

Now please answer in words:
How likely are you to recommend the Better Evidence UpToDate donation program to a friend or a colleague?

◯ Highly unlikely
◯ Somewhat unlikely
◯ Undecided (neither likely nor unlikely)
◯ Somewhat likely
◯ Highly likely

In the past 6 months, have you noticed changes in the way you use UpToDate, such as what you use it for, how often you use it, or when you use it?

◯ Yes
◯ No

Please describe these changes and what caused them.

_____

How has UpToDate changed your confidence in your clinical decisions?

◯ I am much less confident
◯ I am a little less confident
◯ No change in confidence due to UpToDate
◯ I am a little more confident
◯ I am much more confident

In the last 6 months, I feel that using UpToDate CAUSED me to at least once: (select all that apply)

☐ Make a diagnostic error
☐ Make an inaccurate treatment plan
☐ Over use resources (e.g., tests, consultations)
☐ Spend too much time searching or reading UpToDate when unsure about a diagnosis or treatment option
☐ None of the above

In the last 6 months, I feel that using UpToDate HELPED me to at least once: (select all that apply)

☐ Make an accurate diagnosis that I otherwise would not have made
☐ Make a more accurate treatment plan than I would have without UpToDate
☐ More efficiently use resources (e.g., tests, consultations)
☐ Save time by searching or reading UpToDate when unsure about a diagnosis or treatment option
☐ None of the above

When providing clinical care, how true are the following statements for you?

	Not true at all	Hardly true	Moderately true	Exactly true
I will be able to achieve most of the goals that I have set for myself.	◯	◯	◯	◯
When facing difficult tasks, I am certain that I will accomplish them.	◯	◯	◯	◯
In general, I think that I can obtain outcomes that are important to me.	◯	◯	◯	◯
I believe I can succeed at most any endeavor to which I set my mind.	◯	◯	◯	◯
I will be able to successfully overcome many challenges.	◯	◯	◯	◯
I am confident that I can perform effectively on many different tasks.	◯	◯	◯	◯
Compared to other people, I can do most tasks very well.	◯	◯	◯	◯
Even when things are tough, I can perform well.	◯	◯	◯	◯

Is there a topic that UpToDate did not cover or do you have any other comments? Please explain.

_____

Would you be willing to be contacted in the future about your experience with the Better Evidence Donation Program?

◯ Yes
◯ No

What are the barriers to using UTD? Please check all that apply.

a. Having a device to use

b. Access to internet

c. Cost of data access plan

d. Ability to find the information I need

e. Ability to download UpToDate/MobileComplete

f. Relevancy of the information--having the tests or medicines I need to apply the information in clinical practice

g. Understanding the medical content in UpToDate

h. Colleagues—I don't want to use it in their presence and don't have privacy

i. Lack of time

j. Language-- Understanding UpToDate because it is written in English

a. Other (describe below)

b. No barriers

If other: Please describe. [open text]

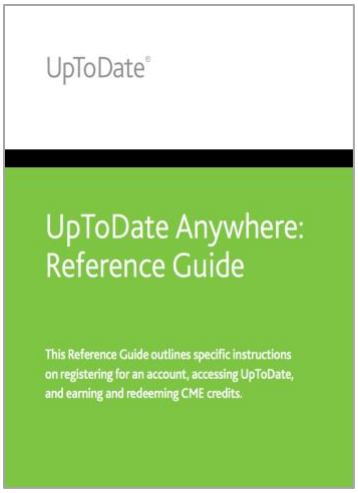
When providing clinical care, how true are the following statements for you?

	Not at all true	Hardly true	Moderately true	Exactly true
a. I will be able to achieve most of the goals that I have set for myself.	1	2	3	4
b. When facing difficult tasks, I am certain that I will accomplish them.	1	2	3	4
c. In general, I think that I can obtain outcomes that are important to me.	1	2	3	4
d. I believe I can succeed at most any endeavor to which I set my mind.	1	2	3	4
e. I will be able to successfully overcome many challenges.	1	2	3	4
f. I am confident that I can perform effectively on many different tasks.	1	2	3	4
g. Compared to other people, I can do most tasks very well.	1	2	3	4
h. Even when things are tough, I can perform well.	1	2	3	4

Follow-up at 6 months

1. Did you use the quick reference guide or online trainings in UpToDate's Training Resource Center shown below? (Select one)

    a. Yes
    b. No (describe below)
    c. I don't know
    d. Please tell us why you did not use the quick reference guide or online trainings in UpToDate's Training Resource Center. [open text]



2. Do you have any problems with **accessing** UpToDate? (Select yes or no for each row and column)

	This was a problem in the beginning	This is an ongoing problem
a. Not having a device to use	yes/no	yes/no
b. Accessing the internet	yes/no	yes/no
c. Cost of the data plan	yes/no	yes/no
d. Downloading UpToDate	yes/no	yes/no
e. Slow internet speed	yes/no	yes/no
f. Other (describe below)	yes/no	yes/no

g. If other: Please describe the problem you experience in the beginning and when it started. [open text]
h. If other: Please describe the ongoing problem and when it started. [open text]

3. Do you have any problems with **using and applying** UpToDate? (Select yes or no for each row and column)

	This was a problem in the beginning	This is an ongoing problem
a. Understanding the medical content in UpToDate	yes/no	yes/no
b. Understanding UpToDate because it is written in English	yes/no	yes/no
c. Finding the information I need	yes/no	yes/no
d. Knowing what is available in UpToDate, such as tables or dosage calculators	yes/no	yes/no
e. Not having the tests, data, or medicines recommended by UpToDate	yes/no	yes/no
f. Other (describe below)	yes/no	yes/no

g. If other: Please describe the problem you experienced in the beginning and when it started. [open text]
h. If other: Please describe the ongoing problem and when it started. [open text]

(If 3e is no in both columns, skip to 5)

4.

a. When you do not have the tests, data, or medicines recommended by UpToDate, what do you typically do? [open text]
b. Do you have advice for dealing with this challenge? [open text]

5. How often do you use UpToDate for ...?

	Never	Rarely	Some-times	Often	Almost always	Always	N/A
a. Determining a diagnosis	1	2	3	4	5	6	7
b. Developing a treatment plan	1	2	3	4	5	6	7
c. Using a medical device	1	2	3	4	5	6	7
d. Preparing for a procedure	1	2	3	4	5	6	7
e. Earning continuing medical education credit (CME credit)	1	2	3	4	5	6	7
f. General learning (not patient-specific)	1	2	3	4	5	6	7
g. Teaching students/colleagues	1	2	3	4	5	6	7
h. Educating patients	1	2	3	4	5	6	7
i. Other (describe below)	1	2	3	4	5	6	7

j. If other, please describe the other ways you use UpToDate and how often you use it that way. [open text]

6.	Never	Rarely	Sometimes	Often	Almost Always	Always
a. How often do you look for information online when a patient presents with a condition you treat frequently?	1	2	3	4	5	6
b. How often do you look for information online when a patient presents with a condition you have not treated before?	1	2	3	4	5	6

7. Approximately how often do you learn useful information from these sources?

	Never	A few times per year	Monthly	Weekly	Daily
c. Colleagues	1	2	3	4	5
d. UpToDate	1	2	3	4	5
e. Other online resources	1	2	3	4	5
f. Textbooks	1	2	3	4	5
g. WHO protocols	1	2	3	4	5
h. In-person lectures or trainings	1	2	3	4	5

8. How easy or difficult is it for you to use UpToDate in your usual workflow? (Select one)

a. Very easy
b. Somewhat easy
c. Somewhat difficult (Skip to 10)
d. Very difficult (Skip to 10)
e. N/A (Skip to 11)

9. What makes it easy to fit UpToDate into your usual workflow? [open text]
(Skip to 11)

10. What makes it difficult to fit UpToDate into your usual workflow? [open text]

11. Approximately how many of the clinical care providers that you work with use UpToDate? (Select one)

a. 100%
b. 75%
c. 50%
d. 25%
e. 0%
f. I don't know
g. N/A (I don't work with other clinical providers.)

12. How often do you refer to UpToDate **with patients during clinical care**, so that they can see you using it? (Select one)

a. Never
b. Rarely (Skip to 14)
c. Sometimes (Skip to 14)
d. Often (Skip to 14)
e. Very often (Skip to 14)

13. If you did use UpToDate during clinical care, how do you think the typical **patient** would view your use? (Select one)

a. Negatively
b. Neutrally
c. Positively
d. It's highly variable
e. I don't know
(Skip to 15)

14. How do you think your typical **patient** views your use of UpToDate during clinical care? (Select one)

a. Negatively
b. Neutrally
c. Positively
d. It's highly variable
e. I don't know

15. How often do you refer to UpToDate **in the presence of other clinical care providers**? (Select one)

a. Never
b. Rarely (Skip to 17)
c. Sometimes (Skip to 17)
d. Often (Skip to 17)
e. Always (Skip to 17)

16. If you did use UpToDate in the presence of other clinical care providers, how do you think the typical **provider** would view your use? (Select one)

a. Negatively
b. Neutrally
c. Positively
d. It's highly variable
e. I don't know (Skip to 18)

17. How do you think the typical **provider** would view your use of UpToDate? (Select one)

a. Negatively
b. Neutrally
c. Positively

d. It's highly variable
e. I don't know

18.	Never	Rarely	Sometimes	Often	Almost always	Always	N/A
a. In the last month, when you've had diagnostic questions, how often have you been able to find the answers?	1	2	3	4	5	6	7
b. In the last month, when you've had questions about creating a treatment plan, how often have you been able to find the answers?	1	2	3	4	5	6	7
c. In the last month, when you've had questions about using a medical device, how often have you been able to find the answers?	1	2	3	4	5	6	7
d. In the last month, when you've had questions about preparing for a procedure, how often have you been able to find the answers?	1	2	3	4	5	6	7
e. Before you had this UpToDate subscription, when you had diagnostic questions, how often were you able to find the answers?	1	2	3	4	5	6	7
f. Before you had this UpToDate subscription, when you had questions about creating a treatment plan, how often were you able to find the answers?	1	2	3	4	5	6	7
g. Before you had this UpToDate subscription, when you had questions about using a medical device, how often were you able to find the answers?	1	2	3	4	5	6	7
h. Before you had this UpToDate subscription, when you had questions about preparing for a procedure, how often were you able to find the answers?	1	2	3	4	5	6	7

19. How likely are you to recommend the GHD-UpToDate donation program to a colleague?

a. Highly unlikely
b. Somewhat unlikely
c. Undecided (neither likely nor unlikely)
d. Somewhat likely
e. Highly likely

20. In the past 6 months, have you noticed changes in the way you use UpToDate, such as what you use it for, how often you use it, or when you use it? (Select one)

    a. Yes
    b. No (Skip to 22)

21. Please describe these changes and what caused them. [open text]

22. How has UptoDate changed your confidence in your clinical decisions?

    a. I am much less confident
    b. I am a little less confident
    c. No change in confidence due to UpToDate
    d. I am a little more confident
    e. I am much more confident

23. In the last 6 months, I feel that using UpToDate **caused** me to at least once: (select all that apply)
    a. Make a diagnostic error
    b. Make an inaccurate treatment plan
    c. Over use resources (e.g., tests, consultations)
    d. Spend too much time searching or reading UpToDate when unsure about a diagnosis or treatment option
    e. None of the above

24. In the last 6 months, I feel that using UpToDate **helped** me to at least once: (select all that apply)
    a. Make an accurate diagnosis that I otherwise would not have made
    b. Make a more accurate treatment plan than I would have without UpToDate
    c. More efficiently use resources (e.g., tests, consultations)
    d. Save time by searching or reading UpToDate when unsure about a diagnosis or treatment option
    e. None of the above

25. When providing clinical care, how true are the following statements for you?

	Not at all true	Hardly true	Moderately true	Exactly true
a. I will be able to achieve most of the goals that I have set for myself.	1	2	3	4
b. When facing difficult tasks, I am certain that I will accomplish them.	1	2	3	4
c. In general, I think that I can obtain outcomes that are important to me.	1	2	3	4
d. I believe I can succeed at most any endeavor to which I set my mind.	1	2	3	4
e. I will be able to successfully overcome many challenges.	1	2	3	4
f. I am confident that I can perform effectively on many different tasks.	1	2	3	4
g. Compared to other people, I can do most tasks very well.	1	2	3	4
h. Even when things are tough, I can perform well.	1	2	3	4

26. Any other comments? [open text]

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-9
Bias	9	Describe any efforts to address potential sources of bias	12-13 (self-efficacy scale)
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8-11
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11-12
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11-13
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) Summarise follow-up time (eg, average and total amount)	

Outcome data	15*	Report numbers of outcome events or summary measures over time	11-16

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (*b*) Report category boundaries when continuous variables were categorized (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	15-16
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	16-17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	18
Generalisability	21	Discuss the generalisability (external validity) of the study results	18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	20

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.