Does Access to Point-of-Care Medical Information Improve Trauma and General Surgeons' Clinical Knowledge in a Middle-Income Country? A Mixed-Methods Study with Random Assignment

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BACKGROUND: Investing in continued medical education strengthens surgical systems. This study assessed the effectiveness of an evidence-based practice (EBP) tutorial and access to UpToDate (UTD) to improve EBP and understand how and why providers practice using evidence.

STUDY DESIGN: This is a mixed-methods, implementation study at 9 public hospitals in Peru consisting of a didactic session for surgeons on EBP and Google Translate and support of applications for UTD access. Change in clinical knowledge scores (CKS), access and use of UTD, and impact of language pre-and postintervention were measured. Qualitative interviews uncovered reasons for these changes.

RESULTS: Intervention participants had lower CKS at follow-up compared with baseline (odds ratio [OR] of higher score 0.41 [0.18,0.98]; p = 0.044), and this effect was modified (p = 0.003) to the extent that the reverse was true for control participants (OR 2.30 [1.13,4.71]; p = 0.022). Participants with 1 to 20 years of experience had significantly improved CKS compared with students/residents (1 to 10 years: OR 4.5 [1.1,18]; 11 to 20 years: OR 4.9 [1.4,17]); there was no evidence of a different CKS between providers with >20 years of experience compared with students/residents (OR 1.3 [0.5,3.7]). Administrative disconnect, usability, motivation, education, time, resources, and age influenced point-of-care medical information systems impact on knowledge and EBP. Participants reporting low English proficiency translated medical literature mostly used Google Translate. Those with low/no English reading proficiency had higher odds of reporting a negative impact on research than those with working (p = 0.007) or professional (p < 0.001) proficiency.

CONCLUSIONS: Providing education on EBP, free UTD access, and translation solutions did not correlate with increased CKS due to complex barriers to using point-of-care medical information systems.

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Abbreviations and Acronyms

CKS	=	Clinical knowledge scores
CME	=	Continuing medical education
EBP	=	Evidence-based practice
GT	=	Google Translate
OR	=	Odds ratio
POCMIS	=	Point-of-care medical information systems
UTD	=	UpToDate

Twenty-eight percent of the global burden of disease, as measured in disability-adjusted life-years, is attributable to problems treated with surgery.[1,2] Building strong surgical systems is a cost-effective means of moving toward global health equity.[3,4] Investing in human resources such as surgeons' continued medical education (CME) reinforces surgical infrastructure and helps improve population-level health outcomes.[5-7] The production of clinical research findings with proven positive impact on morbidity and mortality far outpaces individual providers' ability to review the literature and outpaces the rate at which evidence-based practice (EBP) guidelines can be updated.[8] Without access to the evolving medical literature, providers struggle to stay current after medical school training.[9] One systematic review found a correlation between increased years of provider practice with lower quality of care. Specifically, more years in practice correlated with decreased adherence to updated clinical guidelines, standards of practice and therapies, and decreased knowledge across subspecialties.[10]

Applying primary literature safely to clinical practice requires hours of education to create questions, search databases, analyze data, and apply results to relevant populations.[11] When time and resources prevent the use of primary literature, point-of-care medical information systems (POCMIS) act as a base for building strong health systems by providing an efficient and effective way to encourage CME.[5,12,13] POCMIS encompass a large umbrella of technologic tools that improve providers' decision-making within their setting and clinical workflow.[14] Research from various medical specialties shows the high use and satisfaction with POCMIS in busy healthcare settings globally,[15] and pedagogic studies outline an improvement in self-directed e-learning for CME with POCMIS.[16] However, cost and language of POCMIS are understood to be two of the largest barriers for healthcare providers in non–English-speaking low- and middle-income countries.[5,17]

UpToDate (UTD), one internationally recognized POCMIS, is a dynamic online reservoir with searchable information on evidence-based guidelines for healthcare providers.[18] UTD ties its tiered pricing to a country's gross national income and the user's professional status (eg student, resident, attending).[19] For those unable to pay, UTD provides free annual subscriptions through the "Better Evidence" grant.[20] Nonetheless, healthcare professionals often use public-access forums as a major source of information.[21] Non–English speakers are often unable to access vital information or contribute to international scientific research publications without support of English-speaking collaborators.[22,23] UTD allows providers to search in 10 languages but publishes articles only in English. Google Translate (GT) is a free translation service that has been reported to work well, although imperfectly, in low-resource settings.[24] Although GT used in patient-provider[25] and provider-team communication[26] has shown higher accuracy of English-to-Spanish and Spanish-to-English translations than other languages, 2% of translations imposed a risk for potential patient harm.[27]

In partnership with the Peruvian General Surgery Society, we developed an educational intervention including a didactic session on EBP and use of GT, along with the provision of an application for free UTD access to surgical providers at 9 hospitals throughout Lima, Peru. The objective of the current study was to better understand UTD use, GT use, knowledge acquisition, and reported experiences surrounding EBP (participants' experiences with, and perceptions of, EBP, and the hospital context in which surgeons might use EBP) for trauma and general surgeons in Lima, Peru.

METHODS

Participants

Peru is an upper-middle-income country[28] in the Andean region of South America. The included government-funded hospitals do not reliably have wireless internet, instead, staff members may have access to a few desktop computers with wireless internet or, more routinely, cellular data. Peru's disease pathologies are typical for an upper-middle-income country (eg chronic diseases),[29] and many hospitals do not have the necessary resources to meet international goals for surgical systems.[30] Study investigators included members of the Peruvian National Surgical Society and US partners who have collaborated on previous multi-institution observational studies. The University of Washington and the Universidad Peruana Cayetano Heredia institutional review boards approved this study.

Twelve of the largest hospitals from the military, public, and social security systems in Lima were invited to participate, and nine were enrolled (Fig. 1).[31] A random number generator was used by study staff to allocate hospitals randomly blocking into groups of 5 and 6 for intervention and control, respectively. The COVID-19

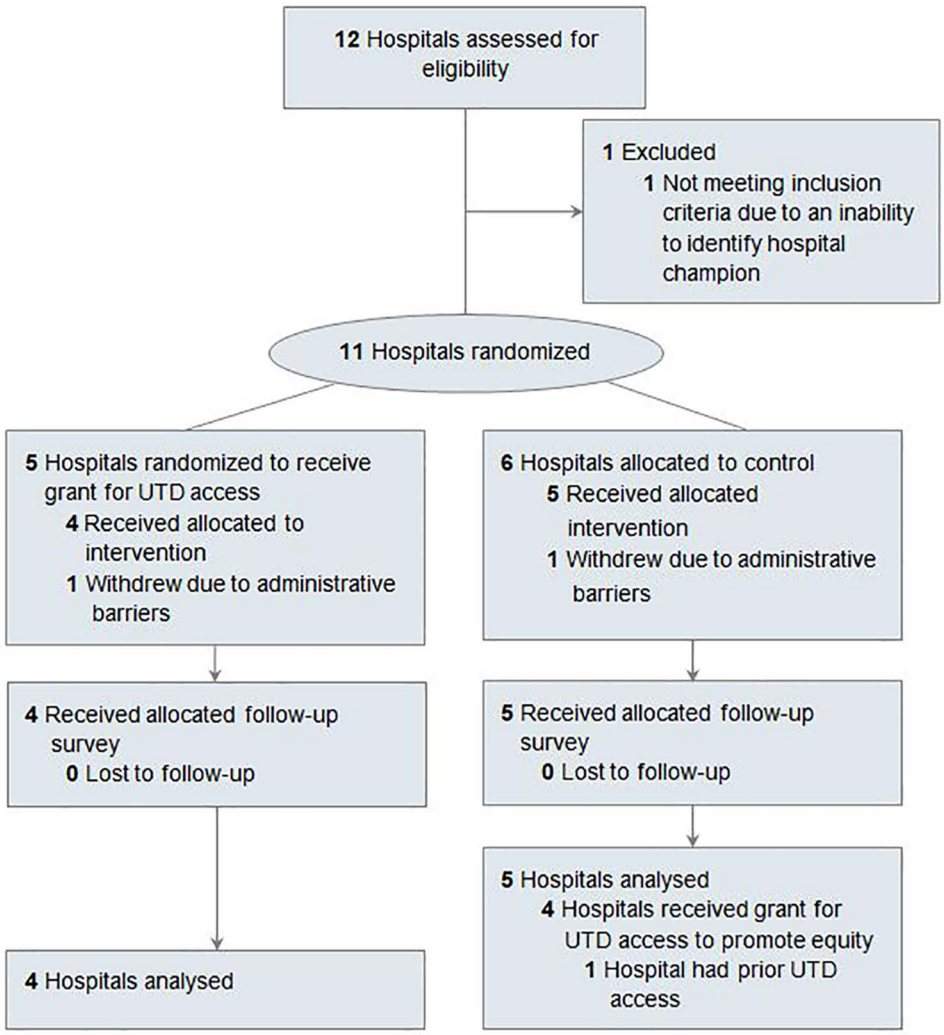

Figure 1. Consolidated standards of reporting trials. Diagram of screening, randomization, follow-up, and analysis. UTD, UpToDate.

pandemic began in Peru month 6 of the 8-month study. During this time, nonessential workers were quarantined at home.

Data Collection

Twelve public hospitals in Lima, Peru, were identified for this study. One did not meet inclusion criteria, so 11 hospitals were randomized, 5 allocated to receive the intervention and 6 allocated to the control group. One hospital per group withdrew due to administrative barriers; 4 hospitals received the intervention and 5 hospitals continued in the control group. These hospitals were included in the final analysis; no hospital was lost to follow-up. To promote equity, all hospitals received access to UTD at the close of the study.

Recruitment

Participants were recruited through Peruvian General Surgery Society meetings and a surgeon champion at each hospital. Inclusion criteria were residents and attending physicians >18 years old who work in the general surgery department at various public hospitals in Lima, and hospitals were excluded when study staff were unable to connect with a staff member from the general surgery department to implement the protocol in their hospital. Participants provided verbal consent. No compensation was given for their time.

Instruments and administration

Presurvey. A single-page baseline quantitative written assessment was completed by consenting participants on the day of the intervention. Questions were based on

theoretical underpinnings from previous EBP surveys[32,33] and written to evaluate clinical knowledge and behavior.[34] Topics were relevant across resource settings, based on common scenarios in high-volume settings, and had recent best-practice changes with international consensus.[35-39] Respondents were asked to identify the time and location they most recently reviewed specific clinical topics (bowel preparation before elective colectomy, perioperative antibiotic use, abdominal wall closure, and fluid resuscitation). For those with previous access to UTD, 2 questions asked about CME credits and most-searched UTD topics. The survey also addressed language and translation services as they relate to EBP. Participants self-administered surveys in Spanish without using external resources.

Postsurvey. Participants at the 4 hospitals that received UTD access were contacted via email and WhatsApp by researchers and their hospital collaborator to complete an online postsurvey 5 to 12 weeks after they began using UTD, as measured by confirmation of UTD grant receival by grant administrators. Questions confirmed their participation in the presurvey at intervention timepoint 1 and mirrored the presurvey for clinical practice and language. Postsurveys of the control group were collected in person at weekly hospital academic sessions, and postsurveys of the intervention group were solicited using email and WhatsApp, and collected using REDCap online, due to the COVID-19 pandemic.

Qualitative interviews

The Consolidated Framework for Implementation Research is a theoretical framework that can be used to standardize the collection of qualitative data driving implementation science. In this study, Consolidated Framework for Implementation Research guided researchers to create a robust list of qualitative questions to understand implementation of POCMIS accurately and adequately. Consolidated Framework for Implementation Research was used to create a semistructured interview question guide focused on how surgeons find information to answer their clinical questions and their experiences using UTD. Questions were intended to ascertain the context, facilitators, and barriers to using POCMIS. Interview participants were recruited via email and WhatsApp to all participants who received UTD access and included in the postsurvey text; the broad recruitment ensured qualitative dependability and transferability of results. Interviews were conducted via phone by a Peruvian researcher with an extensive practical background in qualitative research (CM). Interviews took, on average, 41 minutes and were recorded on the interviewer's laptop for transcription by a bilingual researcher with a background in qualitative theme translation (MDA).

Intervention

Didactic with visual aid

A US-based surgeon, Peruvian General Surgery Society board members, a medical educator, and graphic designer developed the 1-hour presentation that reviewed theories of EBP from previously published EBP courses,[34,40-46] used interactive clinical practice questions alongside UTD articles, and explained GT. One of 9 hospital champions chose to present the slideshow themselves; 8 of 9 chose to have a member of our research team present.[47] After the presentation, participants applied for a grant to receive free, individual access to UTD for 1 calendar year via the Better Evidence UTD Donations Program.[48]

Email and text correspondence

After the grant application process, participants were emailed and texted regarding their application and provided links to recommended UpToDate articles relevant to the survey questions. After closure of data collection, the control group also received the intervention.

Data analysis

Quantitative

The current implementation trial used a pragmatic-led sample size. The clinical knowledge score (CKS) was modeled as an ordinal outcome with a cumulative link ordinal mixed modeled with time, intervention status, and the time-intervention interaction as fixed effects and subject-level random intercepts to account for correlation between outcomes on individuals measured at both timepoints. There were multiple fixed intercepts (one for each unique observed outcome) to denote the odds of getting any score relative to zero. The odds ratios (ORs) measured via the fixed effects were assumed to be proportional across levels of the outcome.

The effect of the intervention on other outcomes of interest (eg UTD access) was assessed using generalized linear mixed models structured similarly to the model as discussed earlier in terms of fixed and random effects, potentially varying the link and family of the model depending on the outcome type. The last review place of clinical topics was dichotomized (online database vs other) due to the large proportion of those reporting online database. For certain questions (years of medical practice, English comprehension, and when topics were most recently reviewed), answer groups with small size were

binned to reduce the variation of estimates. Translation quality and UTD use frequency were excluded from the multivariable models due to a large proportion of missing data, otherwise adjusted models included all variables as additional fixed effects, which are presented as adjusted ORs. Goodness of fit of multivariable generalized linear mixed models was measured with Nagalkerke's pseudo-R^2 statistic, and statistical significance was defined as a p value of 0.05 or less.

Qualitative

Data were uploaded into Dedoose, a secure web-based qualitative data analysis platform for coding and thematic content analysis by 2 researchers using the 3 qualitative steps outlined by Braun and Clarke.[49-52] Code reports produced via Dedoose were synthesized using an annotation and tabular system. A qualitative research expert (KS) advised the interview conception, design, collection, and analysis which solidified data collection and analysis credibility. Two separate researchers (HN, MW) identified themes and separately coded transcripts before reconciling codes together, improving the authenticity of results.

RESULTS

Demographics

Eleven hospitals, 4 interventions, and 5 controls, completed the protocol. One hundred forty-nine surgical providers, 53% attending surgeons and 38% residents, completed the baseline assessment. These providers most often identified as general surgeons (86%), and the majority (64%) reported working in a hospital with <200 beds. Surgeons in all participating hospitals reported knowing about UTD before our research. More control group participants than intervention participants (51% vs 29%) reported having current access to UTD at baseline; all other baseline characteristics were similar (Table 1). Three women and 9 men completed qualitative interviews, including 10 attending surgeons and 2 residents, 8 general surgeons, 2 trauma surgeons, 1 laparoscopic surgeon, and 1 combined general surgeon/surgical oncologist.

Primary outcome: clinical knowledge score

Intervention participants answered fewer clinical knowledge questions correctly at follow-up compared with baseline (OR of higher score 0.41 [0.18,0.98]; p = 0.044), and this effect was significantly modified (p = 0.003) to the extent that the reverse was true for control participants (OR 2.30 [1.13,4.71]; p = 0.022) (Fig. 2; **Supplemental Digital Content 1**, http://links.lww.com/JACS/A184). Neither UTD access nor UTD utilization showed significant evidence of association with CKS scores or CKS changes during time. A multivariable analysis of the intervention group found years of practice between 1 and 20, compared with residents, was associated with a significantly improved CKS (OR 4.5 [1.1,18] for 1 to 10 years and OR 4.9 [1.4,17] for 11 to 20 years). Intervention participants with greater than 20 years of practice did not experience statistically significantly greater CKS than residents (OR 1.3 [0.5,3.7]). The multivariable mixed model had reasonable goodness of fit (pseudo-R^2 0.22). Qualitative analysis revealed that administrative disconnect, POCMIS usability, motivation, education on POCMIS use, time, resources, institutional advocates, age, and hierarchy may influence surgeons' use of POCMIS generally and UTD specifically.

Accessing UpToDate: frequency, topics, sources

Some participants had previous access to UTD, and the intervention would not have increased their access. Many participants reported using UTD after the intervention. One participant described how an UTD search need not be a singular occurrence but can be used repeatedly as needed:

> UpToDate is already in my phone, and I've been using for two months now. I have a topic, I look it up, and since it's saved in my search history, I can read it again if something is not clear.

Intervention participants observed a larger increase in the odds of having recently reviewed perioperative antibiotic use through time compared with control participants (p = 0.005). All participants, regardless of group, were more likely to have recently reviewed abdominal wall closure at timepoint 2 compared with timepoint 1 (p < 0.001), with a significantly larger increase observed in the intervention cluster (p = 0.005). All participants reported the same 3 most recently reviewed sources: online databases, lectures, and guidelines.

Interviewees identified the importance of reviewing evidence to improve clinical practice, patient outcomes, and health systems (Table 2):

> This hospital could benefit from [using POCMIS] because it would help improve the course of treatments and minimize expenses.

Interviews included a vocalization of the importance of reviewing evidence in improving clinical practice, patient outcomes, and health systems:

> Things are constantly changing, there's always new evidence, different [...] therapy or procedures that keep changing. Sometimes you think this procedure is the best option and then you find out it's not. So, you have to be updated on new scientific advances.

Table 1. Baseline Characteristics of Surgical Providers at 9 Hospitals in Lima, Peru

	Preintervention		Postintervention	
Characteristic	**Intervention (n = 5 hospitals, n = 80 providers)**	**Control (n = 6 hospitals, n = 69 providers)**	**Intervention (n = 5 hospitals, n = 25 providers)**	**Control (n = 6 hospitals, n = 69 providers)**
Years of medical practice				
Student	3 (4)	0 (0)	3 (12)	0 (0)
Resident	29 (37)	24 (39)	6 (24)	24 (57)
1–10 y	12 (15)	11 (18)	3 (12)	4 (10)
11–20 y	16 (21)	10 (16)	8 (32)	4 (10)
>20 y	18 (23)	16 (26)	5 (20)	10 (24)
Surgical service				
Emergency	2 (3)	3 (5)	3 (12)	3 (7)
General	70 (89)	58 (92)	22 (88)	36 (82)
ICU	2 (3)	0 (0)	0 (0)	0 (0)
Other	5 (6)	2 (3)	0 (00	5 (11)
No. of hospital beds				
<100	9 (13)	13 (23)	0 (0)	8 (21)
101–200	4 (6)	4 (7)	0 (0)	11(28)
>200	57 (81)	39 (70)	0 (0)	20 (51)
Current UTD access				
Yes	23 (29)	34 (51)	10 (40)	22 (50)
No	55 (71)	33 (49)	15 (60)	22 (50)
Current UTD use				
Yes	37 (63)	35 (76)	12 (80)	25 (71)
No	22 (37)	11 (24)	3 (20)	10 (29)

Data presented as n (%).
UTD, UpToDate.

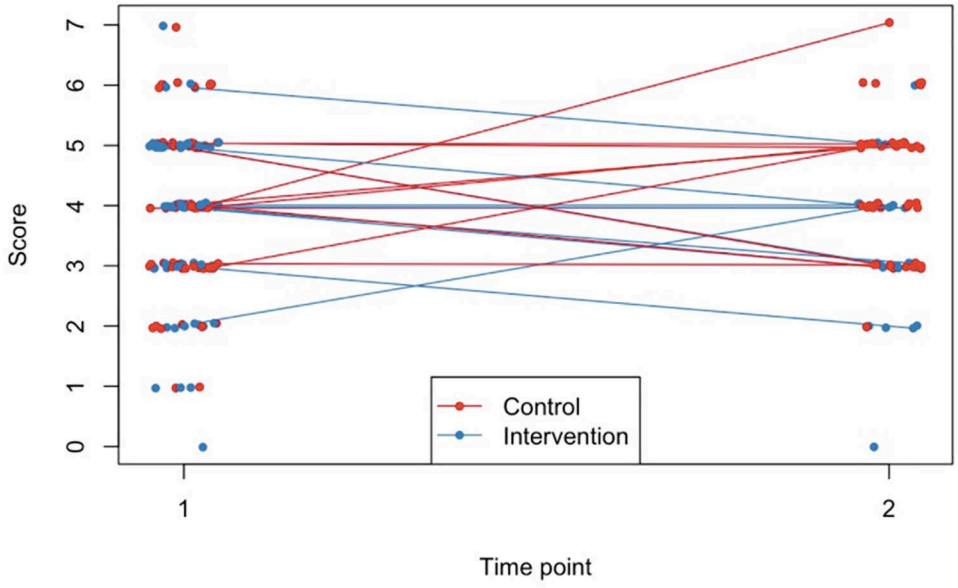

Figure 2. Score of correct responses by randomization and timepoint.

Table 2. Interview Responses Relating to Use of Point-of-Care Medical Information Systems for Surgeons in Lima, Peru, Matched to Consolidated Framework for Implementation Research Constructs

CFIR construct, theme	Quote
I. Intervention characteristics; POCMIS usability	…Once I typed "rhinoplasty" and I got so many results but needed something specific, so I had to filter the information and I spent the entire afternoon doing that. At some point the website kicked me out and I had to do it all over again…
III. Inner setting	
Resources	I have to tell my patients the Ministry of Health thinks we can treat people with holy water. We do not have the supplies we require. For example, we have a patient with an open abdominal wound, and instead of using modern medical inputs, we treat them with gauze and soapy water.
Hierarchy	My boss says, "you have to do this with the patient," "but doctor, this drainage is not recommended," "no, you have to do it," "but literature has shown meta-analysis where this does not work on certain patients," "I do not care, you have to do it, I have more experience with many more patients." That is how they are still thinking. It is difficult to deal with that.
III. Inner setting; V. Process; administrative disconnect	I think the people in charge are busy with other issues… they want to make this a teaching hospital… they are focused on bringing students but not on their training.
IV. Characteristics of individuals	
Motivation	It has to do more with actually wanting to stay updated and make a commitment because as time goes by, we assume more responsibilities in the clinical area… Being left behind and pass with the minimum would be easier.
Age	Many of those who come and ask or make comments about what they read or find are young. Attendings do not do it anymore or do not do it very often.; As years go by, we go on autopilot.
V. Process	
Education on POCMIS use	It would be nice to have a tutorial on how to do a search, how to type in keywords, for example, if we talk about antibiotics, I do not know.
Time	The number of patients during my residency did not even allow me to eat let alone do research.
Institutional advocate	I think this has to be under the supervision of the Teaching and Education Department… The director does not care much for this, neither does the deputy director. If each department does it individually, there will not be a standard response.

CFIR, Consolidated Framework for Implementation Research; POCMIS, point-of-care medical information systems.

Some participants specifically referenced the ways that EBP can encourage deimplementation, preserving resources and optimizing patient outcomes:

> [...] having useful information can modify treatment results. If they are treating the patient with three antibiotics when only one is recommended, these resources would help demonstrate they are wasting money, and this is doing more harm than good to the patient.

Impact of translation services on evidence-based practice

At timepoint 1, 27 (18%) participants reported professional English reading proficiency, and 43 (29%) reported elementary or no proficiency. Sixty-one (41%) participants reported that their language proficiency negatively impacted their ability to find answers to clinical questions, and lower English proficiency strongly correlated with participants' perception that their proficiency negatively impacted their ability to answer clinical questions ($p < 0.001$). Forty-one (23%) participants reported using GT for clinically relevant medical information materials; 63 (29%) reported they were adequate for clinical use; 26 (12%) were neutral or did not think translation quality was adequate for clinical use; and 59% of participants did not answer (Table 3).

Although most participants reported translation tools sufficient for clinical use, translation accuracy could be improved:

> I know we can have a translated version, I've tried it, but the translation is not accurate, so it forces me to read in English too, I have to read twice and that takes up my time.

Expense

Participants endorsed the cost barrier to POCMIS. For example:

Table 3. Reported Participant English Proficiency, Impact of Language on Evidence-Based Practice, and Translation Quality

Variable	Participant (n = 149)*
English reading proficiency	
None	1 (0.6)
Elementary	42 (28)
Working proficiency	58 (39)
Professional proficiency	27 (18)
Language barriers prevent me from searching and finding answers to my clinical questions	
Strongly disagree	11 (7)
Disagree	18 (12)
Neutral	35 (23)
Agree	46 (31)
Strongly agree	15 (10)
My translation is good enough for clinical use	
Strongly disagree	1 (0.6)
Disagree	2 (1)
Neutral	15 (10)
Agree	27 (18)
Strongly agree	14 (9)

*Not all participants answered all questions.
Data presented as n (%).

> This hospital doesn't have money to spare and that's why we never expect to have these resources available. We have always requested them, but I don't think this could be taken as a priority because the hospital doesn't receive too much money and can't generate income, it doesn't bring in money like a private clinic does.

Providers reported having found cost-free ways to access POCMIS or primary literature before the intervention.

> Well, these databases are expensive, but our residents have been able to get a password somehow. Someone went abroad and got a password; they find them somehow.

> Not all the papers are available, except if you use Sci-Hub, piracy has been a big help.

DISCUSSION

This study aimed to evaluate an intervention to measure how removing previously identified barriers to UTD access impacted the use of UTD and changed knowledge of EBP among surgeons at military, public, and social security hospitals in Lima, Peru. Participation in the intervention, access to UTD, and reported UTD use did not significantly improve providers' abilities to answer clinical questions correctly. Although access to and use of UTD were identified by previous studies as main barriers to EBP, more barriers persist. Importantly, our mixed-methods design allowed identification of these continued barriers of EBP, including administrative disconnect, usability of and education on POCMIS, motivation, workflow, available resources, and surgical hierarchies.

Providers with 1 to 20 years of experience had statistically significantly higher adjusted CKS than residents, but providers with more than 20 years of experience had no difference in CKS compared with residents. Our results demonstrated the largest CKS increase for providers with 11 to 20 years of experience, followed by those with 1 to 10 years of experience. Experience allows providers to see patterns in patient care and outcomes, but previous studies also link more years in practice to lower rates of evidence-based care and decreased knowledge.[10] Age is correlated with decreased technologic literacy,[53] which could prevent use of POCMIS as measured in this study. Perhaps providers in the middle of their careers have both the experience to see patterns and the technologic literacy to harness the fullest potential of POCMIS. Further research is needed on customized interventions to address barriers to EBP for various age and experience groups. Online databases and lectures were the most used modes of reviewing a topic across timepoints. These options fit well into daily practice, and fitting EBP into the workflow for surgeons is important for its future use.

Almost one-third of participants reported lower than working English proficiency. Of participants who used translation tools, an overwhelming majority trusted GT for accuracy, yet almost half still felt their own English reading proficiency negatively impacted their knowledge acquisition. Our findings reflect previous research showing that Spanish-to-English GT is better than other languages but can still delay necessary patient care.[25] One study reported 4% of English-to-Spanish medical translations from GT were more likely to have a severe error than a human translation.[54] Therefore, investing in POCMIS written by native speakers in languages other than English could decrease errors by eliminating translation mistakes. Many interviewees mentioned cost as a barrier to EBP, even with access to funds like the Better Evidence Grant. This study found that participants share passwords and use piracy to freely access medical literature, underscoring the importance of continuing to strengthen public access to information.

Limitations

Working with one collaborator per hospital to recruit volunteers may have overrepresented clinicians already interested in EBP and access to information within our sample. Also, surveys were anonymous to decrease self-reported bias, although they were partially linkable through time.

Due to COVID-19, we pivoted to electronic data collection for the intervention group's postsurvey but collected all other surveys in person, and our follow-up data have a smaller sample size as a result. In addition to reducing the precision of our estimates, this attrition may have skewed participation and responses, because many participants did not complete the postsurvey, introducing bias. Some participants may have used additional resources during the postsurvey because it was online, unlike the in-person pretest. In future research, we recommend designing a study inclusive of more surgical providers from urban and rural public hospitals and involving hospital administrators for a comprehensive approach to POCMIS implementation.

CONCLUSIONS

Current solutions to cost and language barriers did not increase use of POCMIS or clinical knowledge among surgeons at public hospitals in Lima, Peru. Addressing complex barriers to EBP, such as administrative prioritization of POCMIS, may improve EBP as the international community expands open access to medical information.

Author Contributions

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