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Strengthening the clinical laboratory workforce in Cambodia; a case study of a mixed-method in-service training program to improve laboratory quality management system oversight.

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Case study

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Abstract

Background: Laboratory diagnostic testing service delivery and compliance with international standards for laboratory quality are directly influenced by laboratory workforce competency. Many hospital laboratories in constrained resource settings such as Cambodia struggle to cope with the training needs of laboratory professionals in an environment of competing healthcare development priorities. Resource limited countries need an adaptable and effective approach to provide laboratory professionals with job-specific quality oversight training to ensure the accuracy, timeliness and reliability of diagnostic services.

Case Presentation: Here we describe the results of an in-service training and mentoring program conducted with the Cambodia Ministry of Health at 12 tertiary level hospital laboratories to drive improvements in laboratory quality management systems toward ISO 15189 accreditation, which demonstrated significant progress between baseline and outcome audits in a concurrent study. This case study describes the program, and evaluates how the four primary activities, including actionable gap assessments and planning, centralized and in-situ training curriculum, in-person mentoring, and remote tele-mentoring via video communication technologies, contributed towards quality improvement in the participating laboratories.

We evaluated participant responses to Likert scale and free response questions from program and training evaluation surveys, and we used thematic analysis to develop a model of best practices within the program's four primary activities to inform future training approaches. Of these activities, participants agreed most highly that in-person visits and planning based on gap assessments contributed to their learning and ability to improve laboratory operations. Tele-mentoring was rated lowest by participants, who were critical of excessive group dialogue and distraction during web-conferencing; however, feedback suggests both in-person and remote mentoring contribute to continuing education, accountability to action, and peer collaboration and problem solving to improve workforce efforts toward improved quality management systems.

Conclusions: We recommend here a package of in-service training activities for laboratory quality management system improvement initiatives in resource constrained settings that includes needs-based curricula and personalized action plans for participants; interactive and on-site training workshops; and in-person mentoring, complemented with well managed and regular tele-mentoring that focuses on knowledge retention, accountability to goals, and collaborative problem solving. Our model presents an adaptable approach to human resource development for quality improvement in medical laboratories.

Background

Laboratory- based diagnostic testing plays a critical role in clinical decision making, informing diagnostics, screening, risk stratification, treatment selection and monitoring, and other aspects of patient care [1]. Accurate and reliable laboratory testing is essential for improved health outcomes [2][3]. Frequent and significant laboratory error, however, can also create a source of harm to patients due to poor quality

management [4]. In countries with constrained resources there can be considerably less confidence and effective use of laboratory testing due to such errors. One international effort to assure a culture of quality and competence in laboratory testing is the standardization of laboratory quality management systems (LQMS) through accreditation to the International Organization for Standardization (ISO) ISO 15189 standard [5]. This standard however, is stringent and many countries lack the resources and trained personnel to achieve and maintain ISO 15189 accreditation [6].

Meeting national healthcare service goals requires a competent health workforce, which includes skilled laboratory workers able to conduct myriad complex and critical diagnostic testing procedures to inform clinical decision making. In lower resource settings, medical laboratory personnel, among other healthcare professionals, are often hindered by professional development factors or environments that can inhibit their ability to carry out basic diagnostic testing procedures with repeatable accuracy [7]. In Cambodia, 94 public health laboratories in the national laboratory system support surveillance, infectious disease detection and medical diagnostics [8]. In 2016, a joint external evaluation through International Health Regulations enrolment found that Cambodia was still in need of workforce capacity development [8] Therefore, further investment in strengthening LQMS and laboratory fundamentals were recommended [8].

In 2014, a technical assistance partnership was formed with the Cambodia Ministry of Health (MOH) Bureau of Medical Laboratory Services (BMLS) to implement a mentored LQMS strengthening program for 12 national and provincial hospital laboratories to improve quality. Between 2014–2016, the program was successfully implemented with measurable progress toward accreditation standards using the Laboratory Quality Stepwise Improvement toolkit developed by the World Health Organization (WHO) and supported by in-service training and mentoring [9][10]. Starting in July 2017, the program added a package of practice-based; *in-situ* quality management education and training activities, and increased remote tele-mentoring all informed by the Cambodia LQMS (CamLQMS) checklist requirements towards meeting the ISO 15189 standard. Between December 2018 to April 2019, audits were conducted at participating laboratories, which showed significant progress, indicating strengthened capacity of laboratory quality assurance personnel to improve and sustain LQMS in their facilities[11]. A moderately strong correlation between audit performance and laboratory participation in the remote mentoring component of this program suggested that remote mentoring could contribute to significant positive outcomes [11]; however, further evaluation was needed to examine the roles of each component of the training and mentoring program and investigate best practices for future programming.

Case Presentation

The goal of the LQMS strengthening program was to improve laboratory operations through improved laboratory quality assurance and management practices in line with national and international quality standards and regulations. The program was implemented through four primary activities with the objectives to educate and mentor the 12 participating laboratories toward this goal. These activities include the implementation of needs assessments and subsequent action plans with laboratories, a

formal LQMS curriculum (a series of educational programs and training workshops), intensive in-person mentoring and follow-up, and regular monitoring and evaluation check-ins through video conferencing technologies. These four activities were hypothesized to contribute to improved LQMS knowledge and conformity to ISO 15189 standards as outlined below.

CamLQMS audit, auditor training and action plan development

The CamLQMS checklist for accreditation was endorsed by the MOH in 2018 and adopted as the primary audit assessment too for laboratory conformity. This tool was utilized to conduct baseline and exit audits of each laboratory participating in the quality improvement program. The elements of the CamLQMS checklist specify national standards for LQMS conformity based on ISO 15189 international standards and, to a lesser extent, Clinical and Laboratory Standard Institute (CLSI) QMS01-A4 guidelines [12]. The checklist is divided into 12 specific sections by topic, each section drawn from a list of Quality System Essentials (QSE) outlined by CLSI guidelines. Each section is then divided into a series of qualifying “yes”, “no” or “NA” questions to comprehensively assess whether conformity to ISO 15189 standards is achieved.

Because the MOH was establishing a regulatory process to audit the quality performance of diagnostic laboratories in Cambodia, 12 laboratory staff were selected auditors trainees who would assist the MOH during the national audit. The auditor training program was conducted over a period of one month and performed via tele-conferencing which focused on theory (four power-point presentations with translation to Khmer), and practice. Each trainee performed an audit independently using the CamLQMS checklist, which was reviewed by experienced auditors. Each trainee then attended at least one formal laboratory assessment during the final 2019 round of audits. All audits were performed by teams composed of members from I-TECH, BMLS and included one to two new auditor trainees as part of a capacity building effort.

Baseline audits were conducted in 2017 and identified areas of laboratory quality management which were commonly low between the 12 participating laboratories [11]. These results were disseminated to laboratories during a week-long workshop in February 2018. Quality mentors then trained participants to develop SMART (specific, measurable, achievable, realistic, and timely) [13] goals and action plans to implement specific quality improvement projects that would eliminate the identified audit gaps. Participants developed action plans collaboratively with peers, presenting implementation strategies for feedback from peer laboratories and quality improvement specialists.

Structured LQMS training workshops

In further response to baseline audits, we developed a needs-based training curriculum for laboratory managers, quality assurance officers (QAOs), and other quality improvement personnel, and implemented the resulting series of workshops within the 12 participating laboratories between February 2018 and April 2019. These sessions were designed to use quality management theory and hands-on skills,

focusing on error detection including non-conforming practices, corrective actions, risk analysis, and quality improvement and thus addressing the greatest needs for training within participating laboratories. Each session included a combination of formal lectures by quality experts, peer collaboration, case presentation and discussion, and experiential training similar to accepted laboratory in-service training design [14]. Each session was conducted in English and translated into Khmer by mentors or professional translators to ensure comprehension among non-English speaking participants.

Sessions were further divided into two types, imparting theory primarily through off-site, classroom-based workshops, while providing hands-on experience through on-site workshops within actual laboratories. Off-site workshops were primarily slide-based presentations, conducted in Phnom Penh as a central location. Workshops included focused QSE trainings as well as one leadership course on the 7 habits of effective leadership and one management laboratory quality course. Workshops used adult learning strategies to engage participation and discussion, including dynamic stimulation, experiential learning, peer collaboration, and transformative learning through problem solving. On-site, hands-on training workshops were introduced during the most recent project specifically to reinforce theory and practical skills. Practical and experiential training activities were hosted by top performing laboratories where adequate training space was available. Additionally, a limited participant study tour to accredited laboratories in Singapore was included as an advanced learning opportunity for high performing laboratories, also motivating healthy competition among participants to complete action items in order to attend.

In-person mentoring

A team of four mentors conducted regular site visits to individual laboratories for individual consultations, each visit designed to guide, support, and engage participants in LQMS improvement efforts by:

a. providing one-on-one follow-up training with laboratories, complementing formal training;
b. holding laboratory management and quality assurance personnel accountable to action plans, ensuring that action plan goals adhered to the SMART format;
c. providing on-site technical guidance and collaboration to identify and resolve problems in LQMS improvement

Mentors were dispatched a minimum of four times to each laboratory following specific sets of technical trainings and were tasked with specific technical topics to address within laboratories in a supervisory role. In-person visits were planned to be thorough and results-oriented, focusing on specific problems of individual laboratories and participants.

Remote tele-mentoring

In contrast to in-person mentoring, remote tele-mentoring was identified as a potentially cost-effective supplement to allow regular support to geographically distant laboratories with minimal resource allocation. The tele-mentoring approach was akin to the “hub and spoke model” used by programs such

as Project ECHO™, which makes specialized medical knowledge accessible to remote populations by linking local clinicians together with specialist teams at academic medical centers in weekly “virtual clinics” using structured video conferencing. Our own tele-mentoring approach uses a similar continuing professional development design to extend LQMS knowledge and skills using trained quality assurance mentors as a central hub. Similar to accepted tele-mentoring methods in clinical medicine[15], our mentors built on an established working relationship with laboratory personnel, aided by regular video and telecommunication technologies, and the mentored participants were selected as capable quality assurance personnel to participate in an established educational framework that prepares them for the experience.

Similar to Project ECHO™, we used web-based video conferencing as the primary means of tele-mentoring, supplemented with SMS communication. We selected Zoom Telecommunication’s professional online platform for videoconferencing specifically for its support of multiple participants, its accessibility to any participant with high-speed internet connection, its video-recording and meeting archiving feature, and its screen sharing and remote desktop access functions. Mentors used Zoom to connect with laboratory managers and QAOs over regular weekly group training to reinforce formal training activities and to support ongoing action plans with trouble-shooting assistance.

Smaller group or individual video conferences between mentors and participants were further provided on an as needed basis, and group SMS forums (informal chat groups) were provided for further group discussion and *en masse* communication. Laboratory mentors also held regular “office hours” during which mentees were free to communicate with mentors via web-conference, telephone, or SMS messaging for immediate guidance when needed.

Evaluation Methodology

We used Likert scale survey responses to quantitatively assess participant ratings of the program’s primary activities on a scale of 1–5, then used qualitative observation and participant feedback to develop and present a model of best practices related to the program’s methodology, specifically identifying factors within the four primary program activities that likely facilitated or hindered the program’s success. Quantitative and qualitative data to assess best practices were collected primarily through a program evaluation survey, which assessed participant feedback after the program’s implementation with a combination of Likert scale and free response questions; additional qualitative data was collected from training evaluation surveys, which were carried out after each individual training. Participants in the post-implementation survey consisted of respondents out of the total list of participants in the training and mentoring program within participating laboratories, which included laboratory managers, QAOs, and other quality assurance staff. Training feedback was expanded to include less frequent participants, such as hospital and laboratory directors.

Program-evaluation surveys were dispersed via email link to an online survey platform. The survey consisted of five statements, declaring the program and each of the four primary program activities to be

effective at improving LQMS systems in participating laboratories. Participants were prompted to rate their agreement with each statement on a scale of 1–5 ranging from strongly disagree to strongly agree and were then prompted to give written feedback to explain their response to each statement. Responses were automatically recorded and entered into a spreadsheet database for analysis.

Training feedback was collected from archived training evaluation surveys. Each participant responded immediately at the end of individual workshops to open-ended prompts for feedback, which were then entered by program staff into spreadsheets for qualitative analysis, who translated comments from Khmer to English where necessary. To quantify Likert scale responses from program evaluation surveys, mean Likert scale ratings and response frequencies of each response were calculated to comparatively assess how well each program activity was perceived to contribute to quality improvement within participant laboratories.

Participant feedback was analyzed by a combination of inductive and deductive analysis. Prior to analysis of participant feedback, we compiled a hypothesized model of best practices within each of the primary program activities that contributed to program outcomes according to observation. We then analyzed feedback text from training evaluations and program evaluation surveys to corroborate and expand on this initial set of themes, categorizing text from participant comments into the relevant themes and inductively identifying new, previously unidentified themes recurring within the text.

Using spreadsheets to organize and filter participant comments, each response was sorted according to the evaluation source and activity in question, then categorized into one or multiple themes occurring within the response. Occurrence frequencies of each best practice theme were then counted to present the frequency of supporting text for each theme, then text attributed to each theme was then analyzed and then summarized in memos for discussion.

Results

Program and activity ratings

Out of a total of 28 participants who were sent the program evaluation survey, 27 (96%) responded. Table 1 presents the distribution of response frequencies and a mean Likert scale rating of each category for comparison. Results demonstrate that participants agreed most highly that in-person mentoring and CamLQMS audits were valuable for achieving quality management improvement in their laboratories (mean = 4.56, 4.52), receiving the highest frequencies of “strongly agree” ratings and the highest mean ratings. Conversely, participants agreed least with the statement that Zoom-call training and question/answer sessions were valuable to quality management improvement in their laboratories (mean = 3.44). Participants agreed moderately, however, with the statement that the overall program structure was effective in their laboratories’ improvement processes (mean = 4.11) (Table 1).

LQMS program best practices

Observations and qualitative analysis of participant evaluations uncovered 23 themes regarding best practices, 21 of which were supported by participant feedback. We analyzed 239 individual comments from training evaluations and an additional 39 textual responses from program evaluation surveys. We identified 147 instances of positive feedback and 99 instances of constructive critique for improvement, from which 123 comments were either corroborated initial best practice themes or introduced novel themes. These themes are organized in a model of best practices in Fig. 1 according to the associated primary activity supported. In this figure, the number of participant comments supporting each theorized best practice is represented in parentheses. Themes with zero supporting comments from participants are theorized based on project manager observations only (Fig. 1).

Discussion

As demonstrated by measurable improvements in quality management at our 12 supported sites [11], our training and mentoring approach in Cambodia made a positive impact in participating laboratories and correlates with similar reports in the region [16]. With the addition of this study, we found reasonable evidence that regular laboratory mentoring, supported by needs based training and inter-laboratory collaboration enhances laboratory quality improvement when it impresses actionable needs-based planning, peer learning in a practical and supportive environment, and collaborative problem solving. It was evident in the implementation of our program that customizing the mentoring and training program for the local environment is more effective than a preconceived and rigid “one size fits all” approach, and that taking an adaptive approach to teaching practice based skills is critical for rapid improvement [17].

Best practices within CamLQMS gap assessments and action planning

Our model of best practices presents how our adaptive approach was received in the context of Cambodia. Multiple comments from participants recognized the adaptive role of CamLQMS gap assessments in their LQMS improvement progress, for example, which is to identify gaps in LQMS conformity and direct improvement plans to address deficiencies. Participants also recognized the part of action planning, which led to specific, measurable, attainable, relevant, and timely goals. Although not corroborated by participant feedback, we further observed a clear benefit from immediate feedback and corrective action by auditors during audits, and from auditors engaging the attention of both hospital leadership and government stakeholders where they otherwise were less engaged. Further research may help to confirm these observations where participant feedback did not recognize the contribution of these practices to improvement.

Best practices within formal LQMS training

In support of our use of a needs-based design of curriculum, 58 participant comments suggested knowledge gain due to training activities, 22 of which referred to concepts specific to the needs-based curriculum such as management review and equipment validation. Additionally, peer learning and

collaboration was remarked highly by participants, who often requested more activities where participants of different labs could share ideas and experiences, learning from each other and collaborating to troubleshoot and solve practical LQMS improvement challenges.

Our program was designed specifically to utilize peer learning among a set of other dynamic, hands-on, and interactive adult-learning strategies implemented as adaptive drivers of change. Such strategies have been shown to be effective within healthcare professional training [14, 18], and participants gave a positive response to many of these training activities, for which we recommend them within our model of best practices. Our program further emphasized a focus on patient safety, which we observed to motivate participants during training, though only one participant comment supports the practice in this study.

Participants expressed considerable preference for on-site training activities, mentioning specifically the practical and experiential learning as important for participant improvement. Theoretically, one of the key benefits to this method is the advanced training and improvement opportunity that it gave to higher performing laboratories, which had the opportunity to present their own quality management systems for critical observation by their peer participants from other laboratories. Lower performing laboratories, meanwhile, were able to learn from the best practices of their peers. This practice addressed the need to match training content to benefit all ranges of participant experience. Participants were also able to acquire practical skills through direct hands-on participation during the experience. “I think practice is better than theory”, one participant suggested. Finally, although our trainers strived to conduct all training in the local language wherever possible as a best practice, feedback from participants expressed strong critique for translators where information was not translated clearly enough. It was apparent that the training curriculum required further strengthening to meet the language needs of participants.

Best practices of In-person LQMS mentoring

In-person mentor visits, which participants agreed most highly to be important to the progress experienced in their laboratories, are purposefully designed to complement training, providing supplementary training and taking the time to answer questions for participants within the context of their own laboratories. Participant feedback appreciated the mentors’ effort to answer those questions and demonstrate how to apply information learned in formal training. Participants also appreciated follow-up from mentors regarding quality improvement plans, driving action and holding participants accountable. Even more feedback appreciated the problem-solving function of mentors, identifying and discussing problems on-site with participants and collaborating to overcome challenges to improvement.

Participants also suggested that face-to-face visits from mentors served to improve the professional mentor-mentee working relationship, and further comments remarked mentor visits to help engage other important leading stakeholders such as hospital directors and MoH regulators in laboratory improvement. One participant addressed both factors, stating “Regular periodic visits from trainers is important because it makes an important connection between the training institute and the laboratory staff. An in-person trainer visit is also important to increase the credibility of the laboratory staff to the lab director.” When mentors visit laboratories, MoH personnel and laboratory directors are invited to meet with mentors

and laboratory quality assurance staff to discuss current and past improvement efforts, garnering support for laboratory improvement efforts; This engagement of leadership is critical.

Best practices of LQMS tele-mentoring

Participant feedback addressing tele-mentoring activities reveals an apparent contradiction from a concurrent study that has found a correlation between participation time spent in Zoom teleconferencing activities and improved conformity to CamLQMS checklist standards. While this association suggests tele-mentoring may be a potentially significant driver of improvement, participant feedback ranked Zoom teleconferencing activities lower than all other primary activities. Participant feedback was critical of group teleconferencing activities in particular, commonly referring to “too much talk” and distraction among participants. This feedback did not, however, critique one-on-one tele-mentoring between mentors and a single laboratory and its staff, which was also common.

Positive feedback demonstrated that tele-mentoring activities fulfilled the same primary aims as in-person mentoring. Participants noted knowledge gained from telementor trainings, appreciated regular feedback from mentors, and again praised the ability to collaborate with both peers and mentors, sharing experience and knowledge. Participants further praised the ready access to mentors, being able to ask questions and get a response immediately, which was an important practice of our mentors, who set regular hours for participants to call for guidance. Further feedback emphasized again the importance of training in the local language, and one comment appreciated the cost effectiveness of telementor training, not just for the implementing organization, but for participants as well, saving them time and money. For these reasons, we recommend that telementor activities be designed to integrate the essential components of continued learning, peer accountability, and collaborative learning and problem solving, implemented cost effectively and in the local language wherever possible. We further recommend that mentors work with smaller groups or individual laboratories as much as possible during tele-mentoring activities for best results, maintaining firm control and structure, limiting back-and-forth between participants to set question and answer periods to make the best use of participant time.

Best practices of LQMS auditee training program

The auditee training was a combination of tele-conferencing and on-site audit training based on auditee assessment of the laboratory using the CamLQMS checklist. In essence, the ITECH auditor trainer feedback and taught on the gaps for improvement at the site of the audited laboratory. The training program had components of the training tools such as the technique of asking objective questions, observations of laboratory process and evidence of LQMS documents at site and ability to rate correctly on the checklist questionnaire. Trainees evaluated the auditor training positively and had learned the skill to rate their own laboratories on the Internal Audit of the QSE element effectively. In summary, the auditor training program was successful in providing MOH with a group of 12 auditors who would be able to assist in the collection of objective evidence, thus permitting an informed judgement about the status of the laboratory quality system that would be audited efficiently.

Limitations

Because most of these best practice themes are derived first from implementing staff observations, this study may be influenced by positive biases toward the implemented activities and practices, missing potentially useful practices not observed by either staff or participants. Data from program participants too is limited by positive response bias from participants, and is further limited to written feedback only, which is limited to short answer responses. Extensive interviews of participants or key stakeholders may provide richer data in following studies.

Program evaluation responses were further limited by language barriers among participants, who had varying abilities to respond clearly to the surveys in English, which resulted in some unclear or truncated responses. Feedback from training evaluations, which were responded to in either English or Khmer, contains the potential for translation error and bias as responses were translated into English by mentors rather than professional translators.

Recommendations and conclusion

This study gives further information to explain how an adaptable package of needs-based planning, training, and mentoring can lead to improved laboratory quality management systems via an informed, trained, and empowered workforce. Our model of best practices serves as a guide for future programs, emphasizing the importance of needs based training and informed planning. Themes from participant feedback highlight the usefulness of on-site training and peer learning, and highly support regular contact with experienced laboratory professionals who can mentor theory and practical skills in the laboratory setting, hold participants accountable to goals, and provide collaboration to identify and solve problems in the laboratory. Tele-mentoring activities appear to be associated with improved outcomes in one concurrent study [11] and in our Auditee Training program suggest that scale up practices for laboratory medicine would be a worthwhile investment, therefore we recommend careful planning and management of these activities to assure effective knowledge uptake and minimum distraction among participants. We further recommend that in-person mentoring be maintained to some degree in such programs, due to its perceived value among mentors and participants in the improvement process.

Declarations

Ethics approval and consent to participate: Following University of Washington IRB review this training program was determined to be non-research (NRD received). No sensitive human subject data was accessed for this project .

Consent for publication: All authors have consented to publication of this manuscript.

Availability of data and materials: Any data generated in this program is available by request.

Competing interests: The authors state no competing interest in the conduct of this program.

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funders.

Authors' contributions: SKO implemented the program in Cambodia as the project manager, influenced the program design, provided writing and editing support, and provided the primary observations of best practices from the standpoint of implementing staff. GD analyzed all survey and evaluation data and acted as the primary writer and editor of the manuscript. NN contributed to program implementation, provided early draft content, and dispersed data collection surveys. LAP was the project director and acquired program funding, informed program's design and implementation and contributed significantly as a writer and editor. SS, SS, and CL were instrumental in program implementation as mentors, collected and translated qualitative data, and provided editorial input on the manuscript.

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List Of Abbreviations

LQMS - Laboratory quality management system

ISO - International Standards Organization

I-TECH - International Training and Education Center for Health

MOH - Ministry of Health

BMLS - Burau of Medical Laboratory Services

WHO - World Health Organization

CamLQMS - Cambodia Laboratory Quality Management System checklist toward accreditation

CLSI Clinical and Laboratory Standard Institute

QSE - Quality systems essentials

SMART - specific, measurable, achievable, realistic, and timely goals

QAO - quality assurance officer

SLIPTA - Stepwise Laboratory Improvement Process Towards Accreditation in the Africa Region

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Table

Due to technical limitations, Table 1 is provided in the Supplementary Files section.

Caption

Table 1: the distribution of response frequencies and a mean Likert scale rating of each category for comparison.

Figures

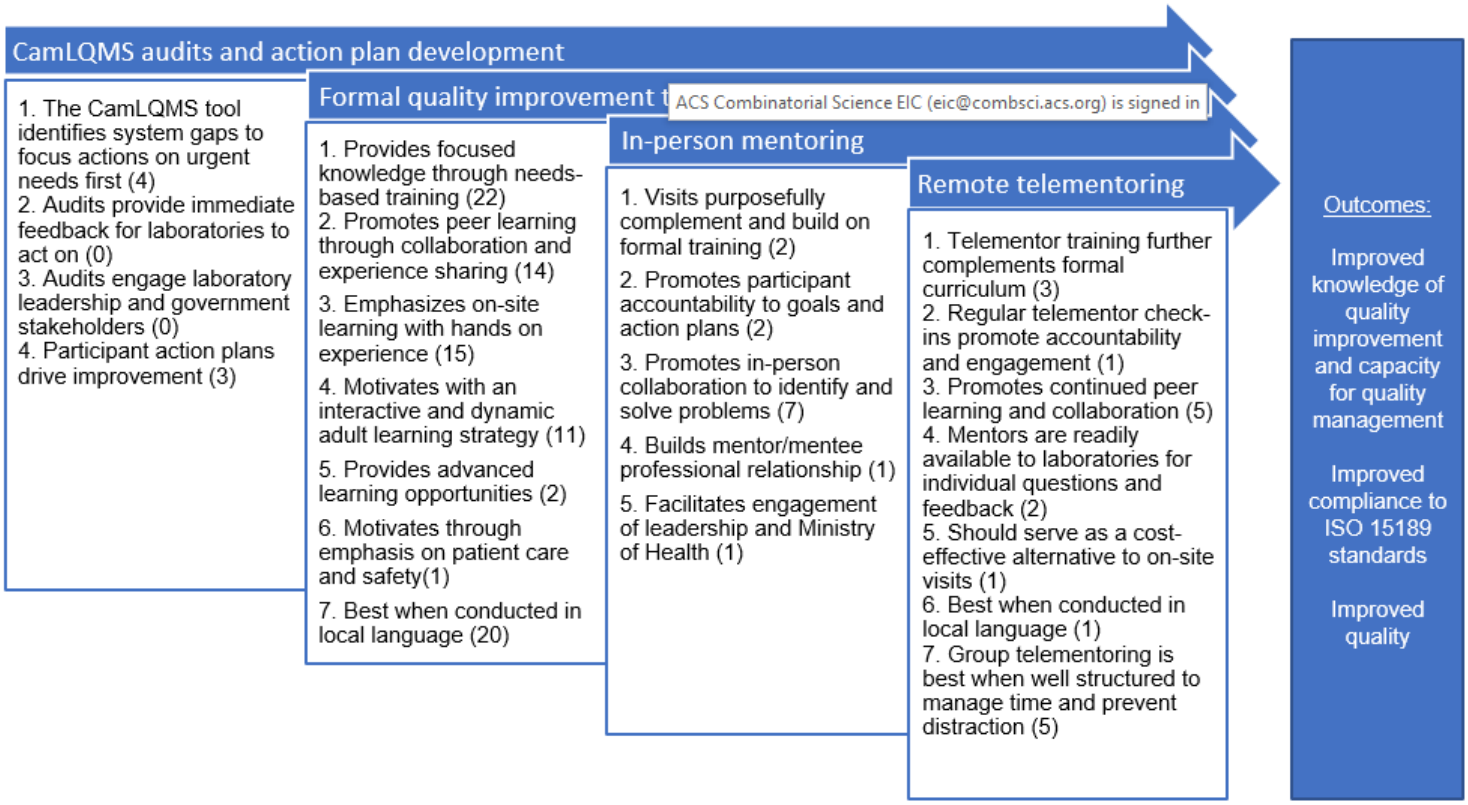

Figure 1

Model of best practices

Supplementary Files

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- table1.png