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ORIGINAL ARTICLE

E-learning in transfusion medicine: An exploratory qualitative assessment

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Abstract

Background and Objectives: E-learning programmes are increasingly offered in transfusion medicine (TM) education. The aim of this study was to explore facilitators and barriers to TM e-learning programmes, including assessment of learning outcomes and measures of effectiveness.

Materials and Methods: Participants selected from a prior survey and representing a diverse number of international e-learning programmes were invited to participate. A mixed methodology was employed, combining a survey and individual semi-structured one-on-one interviews. Interview data were analysed inductively to explore programme development, evaluation, and facilitators and barriers to implementation.

Results: Fourteen participants representing 13 institutions participated in the survey and 10 were interviewed. The e-learning programmes have been in use for a variable duration between 5 and 16 years. Funding sources varied, including government and institutional support. Learner assessment methods varied and encompassed multiple-choice-questions ($n = 12$), direct observation ($n = 4$) and competency assessment ($n = 4$). Most regional and national blood collection agencies rely on user feedback and short-term learning assessments to evaluate their programmes. Only one respondent indicated an attempt to correlate e-learning with clinical practices. Factors that facilitated programme implementation included support from management and external audits to ensure compliance with regulatory educational and training requirements. Barriers to programme implementation included the allocation of staff

time for in-house development, enforcing compliance, keeping educational content up-to-date and gaining access to outcome data for educational providers.

Conclusion: There is evidence of considerable diversity in the evaluation of e-learning programmes. Further work is needed to understand the ultimate impact of TM e-learning on transfusion practices and patient outcomes.

Keywords

E-learning, online education, transfusion

Highlights

- Facilitators for implementing e-learning programmes include funding allocation and leadership support, while barriers include staff time allocation, compliance enforcement and content updates.
- Evaluation of transfusion medicine e-learning ranges from learning assessment and user feedback/surveys to regulatory compliance assessment.
- Behavioural and outcomes-based assessments of e-learning programmes are limited.

INTRODUCTION

The adoption of e-learning has gained increasing attention in the field of transfusion medicine (TM) [1]. Our earlier international survey of 177 respondents revealed a widespread adoption of e-learning programmes in TM, with more than half being developed in-house, and targeting a range of audiences and topics [2]. A scoping review on e-learning in TM revealed limited published data on designs and behavioural impacts, although e-learning programmes often included learner knowledge assessment [3]. As part of an on-going programme of work in this area, we planned the present qualitative study to explore selected aspects of the development and design of existing TM e-learning programmes, with a focus on the facilitators and barriers to implementation, how assessment of learning is performed and how the effectiveness of the programme is evaluated.

We based our interview structure on the Kirkpatrick framework, which offers a structured four-level assessment for learning, each corresponding to different organizational aspects. Assessment refers to the assessment of the learner's knowledge, skills and abilities and can occur at multiple levels. Level 1, Reaction, measures learners' perceptions of training, regardless of its impact on knowledge or practice; Level 2, Learning, concentrates solely on knowledge acquisition; Level 3, Behaviour, scrutinizes changes in behaviour or practice resulting from learning and Level 4, Results, assesses if the training has achieved organizational goals and made a meaningful difference on the primary goals of the organization [4, 5], for example, a change in patient or patient blood management (PBM)-specific clinical outcomes due to the new learning.

MATERIALS AND METHODS

The study was conducted in two phases: a survey followed by qualitative interviews. Participants were selected from 177 respondents from a prior international survey among members of the International

Society of Blood Transfusion to assess the utilization of e-learning in their institutions [2]. The participants were selected based on involvement in the development or implementation of e-learning programmes at their institutions, and who had indicated their willingness to be contacted for future research.

The survey and the interview questionnaire were designed by experts in TM education, e-learning and qualitative research. The initial survey was reviewed by the working group members for face and content validity to ensure it would capture the information needed. The survey was programmed electronically by a research team member (K.J). After multiple rounds of testing and editing, the electronic survey was piloted among the research team members ($n = 5$).

The survey comprised 44 questions that collected information on the participant's contact information, institutional details, description of the TM e-learning programme, topics and intended audience(s), development and implementation, and how learner assessment is performed (Supplementary Material A). The survey also aimed to gather information to guide the subsequent interview phase of the project.

The interviews were conducted from January to March 2023. The interview questions covered in-depth details of the e-learning programme, facilitators and barriers to implementation and how programme effectiveness is evaluated (Supplementary Material B). All interviews were recorded and detailed notes were compiled. We performed an expedited descriptive analysis, identifying commonalities and themes. We also included verbatim quotes from the recordings to provide supporting evidence.

This study obtained ethics approval from the Australian Red Cross Lifeblood Ethics Committee.

RESULTS

Nineteen participants were invited to participate in the survey and 16 participants agreed. Two responses were excluded due to lack of

sufficient data. Fourteen participants with complete responses represented 13 different institutions from 12 countries (Table 1). Nine institutions were university-affiliated (70%), 10 were involved in undergraduate education and 12 in postgraduate education and professional development (Supplementary Material C).

Ten survey participants from nine countries agreed to participate in the interview portion of the study. The results of the surveys and interviews are summarized herein.

Development of e-learning programmes

The majority of the programmes ($n = 10$, 77%) were developed in-house, in consultation with various stakeholders such as TM physicians, nurses and blood bank staff (Supplementary Material D). In many cases, these institutions contributed the TM content for the e-learning programmes but relied on a third-party technical provider to develop the digital learning experience.

The development of e-learning modules depended on the type and the function of the institution. For example, the development and delivery of TM e-learning was the impetus for the formation of the educational providers and is their sole function. Programmes at hospital-based institutions were often reported as resulting from the dedication of the institutions' TM specialists. Some specialists were tasked with creating e-learning materials as part of their regular duties, whereas in other cases, specialists personally initiated the development and implementation of TM e-learning.

Only one of the interviewees represented an institution that had embraced nationally accessible 'off-the-shelf' e-learning programmes. The blood administration and transfusion reactions training programme for nurses in one country was a national e-learning programme available to all hospitals.

[It is] mandatory to study transfusion ...in the nursing school. ...[they are taught] blood component administration RBC (red blood cell) bags and after the session all participants ...are evaluated by senior nurses every three months up to one and a half year.

E-learning topics and learners

The e-learning programmes were developed for different purposes and scopes including being a standard part of competency assessment ($n = 7$), professional development ($n = 6$) and certification ($n = 4$) (Supplementary Material E). The most common target learners are nurses/midwives and physicians. In one case, the training is mandatory for laboratory scientists every 3 years as part of their professional development. The programmes offered by educational providers and national blood services have a broad audience, reflecting the diverse roles these institutions play as blood collectors, education and training providers, and national TM authorities.

The e-learning programmes cover a variety of topics related to the operational needs of the institution, while educational providers and national blood centres appear to offer the most diverse set of topics (Table 1). Blood administration and transfusion reactions are by far the most common topics covered with every programme covering at least one of these topics and often both. Nine programmes include interactive features such as case studies ($n = 7$), interactive animation/video ($n = 5$) and problem-based learning ($n = 5$) (Supplementary Material F).

Interviewees mentioned that topics are often tailored to the specific roles of the learners. For example, one e-learning programme offers more comprehensive training to medical professionals, limited and role-specific training to phlebotomists and specimen collectors, and a short blood administration module for porters and couriers. Similarly, a programme used in a regional blood service/centre offers e-learning education on transfusion reactions and blood administration to nursing students, nurses and physicians, but exclusively offers education in PBM and haemovigilance to physicians.

There are also programmes that are available to learners from outside the institutions. Many institutions surveyed offer their e-learning materials to other institutions as part of their mandate as education providers. The programme developed in one hospital has been adopted by other hospitals that do not have resources to develop their own programmes. While national blood services/centres provide role-specific training to their internal staff, they also extend training to external healthcare providers.

Cost to the user

None of these programmes imposed any cost on the participants. Among the hospital institutions represented in the interviews, training is free to users and the institutions absorb the cost of time and wages lost when participants are temporarily unavailable for their regular duties. Notably, some larger hospitals provide their educational resources to other institutions at no cost, aiming to enhance TM training.

Funding of e-learning education

Funding sources for the development of the e-learning programmes varied, including institutional and governmental or provincial funds (Supplementary Material D). Interviewees generally observed that obtaining the required funding was not a significant obstacle for the development or maintenance of e-learning programmes.

We have the budget or we are able to have the budget for it.

Interviewees based at hospitals discussed how e-learning programmes are supported by administrators in order to demonstrate

TABLE 1 Overview of e-learning programmes (n = 13).

Country	Institution type	Source	Topics covered							Learner assessment	Programme evaluation ^a
			Blood group systems	Blood administration	National Guidelines	Transfusion reactions	Apheresis	PBM	PBM		
Australia	Education Provider	In-house	✓	✓	✓	✓	✓	✓	✓	MCQ	Level 1 Level 2 Level 3 ^b
South Africa	Education Provider	In-house with external technical development				✓		✓	✓	MCQ Open-ended questions Competency assessment	NA
Canada	Education Provider	In-house	✓	✓	✓	✓	✓	✓	✓	MCQ Competency assessment Practical exam	Level 1 Level 2 ^c Level 3 ^b
France	National Blood Service/ Centre	In-house with external technical development	✓	✓	✓	✓	✓	✓	✓	MCQ Competency assessment	Level 1 Level 2
England	National Blood Service/ Centre	In-house with external technical development	✓	✓	✓	✓	✓	✓	✓	MCQ Scenario-based assessment	Level 1 Level 2
Denmark ^d	Regional Blood Service/ Centre	In-house	✓	✓	✓	✓	✓	✓	✓	MCQ	Level 1 ^c Level 3 ^b
India	Regional Blood Service/ Centre	A third-party developer	✓	✓	✓	✓	✓	✓	✓	Nil	Level 1 Level 2
Pakistan	Regional Blood Service/ Centre	In-house	✓	✓	✓	✓	✓	✓	✓	Open-ended questions Direct observation	NA
Norway	Hospital-based Blood Services	In-house with external technical development	✓	✓	✓	✓	✓	✓	✓	MCQ Direct observation	Level 1 Level 2 ^b Level 3 ^b Level 4 Other
Netherlands	Hospital-based Blood Transfusion Service	In-house	✓							MCQ Competency assessment	Level 1
Canada	Hospital-based Blood Transfusion Service	Externally by the Provincial Health Authority	✓	✓	✓	✓	✓	✓	✓	Direct observation	Level 3 ^b Other

(Continues)

TABLE 1 (Continued)

Country	Institution type	Source	Topics covered							Programme evaluation ^a
			Blood group systems	Blood administration	National Guidelines	Transfusion reactions	Apheresis	PBM	Learner assessment	
Japan	Hospital-based Blood Transfusion Service	Externally and used nationally	✓			✓			Direct observation	Other
USA	Hospital-based Blood Transfusion Service	In-house with external technical development	✓			✓		✓	Nil	Other

Abbreviations: MCQ, multiple choice question; N/A, not available; Other, compliance with regulatory obligations; PBM, patient blood management.

^aBased on Kirkpatrick evaluation.

^bAudit(s) conducted by an external agency.

^cA discontinued type of evaluation.

^dPhysicians cover all topics while nurses only cover administration and reactions.

compliance with training regulations, and how funds for development and implementation were simply made available due to necessity.

It probably costs something but I think the hospital wants to have this so I don't think it's a problem, if we talk about money.

I think the funding and resources are pretty much okay for our institute... .. it's an institute of national importance... But yeah, we are given priority as compared to the other institutes...

Delivery of e-learning education

The survey revealed that by far the most common format for e-learning programmes among the examined institutions was online, self-directed lessons. Only one programme used videos instead. The user experience varied among the programmes, including click-through presentations, a recorded lecture or podcast, or an interactive module with mixed media.

Notably hospital-based transfusion services often integrate the TM module into their existing e-learning infrastructure. Interviewees from these institutions explained that their organizations already had e-learning systems in place for various topics like fire safety training. This approach had clear advantages, such as reducing costs and implementation time. However, it also came with a drawback of the technological limitations of the existing systems. For instance, one centre's TM e-learning module could not track user data, including who had completed the modules, because this functionality was not originally built into the underlying system.

The duration of each institution's programme and modules significantly varies based on the type of institution and its specific requirements. Interviewees discussed that hospitals typically opted for relatively short and focused e-learning modules.

Assessment of learning and evaluation of effectiveness

Learning assessment was performed by multiple-choice questions (MCQs) ($n = 8$) open-ended questions ($n = 2$), direct observations ($n = 4$) and competency assessments to assess employee knowledge and areas of improvement ($n = 4$). Assessment records differ significantly among institutions, particularly between those whose core function is to provide education and those whose primary function is healthcare provision. National blood services and educational providers have the most comprehensive assessment records, including pass/fail grades and certificates of completion. In contrast, the hospital institutions surveyed typically rely on a single method of recording learner assessments, such as pass/fail grades, CME/CPD points or certificates of completion. One hospital does not appear to record assessments beyond fulfilling its compliance obligations.

Level 1 and level 2 evaluations

Six institutions (including two educational providers, two national blood services/centres, one regional blood service/centre and one hospital) conducted Kirkpatrick level 1 and level 2 programme evaluations (Table 1).

For Kirkpatrick level 1 evaluation, all six institutions use post-module surveys to assess user feedback and satisfaction. While the response rate is generally low, a substantial amount of feedback has been received. Such surveys were discontinued at two centres due to low response rate. As for knowledge gain by learners (Kirkpatrick Level 2), all institutions, except the hospital in Norway, include learning evaluation/quizzes in their modules and require learners to achieve a passing grade. It is important to note that users can retake these quizzes as many times as needed. One educational provider initially used pre- and post-testing to ensure the programme was resulting in improved learning outcomes, as the pre-test data revealed there was a clear need for the training among transfusion practitioners in the region, while the post-test data demonstrated knowledge improvement. However, this testing has been discontinued, due to concerns about time and usability. The revised programme will include MCQs as learning checks after each section. This programme was developed for all facilities in the province as a professional practice competency requirement (physicians, nurses, midwives, trainees and others), with input provided by the provincial TM service.

Level 3 and level 4 evaluations

Only one of the respondents indicated an audit linked to e-learning that may have demonstrated improvement in the hospital's transfusion practices. This hospital implemented its e-learning programme in response to a regulatory compliance audit by the Health Ministry in 2014. These audits involved staff interviews to evaluate whether they had been trained and if the education provided was of an adequate quality. The audit results pointed out areas where the hospital could improve in demonstrating that their staffs were well-prepared in TM practices. Subsequent external audits in 2019 and 2021 demonstrated improved staff recollection of TM practices (Level 2) and positive changes in TM practices due to the training (Level 3). The hospital also conducts internal audits of blood product utilization and demonstrated improved blood administration practices after introducing the e-learning programme (Level 4). These improvements, along with high training completion rates, were seen as indicators of the e-learning programme's effectiveness.

One of the education providers also employs surveys to measure perceived learning and assess whether users believe they have acquired new knowledge, which will lead to behavioural changes (Level 3). It also has attempted a Level 4 evaluation but faced challenges in obtaining the required governmental and organizational support, as this type of evaluation would need data from institutions using its modules. Instead, this education provider has passed external

audits by regulatory bodies assessing whether the programme delivers high-quality TM education (a valid Level 4 results-based evaluation for an education provider), but it is worth noting that the scope of these audits was limited.

Similarly, another educational provider is interested in evaluating its programme's effectiveness in changing practices and improving patient outcomes at users' hospitals. However, it has limited visibility into patient outcomes, despite conducting audits on product usage and relevant indicators at some hospitals. These audits are slow, resource-intensive, and reportedly of limited value by the time the results are available. Additionally, the programme underwent review by independent external researchers who used the programme at their institution and demonstrated a modest positive effect on product usage and patient outcomes (Level 4).

Staff at one hospital expressed a desire for a higher-level evaluation of their e-learning programme. However, due to the COVID-19 pandemic, it has proven impossible to isolate the effects of the TM e-learning programme on blood administration practices.

What we can really see now, last year and this year, is our blood—how much blood we are using—is going down all the time. But we thought it was a bit different because 2020 came—COVID-19. Naturally it gave a decrease in the spending of blood at the departments, but it has not gone up after the COVID-19 pandemic is over. Actually, we are seeing it's decreasing all the time so fast that we cannot hardly handle it in our blood banks... We have just this year minimised our—how many units we have in common, in-house. But I am not sure it is due to our e-learning program. I do not know.

We had made an audit at the small hospital ... and it actually revealed some points where they could definitely have got a lot of help... if they just had taken the e-learning program...

Other challenges at the hospital level were also described. One hospital-based blood transfusion service is facing limitations in conducting a patient outcomes-based evaluation of its e-learning program due to the implementation of a computer administration system. This implementation has temporarily affected data quality, making it challenging to undertake evaluations.

Facilitators for development and implementation

The implementation of TM e-learning was relatively easy in larger institutions such as national blood services/centres and educational providers. The interviewees from these institutions mentioned the feasibility of in-house development thanks to their access to qualified TM experts capable of providing high-quality educational content, whether to an in-house development team or to an external developer.

All hospital institutions highlighted that regulatory compliance was a core reason for implementing e-learning programmes and the interviewees from these institutions indicated being adherent to these (Table 1). Often, governments or regulating bodies mandate TM education for healthcare institutions under their jurisdictions, and these hospital institutions must provide adequate training to their staff and be able to demonstrate that adequate training has been provided.

The audits from the health authorities helped and I also think this competence portal where you can put all that you need to go through to be certified and all the things you should do has made it much easier for the leaders to follow up and it's much easier to see when it's not followed up...

We're only, I think, pulling [use data] to demonstrate compliance with regulations for PBM recertification.

Barriers to development and implementation

The primary challenge during the development phase usually revolved around time management, securing staff time for the development process and the maintenance of up-to-date educational content. For instance, one programme faced a significant barrier due to the need to switch digital platforms and revise and update e-learning courses.

For hospital-based institutions, institutional inertia also emerged as the most common obstacle to implementing a TM e-learning programme. A noticeable disconnect seems to exist between governing/regulatory bodies, executive management, lower-level management and the institution's TM practitioners. When a governing body mandates TM education after, for example, an unfavourable audit, upper management supports the development of TM e-learning by the institution's TM experts. However, lower-level managers, responsible for departments or clinical teams, are tasked with implementing the training but face competing demands for their and their physicians' and nurses' limited time.

Interviewees discussed how successful implementation of TM e-learning in a hospital-based institution was dependent on having upper management vocally support the new initiative while also supporting structural and procedural changes to allow space for the new training to occur. Institutional leaders that understand the nature of the problem that the new programme can help to solve—and who, crucially, can exert influence elsewhere in the organization to promote its implementation and uptake are the ideal start for any new initiative.

The first years we had this e-learning program it was a challenge—the program was there but it was, I think, the leaders of the clinical departments, they were responsible for the education of their personnel but they were not very much aware the transfusion and e-learning programs so not very many had gone

through this program [2] the first years and that I think it had to do with the consciousness of the leaders at the top of the system.

DISCUSSION

This study provides an exploratory evaluation of different elements of the development and use of TM e-learning in professional education and development. Interviews revealed facilitators for implementation like funding, upper management support and stakeholder management to ensure compliance remains a priority, especially within hospital settings. However, barriers and challenges remained, including in assessing the impact of learning on patient outcomes and organization objectives, due to assessment limitations and inability to access data on behavioural and institutional outcomes. Funding sources for the development of the e-learning programmes varied by institution type. Hospitals typically cover expenses from their budget for in-house initiatives, and for other larger institutions funding is often allocated by governments for the organization to develop and provide training to smaller institutions or individuals. Institutions prioritize education differently, often providing free TM education to learners to cultivate a trained workforce. Most educational institutions and national providers conducted user feedback and knowledge assessments by learners.

Although only a small sample was interviewed, the content of e-learning programmes varied based on learner type and the learning objectives, with variable interactivity levels, potentially reflecting the differences in available resources for their development. Simple learning materials such as PowerPoint presentations and videos offer passive reading and can be quickly developed. However, interactive web-based training requires web developers and media editors [6]. Interactive, individualized and contextual learning, and integrating theory into practice are key enablers affecting e-learning in health science education [1].

A key finding was very limited data on whether e-learning had effects on transfusion practices (Level 3) or patient outcomes (Level 4). This finding is consistent with our scoping review, which identified very few publications describing the impact of e-learning on patient or PBM-specific outcomes [3, 7–10]. Examples of such evaluations of the impact of e-learning interventions on behaviour and patient outcomes include improvement in perinatal outcomes and maternal intensive care unit admissions related to postpartum haemorrhage [7], improvement in blood component ordering, usage and traceability [8] and institutional rates of red blood cell transfusions [9].

Hospital-based institutions primarily focus on regulatory compliance for mandatory training and use surrogate evaluations through performance in audits by external agencies, which does not translate necessarily into better 'down-stream' practices. Even if these audits suggest improved patient outcomes, they cannot definitively attribute these improvements solely to training. Individual and contextual factors such as organizational learning culture, workplace support, staffing and individual's motivation may also play a role [11, 12].

Studies specifically for transfusion have demonstrated that there are many factors in place that influence transfusion behaviour beyond knowledge, which include beliefs about capabilities (confidence in not transfusing a stable patient), beliefs about consequences (reducing infections, saving resources), social influences (from team members or patient family members), motivation and goals (opposing beliefs of the importance of restrictive transfusion and other goals) [13, 14].

In our study, while programme coordinators and institutional administrators expressed the desire to conduct higher Kirkpatrick level evaluations, significant barriers exist for educational providers such as limited access to patient and organizational outcomes from institutions that implemented their programmes, which may not be readily available or routinely collected. Performing these evaluations would require substantial collaboration, additional workload, and changes in data collection practices, which may not be feasible or seen as a top priority for many hospitals participating in these e-learning programmes.

This study offers a description of e-learning programmes in TM, building on our earlier international survey [2] and review [3]. However, it has limitations. The findings are based on data from a small sample of institutions who agreed to participate and cannot be broadly generalized to all institutions running e-learning programmes. Participants' ability to report on certain aspects may have been limited by their roles, tenure, and expertise. The information provided relied on participants' recollection and understanding. For instance, some interviewees lacked insight into programme implementation and integration with other learning forms, particularly when training materials were provided to external organizations. Finally, estimating programme duration was challenging during the interviews, since most interviewees had not personally undergone the training from the perspective of a learner.

In conclusion, our interview data extend the findings of our survey and review, identifying considerable variability in the development, content and evaluation of e-learning programmes. Further research is needed to assess the impact of TM e-learning on transfusion practices and organizational outcomes, including Kirkpatrick Level 3 and 4 assessments, as well as cost-effectiveness compared with other learning methods. This is especially the case with the lack of evidence to assert that e-learning is more cost-effective than face-to-face instruction in health professions education [15]. Moreover, e-learning is a time-, cost- and labour-intensive approach to education [11], and this can limit its application in less resourced countries [16]. Exploring new evaluation methods for learner behaviour and patient outcomes is also needed.

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A.Z.R. initiated the project idea, prepared the list of the participants, reviewed the data, and drafted the manuscript. K.J. wrote the research protocol, performed the interviews, designed the electronic survey, analysed its results and drafted the report of the findings.

A.Z.R., C.S.O., B.S. and Y.L. reviewed the research protocol and finalized the interview questions. S.D. participated in drafting the introduction section of the manuscript. All authors participated in drafting the questions for the survey & interviews, and reviewed the manuscript.

CONFLICT OF INTEREST STATEMENT

Yulia Lin has research funding from Canadian Blood Services and Octapharma. She serves as a consultant for Choosing Wisely Canada. The rest of authors have no conflict of interest to declare.

DATA AVAILABILITY STATEMENT

The data that supports the findings of this study are available in the supplementary material of this article.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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