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Exploring the cost of eLearning within the field of health professions education: Scoping Review

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Exploring the cost of eLearning within the field of health professions education: Scoping Review

Abstract

Background: Existing research on the costs associated for design and deploying eLearning in health professions education is limited. The way in which these learning platforms compare in cost to face-to-face learning is also not well understood. The lack of pre-defined costing models used for eLearning cost data capture has made it difficult to complete cost evaluation.

Objective: The key aim of this scoping review is to explore the state of evidence concerning cost capture within eLearning in health professions education. The review explores what data exists to define cost calculations related to eLearning.

Methods: Scoping review using a search strategy of MeSH terms and related keywords centered on eLearning and cost calculation with a population scope of health professionals in all countries. The search was limited to English language studies. No restriction was placed on literature publication date.

Results: In total, 7344 articles were returned from the original search of the literature. Of these, 232 were relevant to associated keywords or abstract references following screening. Full-text review resulted in 168 studies being excluded. Of these, sixty-one studies were excluded because they were unrelated to eLearning and focused on general education. One-hundred and three studies were excluded because of lack of detailed information regarding costs. These studies referred to cost in ways either indicating cost favorability or unfavorability, but without data to support findings. Finally, four studies were excluded because of limited cost data insufficient for analysis. In total, 42 studies provide data and analysis of the impact of cost and value in health professions education. The most common data source was total cost of training (n=29). Other sources included cost per learner; meaning the cost per individual student (n=13). The population most frequently cited was medical students (n=15), although a group of articles focused on multiple populations (n=12). A further 22 studies provide details of costing approaches for the production and delivery of eLearning. These studies provide insight into ways eLearning has been budgeted and project managed through implementation.

Conclusions: While cost is a recognized factor in studies detailing eLearning design and implementation, the way cost is captured is done so inconsistently. Although there is a perception that eLearning is more cost-effective than face-to-face instruction, there is not yet sufficient evidence to assert this conclusively. A rigorous, repeatable data capture method is needed, in addition to a means to leverage existing economic evaluation methods that can then test whether eLearning cost-effectiveness and how to implement with cost benefits and advantages over traditional instruction.

Keywords: Education (MeSH); Education, Distance (MeSH); Education, Professional (MeSH); Online Education; Online Learning; Costs and Cost Analysis (MeSH); Economics (MeSH)

Introduction

Significant investment is necessary to adapt and expand global healthcare staff to transition to the medical challenges of the 21st century. The demands on the workforce range from an aging population and emphasis on chronic disease management [1], to access to primary care, where there is a direct link to the cost of training medical personnel. Primary care depends more heavily on public-sector investment than other medical specialties and scarce resources limit the numbers who can be trained [2]. As one example, with the increasing cost of delivery of care within the UK, the NHS has recognized that medical providers must take a greater role in education and training [3]. Creating production efficiencies in education and training may assist with the supply of medical personnel, to support clinical skills and applied health-related skills. eLearning, defined as "an approach to teaching and learning, representing all or part of the educational model applied, that is based on the use of electronic media and devices as tools for improving access to training, communication and interaction and that facilitates the adoption of new ways of understanding and developing learning" [4], presents a possible opportunity to change and optimize training by providing a scalable means for instruction, thus reducing the costs necessary in delivery and implementation. A potential critical opportunity of eLearning is the potential long-term efficiency gain in its delivery model in contrast to other forms of instruction, however the costs to develop eLearning are significant when executed to a high standard [5]. To achieve better cost management of eLearning and ensure scale-up and adoption, data is required for the factors which influence eLearning design and production. Research on the use of eLearning in medicine suggests that measurement of costs in studies is often inconsistent [6]. This scoping review aims to provide a broad overview of the state of evidence concerning measurement of costs in eLearning. Understanding these costs will enable better planning in the design & production of eLearning.

Methods

Scoping reviews are a form of rapid knowledge synthesis that identify the sources and evidence available to address research questions in a systematic manner. The established scoping review methodology by Levac, Colquhoun, and O'Brien [7] was chosen for this review, as the research question aims to provide a broad understanding of the literature available in this field, to inform subsequent reviews or research agendas.

Identifying the Relevant Research Question

To establish a comprehensive understanding of the costs[1] [8] associated with eLearning, we conducted a scoping review [7,9] to assess the available literature that quantifies the cost to deliver eLearning in health professions education. The research

[1] For the purpose of this review, cost is defined as the total costs (direct and in-direct) from inception to deployment, ranging from the design, development and delivery (or implementation). Within the study analysis, we attempt to analyze how these costs have been reported by studies, with an understanding that separate factors and sources of these total costs may or may not be reported. Factors influencing these costs could for example include the level of experience of the teams producing content. This aggregate grouping of studies will impact the way studies are compared to each other and should be taken into account when reading this review, as other study themes or classifications could impact interpretation of results.

question under investigation is "What is known in the literature about cost calculations related to eLearning in health professions education in regard to a) practical cost analysis; cost per learner and comparison to face-to-face instruction, and b) the choices in practice of costing methods and models?" A secondary question is: "How has the publication frequency of this developed over time?" These questions were derived using the **PICO** framework [10]. In this review, the **population** is defined as learners in health professions in all countries; this decision was made to ensure comprehensive coverage of all health professionals in order to understand the state of evidence internationally. The **intervention** instrument being evaluated is eLearning in health professions education (inclusive of various forms of training including basic & advanced continuing professional development, university level training, patient education, and various other training forms provided by an equally broad group of education training providers). The **comparison** used in this study is the evaluation of costs between eLearning, other methods of instruction such as face-to-face, alternate approaches to eLearning or studies which do not make use of a comparator. The **outcome** was a quantification and analysis of the difference in costs between within the implementations. We defined costs from cost calculations used in economic evaluation, including cost-consequence analysis, cost-minimization analysis, cost-effective analysis, cost-utility analysis and cost-benefit analysis [11].

Identifying Relevant Studies

Following consultation with an information scientist (RJ) at the Imperial College London Medical School Library, on literature search approaches, a search of the following databases was performed in December 2015 and repeated in December 2018; PubMed, Scopus, the Education Resource Information Centre (ERIC), Web of Science, Embase, Global Health, Health Management Information Consortium (HMIC), Prospero and OVID. In a second search which was completed in December 2018, new papers were added to the original data set but did not undergo exhaustive data charting; the data which was included provided high level summary of contents and relevance to previously categorized themes (these papers can be identified as studies from 2016 to 2018).

The search strategy included use of MeSH terms and related keywords centered on eLearning and cost calculation with a population scope of health professionals in all countries. The search was limited to English language studies. There was no restriction placed on literature publication date – although online technologies have changed rapidly over a short period of time, the authors felt that in order to provide a comprehensive overview of literature it would be useful to first explore research with no date restriction. The primary research questions were kept broad to ensure that there would be inclusion of all studies that recorded the costs to deliver eLearning globally. *A high-level summary of the search strategy is detailed in Table 1; a full summary of the search strategy used per database is detailed in Multimedia Appendix 1.*

Table 1. Sample search terms.

Category	Search Terms
Cost	• Costs and Cost Analysis [Mesh Terms]

	• Cost-benefit analysis [MeSH Terms] • Costs and cost analysis [MeSH Terms] • Cost* • Economic*
Learning	• Learning [MeSH Terms] • eLearning • Blended learning • Online learning

Study Selection

Following the process used in this review method, study selection was based on study identification with data centered on studies which identified cost factors and variables in health professions education eLearning. The literature was reviewed independently by two researchers (JE, EM) to identify articles. A third researcher, CB, adjudicated disagreements when necessary. Article abstracts were first scanned for relevance to the research question and then full articles were downloaded to verify appropriateness. The inclusion criteria included studies and reviews which examined eLearning in health professions education and captured data concerning design, development and production costs. Papers that provided synthesis or editorializing of issues without data i.e. opinion pieces and commentaries, were excluded.

Charting the Data

The definition of cost in this review is centered on the hypothesized cost-savings derived from a possible reduction in labor costs through scaling teaching via digital technology – the cost definition being the production and delivery costs (direct and in-direct) of online learning [12]. Studies included were classified to explore different ways to compare and analyze factors influencing these costs. Studies were chartered into two groups: (1) studies detailing costs for eLearning implementations and (2) studies the detailed costing methods (approaches to capture costs) for eLearning studies without implementation specific data. Group 1 was further charted into two separate groups, (A) studies with comparison to other learning types and (B) studies without. For these two sub-categories, we excluded studies which disclosed that the cost data provided was incomplete.

Collating, Summarizing, and Reporting the Results

Each study was reviewed individually to understand the implementation aspects of each reported eLearning instance. The studies were then summarized into four categories: (1) Studies that detail eLearning costs without a comparator, (2) Studies that detail eLearning costs with a comparator, (3) Related data from two related systematic reviews and (4) Studies that detail costing approaches. The results are presented as a narrative summary of the principal aspects of each study organized via main classification themes in order to present evidence to inform the development and

deployment of eLearning by defining the factors that influence implementation costs and the criteria which should be used to explore cost optimization.

Results

Studies Overview

In total, 7344 articles were returned from the search of the literature (Figure 1). Of these, 232 were relevant to associated keywords or abstract references to cost following screening. Full-text review resulted in 168 studies being excluded. Of these, sixty-one studies were excluded because they were unrelated to eLearning and focused on general education. One-hundred and three studies were excluded because of lack of detailed information regarding costs. These studies referred to cost in ways either indicating cost favorability or unfavorability, but without data to support findings. Finally, four studies were excluded because of limited cost data insufficient for analysis. In total, 42 studies (Table 2) provide data and analysis of the impact of cost and value in health professions education (completeness of data extracted varied and resulted in some data sets in the final inclusion data charts to be designated Not Available/Applicable (N/A) to reflect inability to abstract usable information, however remained within the inclusion set because of partial data which contributed to the narrative analysis. These studies contrasted to studies excluded at earlier screening stage because of cost being a secondary outcome of investigation and the cost data being of greater focus than those of the excluded studies). The most common data source was total cost of training (n=29). Other sources included cost per learner; meaning the cost per individual student (n=13). The population most frequently cited was medical students (n=15), although a group of articles focused on multiple populations (n=12). A further 22 studies provide details of costing approaches for the production and delivery of eLearning. These studies provide insight into ways eLearning has been budgeted and project managed through implementation.

Figure 1. Flow diagram of search and screening for costs of eLearning implementation.

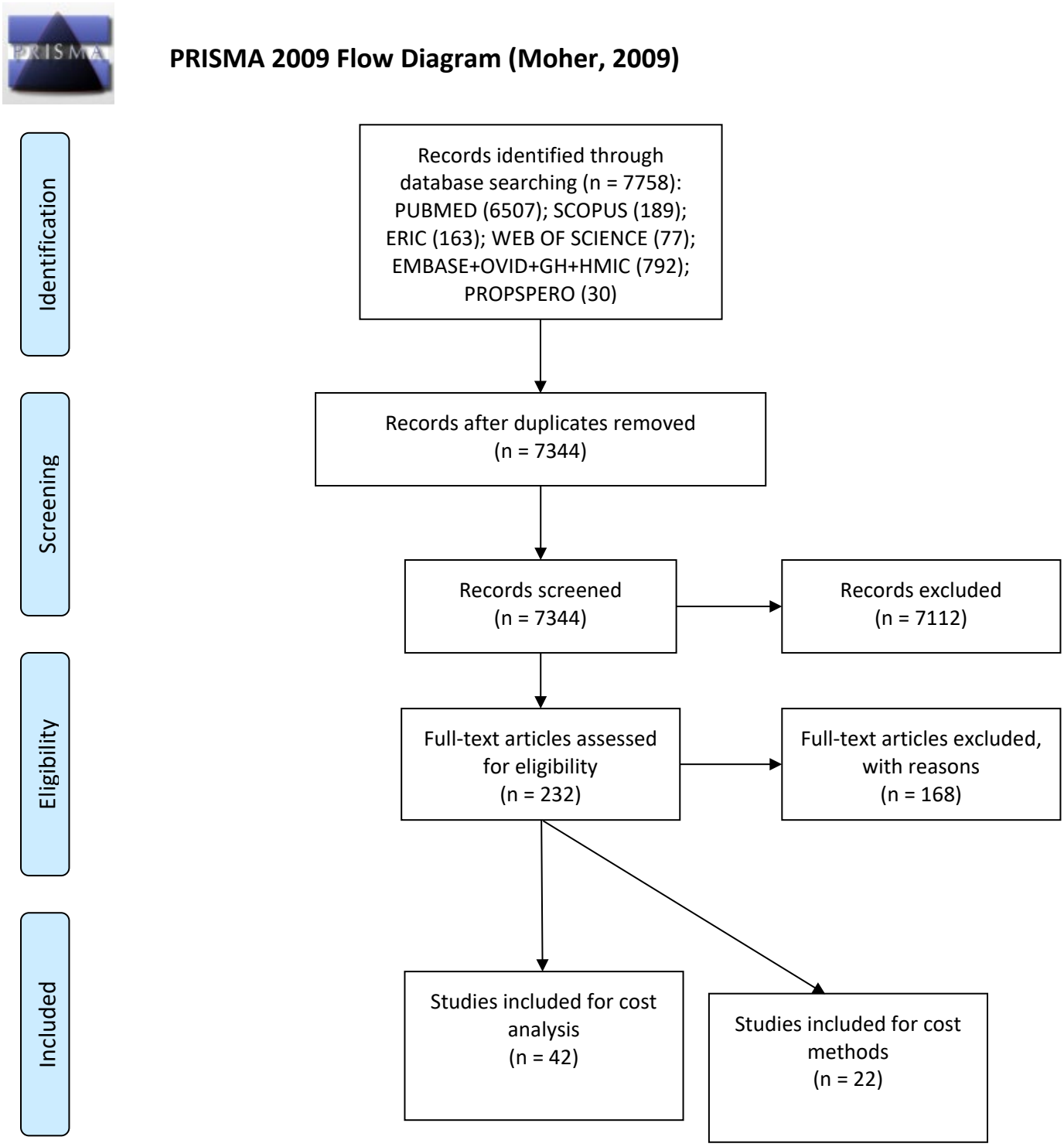

Table 2. Studies that provide costs for eLearning implementation.

Prefix	Number	First Author	Year	Comparison	Study design	Subject	Cost source	Population (HCPs)
INC	1	Allan [13]	2008	None	Case	Evidence Based Medicine	Total cost	Clinicians
INC	2	Bandla [14]	2012	None	Case Control Study	Sleep Medicine	Total cost	Medical Students
INC	3	Berger [15]	2009	Face to Face	Case Control Study	Patient Education	Per learner	Nurses
INC	4	Butler [16]	2013	None	RCT	Behavior Change Counselling	Per learner	Clinicians, Nurses
INC	5	Choi [17]	2008	Other learning	Case Study	Surgical Anatomy	Total cost	Medical Students
INC	6	Collins [18]	2018	None	Course Review	Nutrition	Total cost	AHPs, Medical Students
INC	7	Downer [19]	2018	None	Case Study	Leadership and Management in Health	Total cost	AHPs, Medical Students, Clinicians
INC	8	Dumestre [20]	2014	Other learning	Systematic Review	Microsurgical Skill-Acquisition	Per learner	Clinicians, Medical Students
INC	9	Glasbey [21]	2017	Face to Face	Case Study	Surgical training	Total cost	Medical Students
INC	10	Grayson [22]	2018	None	Longitudinal Study	Hand Hygiene	Total cost	AHPs, Medical Students, Clinicians
INC	11	Hardwick [23]	2011	None	Case Study	Pathology	Total cost	Clinicians
INC	12	Jerin [24]	2005	None	Case Study	Emergency Medicine	Per learner	Allied Health Professionals

INC	13	Joshi [25]	2012	Other learning	Case Study	Public Health Informatics	Total cost	Allied Health Professionals
INC	14	Kaufman [26]	2010	None	Case Study	Treatment of diabetes	Per learner	Patients (Patient education used by HCP)
INC	15	Knapp [27]	2011	Face to Face	Case Study	HIV detection	Total cost	AHPs, Clinicians
INC	16	Kumpu [28]	2016	Face to Face	Case Study	Global Health	Total cost	AHPs, Medical Students, Clinicians
INC	17	Letterie [29]	2003	None	Literature Review	Computer-assisted medical education	Total cost	AHPs, Medical Students, Clinicians
INC	18	Likic [30]	2013	None	Cohort Study	Rational Therapeutics	Total cost	Medical Students
INC	19	Manring [31]	2011	None	Case Study	Psychotherapy	Total cost	Clinicians
INC	20	McConnell [32]	2009	None	Case Study	Pharmacy CPD	Per learner	Pharmacists
INC	21	McDuffie [33]	2011	None	Case Study	Experiential Pharmacy Training	Per learner	Pharmacists
INC	22	Moreno-Ger [34]	2010	No Intervention	Case Control Study	Practical Skills Simulation	Per learner	Medical Students
INC	23	Nickel [35]	2015	Other learning	RCT	Laparoscopic Cholecystectomy	Total cost	Medical Students
INC	24	Nicklen [36]	2016	None	Case Study	Physiotherapy	Total cost	Undergraduate AHPs
INC	25	Padwal [37]	2017	Other learning	RCT	Weight management	Total cost	Patients (Patient education used by HCP)

INC	26	Padwal [38]	2013	Other learning	RCT	Weight management (Study protocol)	Total cost	Patients (Patient education used by HCP)
INC	27	Palmer [39]	2015	None	Case Study	Clinical Skills	Total cost	Medical Students
INC	28	Pentiak [40]	2013	None	Clinical Review	Surgical Skills	Per learner	Clinicians
INC	29	Perkins [41]	2012	Face to Face	RCT	Advanced Life Support Training	Per learner	Allied Health Professionals
INC	30	Reeves [42]	2013	Other learning	Literature Review	Interprofessional Education	Total cost	Allied Health Professionals
INC	31	Schopf [43]	2011	None	Case Study	Interprofessional training - Dermatology	Total cost	Clinicians, Nurses
INC	32	Shepler [44]	2014	None	Cohort Study	Advanced Pharmacy Practice Experience	Total cost	Pharmacy Students
INC	33	Sivamalai [45]	2011	None	Case Study	Pathology	Total cost	Medical Students
INC	34	Spanou [46]	2010	Face to Face	RCT (Protocol)	Behavior Change Counselling	Total cost	Clinicians, Nurses
INC	35	Stansfeld [47]	2015	Other learning	RCT	Employee Well-Being	Total cost	Allied Health Professionals
INC	36	Stromberg [48]	2012	None	Cohort Study	Heart Failure Nursing	Total cost	Nurses
INC	37	Thomas [49]	2010	None	Case Study	Family Planning	Total cost	Allied Health Professionals
INC	38	de Ruijter [50]	2015	None	Case Study	Business Eng. Surgical Tech.	Total cost	Medical Students

INC	39	Weiss [51]	2011	Other learning	Cohort Study	Antibiotic Prescribing	Total cost	Clinicians, Pharmacists
INC	40	Williams [52]	2009	None	Cohort Study	Practice Based Research Networks	Per learner	Clinicians
INC	41	Young [53]	2017	None	Case Study	Research skills	Per learner	Allied Health Professionals
INC	42	Zhou [54]	2018	None	Case Study	Resource stewardship	Per learner	Medical Students, Clinicians

Note: The prefix INC indicates that this group was inclusive of comparator and non-comparator studies (for eLearning costs) and the combination of the prefix and number can be used to provide a unique ID to refer to studies. This prefix approach is also used in the remaining data tables.

Studies that Detail eLearning Costs without a Comparator

Twenty-two studies [13,16,19,22,23,26,30–34,39,40,43–45,48,50,52–55] provided analysis of implementation costs in eLearning without comparison to other learning platforms. The studies primarily reported total costs and cost per learner (Table 3). The studies suggested that eLearning should be less costly than face to face learning, however without a comparator, it is not possible to substantiate these claims. Despite these deficiencies, what the studies provide are varying means of cost calculation across different forms of instructional design.

Table 3. Studies that detail eLearning costs without a comparator.

Prefix	ID	First Author	Year	Instructional Design	Sample	Total Cost (USD)	Cost per Learner	Notes
SUM	1	Allan [13]	2008	Asynchronous, Blended	304	$8,209	$24	No blended learning cost
SUM	2	Butler [16]	2013	Blended	80	$2,075	$26	No explicit cost methodology/technique described
SUM	3	Downer [19]	2018	Asynchronous	53	$23,000	$394	No explicit cost methodology/technique described
SUM	4	Grayson [22]	2018	Asynchronous	1989713	N/A	$.04	Provided aggregate cost per leaner
SUM	5	Kaufman [26]	2010	Asynchronous	787	N/A	$1,453	Reported overall cost per learner
SUM	6	Hardwick [23]	2011	Asynchronous	N/A	N/A	N/A	Provided cost modelling approach
SUM	7	Likic [29]	2013	Asynchronous	393	$10,000	$23	Use of online course deemed lower cost than F2F Problem Based Learning
SUM	8	Manring [31]	2011	Blended	35	$5,250	$137	Only costs of physical implementation
SUM	9	McConnell [32]	2009	Asynchronous	8120	$610	$.07	No explicit cost methodology/technique described
SUM	10	McDuffie [33]	2011	Blended	382	N/A	$21	No explicit cost methodology/technique described

SUM	11	Moreno-Ger [34]	2010	Asynchronous	400	$2,630	$6	No explicit cost methodology/technique described
SUM	12	Palmer [39]	2015	Synchronous	9	$5,000	$506	No explicit cost methodology/technique described
SUM	13	Pentiak [40]	2013	Asynchronous	N/A	$32,685	N/A	Total Curriculum Delivery
SUM	14	Schopf [43]	2011	Asynchronous	88	$84,229	$858	No explicit cost methodology/technique described
SUM	15	Shepler [44]	2014	Asynchronous	580	N/A	N/A	$148 USD savings per intervention
SUM	16	Sivamalai [45]	2011	Asynchronous	200	$392,468	$1782	Cost of Digital Microscopy 1/3 Cost of Physical Microscopy
SUM	17	Stromberg [48]	2012	Asynchronous	183	N/A	N/A	Total cost reduction compared over previous methods
SUM	18	Thomas [49]	2010	Asynchronous	273	$21,000.00	$70	No explicit cost methodology/technique described
SUM	19	de Ruijter [50]	2015	Asynchronous	803	$44,986	$49	No explicit cost methodology/technique described
SUM	20	Williams [52]	2009	Asynchronous	103	$3,732	$33	No explicit cost methodology/technique described
SUM	21	Young [53]	2017	Asynchronous	679	N/A	$38	Did not report total cost
SUM	22	Zhou [54]	2018	Asynchronous	48	N/A	$148	Did not report total cost

Note: The prefix SUM indicates that this group was a summary of costs without a comparator; the prefix and number can be used to provide a unique ID to refer to studies.

The studies in this set engaged the scope of the review question focused on the costs associated with eLearning in health professions education but lacked the comparison variable of the **PICO** framework. While these studies suggest that eLearning implemented could provide self-reported high-value through low cost delivery and thus cost effectiveness, they offer no comparative framework to justify these assertions. Among the studies that quantify eLearning costs, three groups emerged. The first included studies which demonstrated that eLearning was low cost but had no or limited evidence of self-reported educational impact [13,16]. The second group demonstrated eLearning was low cost and demonstrated high self-reported education impact [23,30–34,43–45,48–50,52–54]. A third group [19,22,26,39,40] demonstrated that eLearning was high cost and had high self-reported educational impact.

Allan, Korownyk, Tan, Hindle, Kung, and Manca [13] and Butler, Simpson, Hood, Cohen, Pickles, Spanou, McCambridge, Moore, Randell, Alam, Kinnersley, Edwards, Smith, and Rollnick [16] present examples of low cost eLearning delivery but without demonstrated educational impact, with low cost in these studies presented from the perspective of the cost per learner. In Allan, Korownyk, Tan, Hindle, Kung, and Manca [13] the key research question was whether this research group could implement an evidence-based medicine (EBM) curriculum for clinicians. Although quantifying costs was an aspect of the reported results, like many of the studies in this review, it was not a primary focus and was done so in an informal fashion without explicit unit cost breakdown or listing of all the components that would impact learning production. In contrast to the use of a comprehensive program including multiple forms of learning and the establishment of a learning community, Butler, Simpson, Hood, Cohen, Pickles, Spanou, McCambridge, Moore, Randell, Alam, Kinnersley, Edwards, Smith, and Rollnick [16] made use exclusively of blended learning in a course. Butler, Simpson, Hood, Cohen, Pickles, Spanou, McCambridge, Moore, Randell, Alam, Kinnersley, Edwards, Smith, and Rollnick [16] reveals that the complete training costs are not captured when creating online and/or blended courses in primary care. Despite comprehensively capturing unit costs of delivery in the implementation of the study (by providing segmentation of costs across administrators, actors, trainers, clinicians, nurses and costs per practice), it treats eLearning as a single group cost reflecting the time per participant to complete the eLearning – there is no accounting of the required system implementation time and production time for the creation of eLearning. Like Allan, Korownyk, Tan, Hindle, Kung, and Manca [13], Butler, Simpson, Hood, Cohen, Pickles, Spanou, McCambridge, Moore, Randell, Alam, Kinnersley, Edwards, Smith, and Rollnick [16] highlights cost omissions that are endemic in studies in this review.

A second group of studies demonstrate eLearning as having low cost and high educational impact [23,30–34,43–45,48–50,52–54]. Of this set, Likic, White, Cinti, Purkiss, Fantone, Chapman, Bielen, Francetic, and Engleberg [30], McConnell, Newlon, and Dickerhofe [32], McDuffie, Duke, Stevenson, Sheffield, Fetterman, Staton, and McCullough [33], de Ruijter, Halvax, Dallemagne, Swanström, Marescaux, and Perretta [50], Moreno-Ger, Torrente, Bustamante, Fernández-Galaz, Fernández-Manjón, and Comas-Rengifo [34], Thomas, Fried, Johnson, and Stilwell [49], Williams, McPherson, Kong, Skipper, Weller, and PRIME Net clinicians [52], and Young, McLaren, and Maden [53] each represent online courses making use of asynchronous online learning at low cost per learner (below £50/learner). The key issue among the studies in this literature cluster is that although they may provide

evidence of low cost per learner, without a comparison point to comparable face-to-face delivery there is no way to assert with any certainty that eLearning is a lower cost option. The final group of studies in this set [19,22,26,39,40] indicate that eLearning was of higher cost and had high educational impact. This group shared similar data recording issues as those from the previous set, but also provide evidence to indicate the high start-up costs associated with eLearning production.

It is challenging to draw strong inferences based on an aggregation of the studies that summarizes eLearning costs because of the different methods that were used in cost-calculation, the difference in subjects instructed, the rapid changes in web platforms for learning, and other factors impacting the way costs were calculated. However, it is possible to observe some trends from this grouping. For pure online courses, the studies suggest that total cost per learner are low; however, there is often acknowledgement in the studies that not all implementation costs have been captured in the cost calculations; this lack of included costs, included sunk costs indicates that reported costs are not accurate. Although some studies identify the costs that were not captured, many do not, and these gaps are only evident to researchers who have a background and understanding of the issues involved in the delivery of eLearning. Additionally, most studies are cases of specific instances of eLearning implementation, making it difficult to gauge what the results mean in contrast to face-to-face learning and case study methods make it hard to generalize results. Some studies indicated high total costs but, in those instances, [40] the eLearning costs were embedded in total curriculum delivery.

Studies that Detail eLearning Costs with a Comparator

Seventeen studies [14,15,17,21,24,25,27,28,34–37,41,46,47,51] compared eLearning costs to those of face-to-face learning or other types of learning (Table 4). These comparative studies provided more evidence that the use of eLearning demonstrated cost efficiencies than did the studies in the previous group, which provided no comparative data.

Table 4. Studies that detail eLearning costs with a comparator.

Prefix	ID	First Author	Year	Instructional Design	Comparison	Sample Size	eLearning	Face to face	Notes from Study
							Cost Comparisons		
COMP	1	Bandla [14]	2012	Asynchronous Online	Face to Face	173	$21,752	$21,752	
COMP	2	Berger [15]	2009	Blended	Face to Face	1661	$4	$110	Cost per learner
COMP	3	Choi [17]	2008	Asynchronous Online	Other learning	34	N/A	N/A	Provided costs of online platforms without complete cost comparison
COMP	4	Glasbey [21]	2017	N/A	N/A	570	N/A	N/A	Online curriculum embedded; core costs not separated in study
COMP	5	Jerin [24]	2005	Asynchronous Online	Asynchronous Online	9353	$3	$52	Cost per learner
COMP	6	Joshi [25]	2012	Asynchronous Online	Other learning	15	$14,085	$20,714	Online vs F2F Total Costs
COMP	7	Knapp [27]	2011	Asynchronous Online	Face to Face	91	$157	$4,386	
COMP	8	Kumpu [28]	2016	Blended	Face to Face	28	$2,431	$1,054	
COMP	9	Moreno-Ger [34]	2010	Asynchronous Online	Face to Face	400	$7	$2,630	
COMP	10	Nickel [35]	2015	Virtual Reality	Other learning	84	$3,900	$82,500	Virtual Reality vs Blended Learning
COMP	11	Nicklen [36]	2016	Blended	Face to Face	78	$5,904	$6,856	
COMP	12	Padwal [37]	2017	Asynchronous Online	Face to Face	651	$11,727	$477,000	

COMP	13	Padwal [38]	2013	Asynchronous Online	Face to Face	N/A	N/A	N/A	Protocol
COMP	14	Perkins [41]	2012	Blended	Face to Face	3732	$438	$935	
COMP	15	Spanou [46]	2010	Asynchronous Online	Face to Face	N/A	N/A	N/A	Protocol
COMP	16	Stansfeld [47]	2015	Asynchronous Online	Face to Face	350	N/A	N/A	Captured approach to total costs but incomplete comparison data to non-online approach
COMP	17	Weiss [51]	2011	Asynchronous Online	Other learning	N/A	N/A	N/A	Cost reduction per inhabitant following education program

Note: The prefix COMP indicates that this group was a summary of costs with a comparator; the prefix and number can be used to provide a unique ID to refer to studies.

The studies in this set can be divided into two groups: studies that demonstrated that eLearning was lower cost but had no or limited evidence of self-reported educational impact and studies that demonstrated that eLearning was lower cost and had self-reported high educational impact [25,51].
Of the studies that demonstrated that eLearning was lower cost and had low education impact, the key data issue with the studies in this set were that although they suggested that eLearning was lower cost; they continue to omit key components in the design and production of eLearning, creating an incomplete cost profile of the total costs of delivery. Two studies in this set demonstrated that eLearning was lower cost and demonstrated high education impact; although each study completed a full comparison demonstrating a reduction in costs (in some instances a dramatic reduction), the studies suffer from a lack of methodological consistency in the way they capture costs and evaluate effectiveness. As was the case in the previous set of study classifications, the continued differences in cost accounting, learning delivery platforms and various forms of assessments make synthesis challenging.

Literature Reviews that Quantify eLearning Costs

Two review studies [20,42] analyzed the use of training where eLearning was used as a delivery platform. Both studies revealed that there was a lack of sufficient evidence to analyze whether training methods using aspects of online learning were more pedagogically effective. The studies were also unable to provide findings that created a holistic understanding of associated cost ingredients. Dumestre, Yeung, and Temple-Oberle [20], suggests that within the field of microsurgical training, there are many available methods of implementing instruction and that cost is the determining factor in what is used by institutions. Reeves [42] performed a Cochrane systematic review protocol that included 15 studies. This study found that due to the small number of studies (n=15) and the heterogeneity of interventions and outcome measures, it is not possible to draw inferences about the key elements of inter-professional education and its effectiveness. In order to make such evaluation possible, there must be implementation of cost-benefit analysis, separation of review within specific professions and studies using qualitative methods to evaluate effectiveness. Although both studies were concerned with evaluation of the effectiveness of specific education training, the way they engaged with the literature review question was limited as both studies collected limited information on eLearning and only gave broad summary generalizations about cost reductions in their respective field of focus. Costs were identified by looking at the total costs of delivery of programs, but because the costs were not described as units it is not possible to examine the extent and quality of the results. There was no accommodation for differential timing or impact of the consequences of cost decisions. These issues are similar to the weakness in cost analysis of the other studies in this review.

Studies Detail Costing Approaches

Twenty-two studies [56–77] referenced economic evaluation (analyzing cost benefits or cost effectiveness) or used the ingredients method [78] to calculate costs in production of eLearning (Table 5). Reflecting on the broader set of studies in this review, it is important to note that while many studies suggest the cost-effectiveness of eLearning, following

completion of this review, we have only identified five cost-effectiveness analysis studies completed on eLearning. Regarding specific cost approaches, using the ingredients method is referenced often in this set (twelve times), although the mechanisms for cost capture and subsequent project delivery management of production of learning within this group despite using the same methods are inconsistent.

Table 5. Studies detailing costing approaches or economic evaluation.

Prefix	ID	First Author	Year	Costing approach
COS	1	Brown [56]	2014	Cost benefit analysis
COS	2	Buntrock [57]	2014	Cost effectiveness analysis
COS	3	Pettit [58]	2017	Ingredients Cost Method
COS	4	Carlson [59]	2008	Ingredients Cost Method
COS	5	Carpenter [60]	2016	Ingredients Cost Method
COS	6	Chambers [61]	2017	Cost utility analysis
COS	7	Chhabra [62]	2013	Cost effectiveness analysis
COS	8	Cousineau [63]	2008	Cost effectiveness analysis
COS	9	Curran [64]	2006	Ingredients Cost Method
COS	10	Cook [65]	2014	Ingredients Cost Method
COS	11	Delgaty [66]	2013	Ingredients Cost Method
COS	12	Djukic [67]	2015	Ingredients Cost Method
COS	13	Gallimore [68]	2012	Ingredients Cost Method
COS	14	Isaacson [69]	2014	Ingredients Cost Method
COS	15	Lonsdale [70]	2016	Cost effectiveness analysis
COS	16	Papadatou-Pastou [71]	2017	Multiple; survey of methods
COS	17	Pardue [72]	2001	Ingredients Cost Method
COS	18	Pickering [73]	2016	Multiple; survey of methods
COS	19	Rondags [74]	2015	Cost effectiveness analysis
COS	20	Sharma [75]	2018	Ingredients Cost Method
COS	21	Tung [76]	2008	Perceived financial cost
COS	22	Zary [77]	2006	Ingredients Cost Method

Discussion

Principal Findings

Our review was focused on identifying literature that would define the associated costs in the delivery of eLearning in health professions education. Broadly speaking, we were able to answer this question as we collected data that documented a trend of reported eLearning costs per learner and their general low cost. However, we have questions about how conclusive this data was because of the issue of consistency regarding cost data capture, the lack of standard mechanisms for cost data collection for online learning, and the lack of primary studies that focused on cost analysis as a primary research objective. Our review findings were consistent with views in previous research that understanding of the relationship of cost in eLearning is not well developed [6,79,80]. The studies included provide a cross-section of various instances of eLearning across many disciplines in health professions education. This collection of studies allowed a deeper understanding of the various ways in which eLearning is being used and the cost considerations when applying different platforms of education delivery. The key limitations of the included studies were the lack of consistency of methodology for cost analysis. Cost evidence provided by the included studies was challenging for the purposes of comparison due to these deficiencies.

Strength and Limitations

The strengths of this review are that it completed a comprehensive search of the major literature databases. The search question and the associated terms provided broad enough scope to ensure that there was coverage to any study which recorded cost and maintained relevance to the inclusion criteria. The search approach was consulted with leading researchers who investigate cost in education and the final results provide a rich background of materials to explore the issues associated with the research question. There are four limitations to the process used in this literature review. As only English language papers were searched, relevant foreign language papers could have been excluded, in addition to the publication bias of health science papers for positive results. Additionally, industry literature was not explicitly searched for in the search strategy further adding to the limitation of study papers under review. Secondly, due to the inconsistency in capturing costs and lack of standardization in cost reporting, meta-analysis for quantifying costs is not be possible because of the lack of pre-defined costing models for eLearning used in standard ways across studies, the significant variance in the way costs are recorded, variant experimental methods with different outcome conclusions, and the variance in implementation between different eLearning types. Thirdly, a significant limitation is that in comparing costs of eLearning within the included studies of the review, each study is treated equally in comparison, when the costs for a team which is new to eLearning production will cost more to an experienced team who have produced many courses. Additionally, reported costs could have been on segments of the production process, resulting in inconsistency in reporting. Further research could explore specific aspects of design, development and delivery to allow for more refined comparison and analysis, including quantitative cost analysis, including that of fixed versus variable costs. In addition to this cost analysis, further work could explore the relationship between learning impact and associated effort as attributed to cost. Lastly, a significant limitation is that this review was re-run in December 2018 to update results from spring 2016 in an

original scoping of the literature completed in December 2015, but detailed analysis of new studies identified from 2016 to 2018 are not included in the narrative of this review. While the newly included studies are incorporated into the data tables because of time constraints, further analysis of these new studies will be completed in a separate update of this review.

While the review could be strengthened by taking further measures to either refine the research question into a narrower scope or attempting cost modelling with accepted deficiencies, the review as completed provides a comprehensive scoping of evidence and highlights a gap in the literature indicating there is a need for a protocol that can capture costs in eLearning interventions in order to allow a basis for comparison in similar educational subjects or across variant curriculum implementations. Such a protocol would provide a systematic mechanism for calculating online learning costs to allow for a basis of various form of economic evaluation, would assist course designers in understanding the total costs in delivery of eLearning and address the standardization issues incumbent with a lack of a standard as evidenced by this review.

Conclusions

While cost is a recognized factor in studies exploring eLearning design and implementation, the way cost is captured is collected inconsistently and in relation to a wide variety of factors or had an alternate study-related focus. Although there is a perception that eLearning is more cost-effective than face-to-face instruction, there is not yet sufficient evidence to assert this conclusively. Among the many factors for considering implementing eLearning is the potential long-term cost-effectiveness of its delivery model in comparison to other education delivery formats. A rigorous, repeatable and data capture method is needed, in addition to a means to leverage existing economic evaluation methods that can then test whether eLearning cost-effectiveness and how to implement with cost benefits and advantages over traditional instruction. If proven more cost effective, this could assist in addressing the high cost of delivering of health professions education. On the other the hand, should evidence point the other way, having discrete data points will allow those involved in health education to identify ways to optimize costs in eLearning delivery to create cost efficiency. To evaluate and optimize cost in education delivery, there must be a rigorous standard through which to score and assess cost-effectiveness - to analyze whether investments are justified.

In order for there to be understanding of the way cost impacts the deployment of eLearning in comparison to face-to-face instruction, a body of evidence that makes use of economic evaluation must be developed to allow for systematic analysis of how these results demonstrate the strength and weakness of comparative cost delivery. This review has identified that there has been limited use of economic evaluations to achieve this aim and that, even in studies that make use of cost summaries in their results, there is a lack of sufficient rigor to provide insight to the way in which these costs impact education delivery or to allow comparisons to other forms of learning.

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Ethics and Dissemination
As data collection was executed via published literature, ethical approval was not be required for this review.

Contributorship Statement
JC conceived the study topic and EM under supervision of JC, devised the primary research question, scope, structure and methods of the investigation. EM executed and completed primary manuscript drafting; the text is drawn from EM's doctoral thesis at Imperial College London. JE and CB completed peer review of papers for selection and analysis. SR, SM, GR, DI, KW, AM provided feedback on the draft texts. EM responded to peer review feedback. The final manuscript was approved by all authors. EM is the guarantor.

Conflicts of Interest
All authors completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf. There are no relevant conflicts of interest, financial or other types of relationships that may influence the manuscript declared by authors. Authors do not have any patents and are not associated to any conditions or circumstances that may lead to conflicts of interest.

Multimedia Appendix 1: Full Search Strategy
Multimedia Appendix 2: Eligibility Stage Search Exclusions

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