Evaluation of a massive open online course for just-in-time training in resource-limited settings: evidence from a COVID-19 course for healthcare workers

Matthew Charles Strehlow, Kelly Zhang Aluri, Jamie Sewan Johnston, Charles G Prober, Peter Corrigan Acker, Avinash S Patil, Swaminatha V Mahadevan

Submitted to: Journal of Medical Internet Research
on: December 29, 2020

Table of Contents

Original Manuscript **5**
Supplementary Files **20**
Figures **21**
Figure 1 ..... **22**
Figure 2 ..... **23**
Figure 5 ..... **24**
Figure 6 ..... **25**
Figure 3 ..... **26**
Figure 4 ..... **27**
Multimedia Appendixes **28**
Multimedia Appendix 1 ..... **29**
Multimedia Appendix 2 ..... **29**
Multimedia Appendix 4 ..... **29**
Multimedia Appendix 5 ..... **29**
Multimedia Appendix 3 ..... **29**

Evaluation of a massive open online course for just-in-time training in resource-limited settings: evidence from a COVID-19 course for healthcare workers

Matthew Charles Strehlow[1] MD; Kelly Zhang Aluri[2] BSc; Jamie Sewan Johnston[2] PhD; Charles G Prober[3] MD; Peter Corrigan Acker[1] MD, MPH; Avinash S Patil[1] MD; Swaminatha V Mahadevan[1] MD

[1]Department of Emergency Medicine Stanford University Palo Alto US
[2]School of Medicine Stanford University Stanford US
[3]Stanford Center for Health Education Stanford University Stanford US

Corresponding Author:
Matthew Charles Strehlow MD
Department of Emergency Medicine
Stanford University
900 Welch Rd Suite 350
Palo Alto
US

Abstract

Background: The COVID-19 pandemic created an urgent global need for healthcare worker (HCW) training. Initial COVID-19-related online courses focused primarily on training public health workers and physicians caring for patients in intensive care units (ICUs). However, in resource-constrained settings, nurses and general practitioners are responsible for providing most COVID-19 patient medical care, typically lacking the training and equipment necessary to manage complex, critically ill patients. In these environments, early recognition and interventions to prevent patient deterioration are essential to optimizing outcomes. We developed a massive open online course (MOOC) for HCWs in resource-constrained settings aimed at training bedside providers caring for patients with COVID-19.

Objective: This study evaluates the impact of this MOOC by assessing HCW course engagement, knowledge, confidence in caring for COVID-19 patients, and user experience.

Methods: From May thru June of 2020, the course was rapidly developed by a team of physicians, educators, medical illustrators, and education technology staff, and was subsequently launched on two online platforms in July 2020. The approximately 4-hour course comprises 6 video-based modules with accompanying handouts. Student knowledge was assessed using pre- and post-module quizzes and a final exam, while demographics and user experience were evaluated by pre- and post-course surveys and data collected through the platforms.

Results: From July 17th to September 24th, 30,859 students enrolled, 18,818 started, and 7,101 completed the course. Most participants worked in healthcare (86%) and resided in lower middle- (36%) or upper middle- (21%) income countries. Higher course completion rates were observed among learners who were from upper middle-income (aOR 1.152 [95% CI 1.019-1.303]) and lower middle-income countries (aOR 1.229 [95% CI 1.104-1.368]). Significant knowledge gains were observed from pre-module (mean 56% [SD 17%]) to post-module quizzes (80% [SD 15%], P<.001), and from pre-module quizzes to the final exam (78% [SD 17%], P<.001). After course completion, participants reported increased self-efficacy regarding the course objectives, with a 0.63 mean increase on a 4-point scale (95% CI [0.60,0.66]). Overall, there was high satisfaction with the course experience, with 93% of participants reporting they would recommend the course to others.

Conclusions: This study demonstrates the potential of MOOCs to rapidly provide access to emerging medical knowledge during a public health crisis, particularly for HCWs in high- and middle-income countries. Further research is required to understand the impact of such online courses on patient care and how to better reach learners in low-income countries.

(JMIR Preprints 29/12/2020:26815)
DOI: https://doi.org/10.2196/preprints.26815

Preprint Settings

1) Would you like to publish your submitted manuscript as preprint?

✓ **Please make my preprint PDF available to anyone at any time (recommended).**
Please make my preprint PDF available only to logged-in users; I understand that my title and abstract will remain visible to all users.
Only make the preprint title and abstract visible.
No, I do not wish to publish my submitted manuscript as a preprint.

2) If accepted for publication in a JMIR journal, would you like the PDF to be visible to the public?

✓ **Yes, please make my accepted manuscript PDF available to anyone at any time (Recommended).**
Yes, but please make my accepted manuscript PDF available only to logged-in users; I understand that the title and abstract will remain v
Yes, but only make the title and abstract visible (see Important note, above). I understand that if I later pay to participate in <a href="http

Original Manuscript

Title

Evaluation of a massive open online course for just-in-time training in resource-limited settings: evidence from a COVID-19 course for healthcare workers

Abstract

Background:

The COVID-19 pandemic created an urgent global need for healthcare worker (HCW) training. Initial COVID-19-related online courses focused primarily on training public health workers and physicians caring for patients in intensive care units (ICUs). However, in resource-constrained settings, nurses and general practitioners are responsible for providing most COVID-19 patient medical care, typically lacking the training and equipment necessary to manage complex, critically ill patients. In these environments, early recognition and interventions to prevent patient deterioration are essential to optimizing outcomes. We developed a massive open online course (MOOC) for HCWs in resource-constrained settings aimed at training bedside providers caring for patients with COVID-19.

Objective:

This study evaluates the impact of this MOOC by assessing HCW course engagement, knowledge, confidence in caring for COVID-19 patients, and user experience.

Methods:

From May thru June of 2020, the course was rapidly developed by a team of physicians, educators, medical illustrators, and education technology staff, and was subsequently launched on two online platforms in July 2020. The approximately 4-hour course comprises 6 video-based modules with accompanying handouts. Student knowledge was assessed using pre- and post-module quizzes and a final exam, while demographics and user experience were evaluated by pre- and post-course surveys and data collected through the platforms.

Results:

From July 17th to September 24th, 30,859 students enrolled, 18,818 started, and 7,101 completed the course. Most participants worked in healthcare (86%) and resided in lower middle- (36%) or upper middle- (21%) income countries. Higher course completion rates were observed among learners who were from upper middle-income (aOR 1.152 [95% CI 1.019-1.303]) and lower middle-income countries (aOR 1.229 [95% CI 1.104-1.368]). Significant knowledge gains were observed from pre-module (mean 56% [SD 17%]) to post-module quizzes (80% [SD 15%], *P*<.001), and from pre-module quizzes to the final exam (78% [SD 17%], *P*<.001). After course completion, participants reported increased self-efficacy regarding the course objectives, with a 0.63 mean increase on a 4-point scale (95% CI [0.60,0.66]). Overall, there was high satisfaction with the course experience, with 93% of participants reporting they would recommend the course to others.

Conclusions:

This study demonstrates the potential of MOOCs to rapidly provide access to emerging medical knowledge during a public health crisis, particularly for HCWs in high- and middle-income countries. Further research is required to understand the impact of such online courses on patient care and how to better reach learners in low-income countries.

Trial Registration:

NA

Key Words:

COVID-19; MOOC; continuing education; inservice training; online education; LMICs; rural and remote learning;

Introduction

Since the first patients with COVID-19 were reported in Wuhan, China, at the end of 2019, cases have been documented on every continent in the world (except for Antarctica) with current estimates in excess of 73 million cases worldwide.[1] While countries spanning the entire income spectrum have been impacted, low- and middle-income countries (LMICs) as well as remote and rural healthcare systems in high-income-countries (HICs) are particularly vulnerable — at risk of being completely overwhelmed, potentially leading to enormous, yet preventable, loss of life.[2] Though many health system elements are required to respond to this health crisis, equipping providers with the appropriate knowledge and skills to care for patients with COVID-19 infections is one critical component. Evidence suggests that the case fatality rate for infected patients has dropped 20%, in part, through increased provider experience and the resulting improvements in their routine care.[3] This pandemic has therefore highlighted the need for timely, widespread, and effective healthcare worker training focused on the bedside care of patients during global health crises.

In early 2020, during the initial stages of the pandemic, a number of educational initiatives were launched at global, national, and local levels. The first open-access COVID-19 educational programs focused on caring for critically ill patients requiring invasive mechanical ventilation or public health interventions.[4,5] These programs mirrored synchronous efforts to strengthen infrastructure, such as increased intensive care unit bed capacity and ventilator availability. While the vast majority of patients suffering from COVID-19 did not require invasive mechanical ventilation, the mortality of those who did require intubation remained stubbornly high.[6,7]

In most settings worldwide, and particularly in resource limited settings, patient care is primarily provided by nurses and other non-physician providers in conjunction with generalist physicians. These providers typically have minimal training in performing advanced airway interventions or managing complex, critically-ill patients.[8-10] Consequently, the opportunity for improving patient outcomes in most regions of the world may lie in strengthening the skills necessary for the identification, evaluation and treatment of COVID-19 patients with mild to moderate illness — where appropriate early intervention can obviate the need for invasive mechanical ventilation.[11-13] To date, however, there is a paucity of evidence that exigent inservice training targeting providers in LMICs and rural and remote areas, particularly in the midst of a global health crisis, is effective for knowledge uptake or influencing clinical practice.[14,15]

Massive open online courses (MOOCs) may be a valuable method of disseminating optimal patient care recommendations to bedside healthcare workers during the COVID-19 pandemic. Thus far, the vast majority of MOOCs have been designed for, and utilized by, students in North America and Europe.[16,17] Further, most analyses of MOOCs have focused on xMOOCs, a type of online course that extends access to traditional university-level courses by moving classroom-based courses online. Very little published literature has reported on MOOCs designed for inservice training of healthcare workers, despite their significant potential impact in this space.[18.19]

In addition to identifying effective methodologies for reaching and training healthcare workers in lower resource settings, presenting credible and evidence-based training materials is also critical. An infodemic — where vast amounts of information and misinformation on a topic are

readily available leading to confusion and fallacy — has been a consistent challenge during the COVID-19 pandemic.[20] To combat this, a recent WHO technical consultation on the COVID-19 infodemic has called for strategic partnerships across all sectors, including social media/technology, academia, and civil society, to serve as trusted information sources.[21]

A SWOT analysis of our team's capacity to contribute to the global pandemic response demonstrated an opportunity to fill the urgent need for trusted information and for inservice training of healthcare workers caring for patients in the early and middle stages of COVID-19 illness. In response to this analysis, and using a Self-Directed Learning Theory, we developed and deployed a free-of-charge MOOC entitled "COVID-19: Training for Healthcare Workers."[16,22] This study describes the characteristics of course participants and evaluates course effectiveness via participant knowledge gain and individual self-assessment.

Methods

Educational Design and Delivery

In May thru July of 2020, while working remotely in accordance with our local public health guidelines, we developed a massive open online course using an international team of 22 emergency medicine physician educators (across four training programs), 3 medical illustrators, 3 video editors, 2 education technology staff, and 1 project manager. The majority of the development team had prior experience designing and building online educational programs. Learning objectives were defined by a core physician leadership team and were subsequently reviewed and edited by the individual physician leads for each module. These objectives focused on the essential knowledge and skills deemed necessary for bedside healthcare workers to recognize and care for suspected and confirmed COVID-19 patients in the early and middle stages of their disease course. Information on contact tracing, quarantine management and other public health measures important to combatting the pandemic were not included in the course. Content area experts were then recruited to create the learning materials, working to adapt both their prior clinical experience and the best available practices to lower-resource clinical care settings. The course was broken down into 6 modules comprising 15 topic-focused lecture videos (as noted below in Box 1) and content experts worked in groups to create the material for each of these modules with a senior team member providing peer review.

We anticipated that the majority of our target learners — self-directed, currently practicing healthcare workers in LMICs and remote and rural settings — would engage in course content via mobile devices. To optimize uptake by these learners, we aimed to produce brief (≤10 minute) videos with minimal amounts of simplified text and universal imagery. We followed design principles developed through prior work aimed at using visual styles that resonate across diverse global audiences. The 15 video-based lectures totaled approximately 3-hours in length and were accompanied by lecture handouts for review and reference (Textbox 1). The course was subsequently launched on two online platforms, Coursera and EdX, on July 17th, 2020. It was also offered as a course on the free mobile application, Digital Medic.

Textbox 1: COVID-19 course modules

Key features and PPE

- Recognizing key features
- PPE and scene safety

Clinical assessment
- Approach to the sick patient
- Shock evaluation at the bedside
- Assessing the dyspneic patient - clinical

Diagnostic assessment
- Assessing the dyspneic patient - diagnostic
- Ultrasound in COVID-19

Early treatment
- Treating the mildly dyspneic patient
- Treating the moderately dyspneic patient - part 1
- Treating the moderately dyspneic patient - part 2

Advanced treatment
- Treating the severely dyspneic patient - part 1
- Treating the severely dyspneic patient - part 2
- Treating the severely dyspneic patient - part 3

Invasive mechanical ventilation
- Ventilator management - part 1
- Ventilator management - part 2

Course promotion was accomplished in a number of ways. From July thru August 2020, emails were sent to over 100,000 Coursera listserv subscribers, the course was promoted through a variety of Stanford-affiliated social media channels and online publications, it was promoted by YouTube's spotlight channel, and it was shared directly with a network of health education collaborators throughout the world by Stanford team members.

Setting and Population (Participants)

From July 17th to September 24th, 2020, we recruited learners who enrolled in the course on Coursera and EdX to participate in our study. Learners who chose not to participate in the study could still access the same course materials as participants. Consenting participants completed questionnaires before and after the course and their course quiz and exam scores were de-identified and included in the study. All study procedures were approved by the institutional review board at Stanford University.

Measures

Demographics:

In the baseline survey, participants reported their age, gender, profession, context of employment, education level, and ethnicity/race. Participants' country of occupancy was obtained from Coursera and EdX directly, who extract the data from user profiles or, if no country is reported, their IP addresses.

Knowledge:

Participant knowledge was assessed using pre- and post-module quizzes and a final exam. Knowledge questions were drafted by the faculty content experts who designed the module materials and reviewed by at least two additional faculty and education and instructional design team members. There were two questions in each of the 15 pre-module quizzes, four questions in each of the post-module quizzes, and 20 questions in the final exam. The final exam was designed to test the same concepts as the module quizzes, but questions were

reframed to minimize question recognition. The percentage of correct answers during a participant's first attempt was used to determine their score. Because first-attempt data was not available for EdX users, only Coursera users were included in our knowledge analysis.

Self-efficacy:

Self-efficacy regarding key learning objectives was assessed before and after the course. Students were asked to rate their confidence in various domains using a 4-point Likert scale. A 4-point scale was chosen in order to force a specific opinion and eliminate a "neutral" option. Each item was rated as follows: 1 = Strongly disagree, 2 = Somewhat disagree, 3 = Somewhat agree, 4 = Strongly agree.

User experience:

In a post-course survey, participants were asked to report their satisfaction with various aspects of the course. Using the same 4-point Likert scale as the self-efficacy questions, participants rated their agreement with statements, including whether the course provided them with new knowledge, helped change their practice, was relevant to their work, and was the right difficulty level.

Completion:

The course was considered complete if all modules and the final exam were completed. The number of participants who completed the course and each participant's time to completion was obtained directly from the platforms.

Statistical Analysis

Data from the pre-course demographic survey were summarized using descriptive statistics. To evaluate predictors of course completion, univariate and multivariate logistic regression was used. The dependent variable was course completion, defined as completion of all modules and the final exam. Independent variables in the multivariate analysis were age, gender, profession, context of employment, highest education level, and World Bank income group of the student's country of residence. Due to collinearity with World Bank income group, geographic region and race were excluded from the multivariate analysis.

Paired t-tests were used to detect differences in participant knowledge and self-efficacy scores before and after the course. To assess changes in knowledge, we compared pre-module versus post-module scores, as well as pre-module versus final exam scores. To examine whether there were differences between learners from different backgrounds, knowledge and self-efficacy scores were stratified by occupation and country income level for additional analysis. Data from the participants' course satisfaction ratings were summarized using descriptive statistics (mean, standard deviation, and response rates). All statistical analyses were performed using STATA SE version 16.

Results

Overall Course Engagement

Between July 17th and September 24th, 2020, 30,859 learners enrolled in the course with 18,818 starting the course. Of those who started the course, 10,714 participated in the pre-course survey, 7,101 completed the course, and 5,184 completed the post-course survey. (Figure 1) Female participants accounted for 55% of enrollees that started the course. (Table 1) The majority of participants (69%) were less than 40 years of age. The median time to course

completion was 4.2 days (IQR 1.0 - 11.9 days).

Table 1: Characteristics of participants who started the course

	Number of participants (%) (N = 10714)
Age	
18-39 years	7353 (69%)
40-59 years	2445 (23%)
60 years or older	525 (5%)
Gender	
Male	4325 (40%)
Female	6161 (58%)
Other	101 (1%)
Profession	
Healthcare (non-physician/-nurse)	3346 (31%)
Physician	2204 (21%)
Nurse	1286 (12%)
Student (non-clinical)[a]	1368 (13%)
Student (clinical)[a]	1185 (11%)
Non-healthcare	875 (8%)
Context of employment	
Hospital / Inpatient	3891 (36%)
Non-hospital / Outpatient	3428 (32%)
Non-healthcare	2866 (27%)
Highest level of education	
High school degree or lower	1982 (18%)
College degree	3060 (29%)
Master's degree	1419 (13%)
Doctorate, professional, or medical degree	3307 (31%)
Race	
Arab	600 (6%)
Black, African, or African American	1041 (10%)
East Asian	557 (5%)
Hispanic	1848 (17%)
South or Southeast Asian	3148 (29%)
White or Caucasian	1855 (17%)
Other	789 (7%)
World Bank Income Group	
High income	3832 (41%)
Upper middle income	1958 (21%)
Lower middle income	3435 (37%)
Low income	119 (1%)
Geographic Region	
East Asia & Pacific	889 (10%)
Europe & Central Asia	832 (9%)
Latin America & Caribbean	1602 (17%)
Middle East & North Africa	770 (8%)
North America	2381 (25%)
South Asia	2277 (24%)

Sub-Saharan Africa	593 (6%)

[a] Students were categorized as clinical if they reported working in an inpatient or outpatient clinical context

Participants by Provider Type

Healthcare workers that were neither physicians nor nurses accounted for the highest percentage of course participants who started the course (31%) while physicians accounted for one fifth of all learners. (Table 1) Students made up one quarter of participants. This included both those who identified as working at a clinical site and those that reported not practicing clinically. Non-healthcare workers accounted for nine percent.

Geographic Distribution of Participants

A plurality of participants (41%) came from high-income countries (HICs) followed closely by lower-middle (37%) and upper-middle income (21%) countries. (Table 1) Participation by geographic region was highest in North America (25%) but closely followed by South Asia (24%) and Latin America and the Caribbean (17%). (Figure 2) The smallest percentage of participants came from Sub-Saharan Africa (6%).

Knowledge Gain

Overall course participants demonstrated significant improvement in knowledge upon course completion. While the mean score of pre-module quizzes was 52%, participants averaged 74% on post-module quizzes and 78% on the final exam (mean difference pre vs post 23% [*P*<.001] and pre vs final 26% [*P*<.001]). Non-physician healthcare workers and students demonstrated knowledge gain on par with physician participants (Figure 3a). While eight percent of participants were not in healthcare and scored consistently lower than participants who work in healthcare, their knowledge gained from pre-module to final score did not differ significantly (*P*=.436). Similar improvements in knowledge were obtained by participants from HICs compared to LMICs, with participants in LMICs demonstrating slightly greater improvements in knowledge (mean difference, pre vs post: 23% LMICs vs 22% HICs (*P*<.001) and pre vs final: 27% LMICs vs 25% HICs [*P*<.001]) (Figure 3b).

Predictors of Course Completion

On multivariate analysis, participants from low-middle and high-middle income countries were more likely to complete the course compared to learners from HICs. (Table 2) Physicians, nurses and students had similar course completion rates with lower completion rates noted in other healthcare workers and non-healthcare workers. Additionally, participants from 40-59 years old were less likely to complete the course compared with those <39 years of age.

Table 2: Course completion rates by characteristic[a]

Characteristic	Adjusted Odds Ratio	Std. Err.	*P*-value	[95% Conf. Interval]
Age				
18-39 years	Ref			
40-59 years	0.887	0.051	.036	0.793 - 0.992
60 years or older	1.079	0.116	.478	0.874 - 1.332
Gender				
Male	Ref			
Female	0.917	0.043	.067	0.837 - 1.006

Other	0.677	0.168	.117	0.416 - 1.103
Profession				
Physician	Ref			
Nurse	1.151	0.103	.119	0.965 - 1.372
Other healthcare	0.812	0.057	.003	0.708 - 0.931
Student (healthcare)	1.145	0.104	.136	0.958 - 1.368
Student (other)	0.891	0.108	.342	0.703 - 1.130
Non-healthcare	0.571	0.065	<.001	0.457 - 0.714
Context of Employment				
Hospital / Inpatient	Ref			
Non-hospital / Outpatient	0.926	0.050	.149	0.834 - 1.028
Non-healthcare	0.919	0.078	.320	0.778 - 1.085
Highest education level				
Doctorate, professional, or medical degree	Ref			
Master's degree	0.855	0.065	.040	0.736 - 0.993
College degree	1.013	0.064	.841	0.894 - 1.147
High school degree or less	1.105	0.082	.179	0.955 - 1.277
World Bank Income Group				
High income	Ref			
Upper middle income	1.152	0.072	.944	1.019 - 1.303
Lower middle income	1.229	0.067	<.001	1.104 - 1.368
Low income	1.014	0.200	.953	0.689 - 1.492
N	8,309			
Likelihood ratio chi-squared (G^2)	252.89			
Pseudo R^2	0.048			

[a] Multivariate logistic regression, univariate regression model provided in Appendices

Survey results

Following course completion, there were substantial improvements in learner confidence in caring for COVID-19 patients and in their self-assessment of both the adequacy of their training and access to information regarding COVID-19. (Figure 4) Further, healthcare workers who completed the course strongly agreed that the course was relevant and provided them new knowledge about COVID-19. (Figure 5) Most learners (92.5%) stated they were likely to recommend this course to their colleagues.

Discussion

Principle Results

This study demonstrates that MOOCs can effectively reach practicing healthcare workers in both high-income and middle-income countries and provide timely clinical training during a healthcare crisis. Providers from a multitude of backgrounds sought out self-directed clinical training on the recognition and care of COVID-19 patients, with a high percentage of learners

completing the course. Survey findings revealed that knowledge scores improved regardless of provider background and geography. Supplementing these gains, providers reported increased confidence in their clinical skills to care for COVID-19 patients as well as the availability of both relevant and accurate information regarding the pandemic. Lastly, course content and the online format were appreciated by learners.

Comparison with Prior Work

Just-in-time learning during a pandemic or other health crisis is imperative to improving patient outcomes and protecting the healthcare workforce. While healthcare resources have been strained in many environments during the pandemic, those in LMICs and rural and remote areas are scarce at baseline, making their response to the pandemic even more challenging.[23-26] The immediate necessity of healthcare worker training during the pandemic adds substantially to the ongoing burden of delivering quality care to patients. However, with the rapid rise in access to smartphones over the past decade, mobile online training has become feasible and accepted in many settings. This approach allows for the development of rapidly scalable training programs with the potential for broad distribution, without taxing the already-limited local resources. In addition to our course, other international health organizations, universities, and nations have launched online training programs that have engaged large numbers of users during the pandemic.[5, 27-29] The distribution of users accessing these courses has skewed towards middle-income-countries. While MOOC's can clearly reach healthcare workers in middle- and high-income countries, it remains unknown whether open-access online training solutions are equally viable options in low-income countries (LICs) at this time, given limited data due to low enrollment of providers from LICs.

Encouragingly, course completion rates, knowledge scores, and survey responses all suggested — despite the course materials being developed in English and mostly by providers based in the United States — that the course was effective across diverse geographic locals. In contrast to the typical <10% completion rates among MOOCs, our course had a completion rate of 38%. Additionally, knowledge scores improved significantly regardless of provider geography. The improvement in knowledge was also reflected in learner sentiment, with over 90% of learners reporting the receipt of adequate training and improved confidence in their ability to care for patients with COVID-19. These positive study results were consistent for non-physician healthcare workers too, as this cohort reported strong improvements in knowledge and self-efficacy.

Non-physician providers make up the majority of all healthcare workers, and account for even higher percentages of the workforce in LMICs.[30] A plurality (31%) of learners in our program were healthcare workers representing neither physicians (21%) nor nurses (12%), such as pharmacists (3%) and emergency medical technicians (2%). The diverse training backgrounds of our enrolled providers, including non-physician healthcare workers, attests to their substantial interest in clinical training during a global health crisis; and, a free-of-charge MOOC effectively contributed to meeting this widespread demand. Despite similar improvements in knowledge scores, non-physician participants felt the course was less likely to change their approach to clinical practice, as indicated by the lowest participant self-assessment scores of all respondents. This finding suggests that continued barriers to care, such as limitations on resources and equipment, can hamper the translation of gained knowledge into clinical practice following inservice training. These barriers require further investigation.

Several factors may have contributed to the course's relatively high completion rate, knowledge gain, and feedback scores documented in this report. First, our education and design teams have extensive experience in delivering both in-person and online content to healthcare providers from across the globe. This experience enabled course creators to adopt a versatile style that incorporated limited text, simple language, references to trusted materials, and highly focused content with direct relevance to clinical practice. Second, unlike traditional MOOCs, which often take months to complete, our MOOC was developed with an eye towards practicing healthcare workers whose time for continuing education was extremely limited and who required information on COVID-19 immediately. Accordingly, the entire course was designed to be completed within five hours, and its duration was segmented into brief modules requiring <15 minutes of continuous engagement. This time-sensitive format was intended to boost engagement from providers in LMICs, who might have restricted availability (due to job or home commitments) or unreliable internet access. Third, we were able to offer the course and certification free of charge (Coursera) or at an extremely reduced cost (EdX). Many non-physician healthcare workers in LMICs are often living near the poverty-line themselves and cost may heavily influence their ability to access training programs.

Limitations and Next Steps

Our study found the course was successful on many fronts, however, a number of limitations exist. First, the COVID-19 pandemic has brought with it innumerable challenges, one of which is the deluge of information, and misinformation, available to individuals and communities. [20,21] The rapidly evolving evidence used to guide best clinical practices along with the disparate recommendations from local, national, and international health organizations, particularly early on during the pandemic, made it challenging to produce educational materials that could gain broad acceptance yet contain clinically actionable information. Furthermore, as information evolves, keeping materials up to date poses a significant challenge. Even when course materials are kept current, providers that have completed the course may not continue to engage with new or revised materials. While we aimed to keep the content streamlined for efficiency, we continue to add modules on COVID-19 in children, telehealth, and patient risk stratification. Moving forward, we plan to offer course participants a mobile gaming app where learners can repeatedly engage with updated materials and refresh their knowledge.

Second, while the study's findings of short-term knowledge gain and improvements in participant self-assessment are encouraging, they may not be clinically meaningful. Further research is required to evaluate if inservice training for healthcare workers via a MOOC during a healthcare crisis improves long term knowledge, clinical decision making and patient oriented outcomes. We plan to conduct longer term retention testing and evaluate changes in clinical practice among a cohort of our learners practicing in LMICs.

Third, while thousands of healthcare workers were trained, millions more healthcare workers are practicing on the frontlines and require clinically relevant information during the pandemic. From our results, it is unclear if MOOCs can effectively reach providers in low-income-countries and in rural and remote environments, where access to the internet may be tenuous or nonexistent. Alternative delivery options exist and need to be evaluated including setting up Local Area Networks (LANs) in healthcare facilities where providers can use computers, tablets and smartphones to access materials without requiring an active internet connection, and partnering with local organizations that utilize more traditional in-person training modalities. Additionally, a Spanish version of the course is being launched and other

languages are being considered as prior research demonstrates that offering MOOCs in multiple languages can dramatically increase enrollment.[5]

Conclusions

This study demonstrates that MOOCs can effectively reach practicing HCWs and provide inservice training during a global health crisis. Physician and non-physician providers from a multitude of geographies and backgrounds sought out self-directed clinical training on recognizing and caring for COVID-19 patients with a high percentage of learners completing the course. Knowledge improved across all participant groups regardless of demographic and other characteristics. Further research is required to understand the impact on patient-oriented outcomes and how to better reach HCWs in low-income-countries.

Acknowledgements

All authors contributed to the development of the training course and to reviewing, editing, and approving the study findings and manuscript. MS, SM, KZ, CP, and JJ designed of the study and analysis. No funding was received for course development or the research study. The authors would like to acknowledge the many individuals that contributed to training course development and review. We would also like to thank the front-line healthcare workers who are struggling daily to ameliorate the impact of the COVID-19 pandemic.

Conflicts of Interest

No authors have financial interests to disclose.

Abbreviations

HCW: healthcare worker
HICs: high-income-countries
ICUs: intensive care units
LMICs: low- and middle-income-countries
MOOC: massive open online course
PPE: personal protective equipment
SD: standard deviation

Multimedia Appendices

Appendix 1: End of Course Survey
Appendix 2:

References

1. WHO Coronavirus Disease (COVID-19) Dashboard. Accessed December 18, 2020. https://covid19.who.int
2. Stewart R, El-Harakeh A, Cherian SA. Evidence synthesis communities in low-income and middle-income countries and the COVID-19 response. The Lancet; 2020;0(0). doi:10.1016/S0140-6736(20)32141-3 PMID: 33096041
3. Ledford H. Why do COVID death rates seem to be falling? Nature; 2020;587(7833):190-192. doi:10.1038/d41586-020-03132-4 PMID: 33177662
4. Mechanical Ventilation for COVID-19. edX. Accessed November 11, 2020. https://www.edx.org/course/mechanical-ventilation-for-covid-19
5. Utunen H, Ndiaye N, Piroux C, George R, Attias M, Gamhewage G. Global Reach of an Online

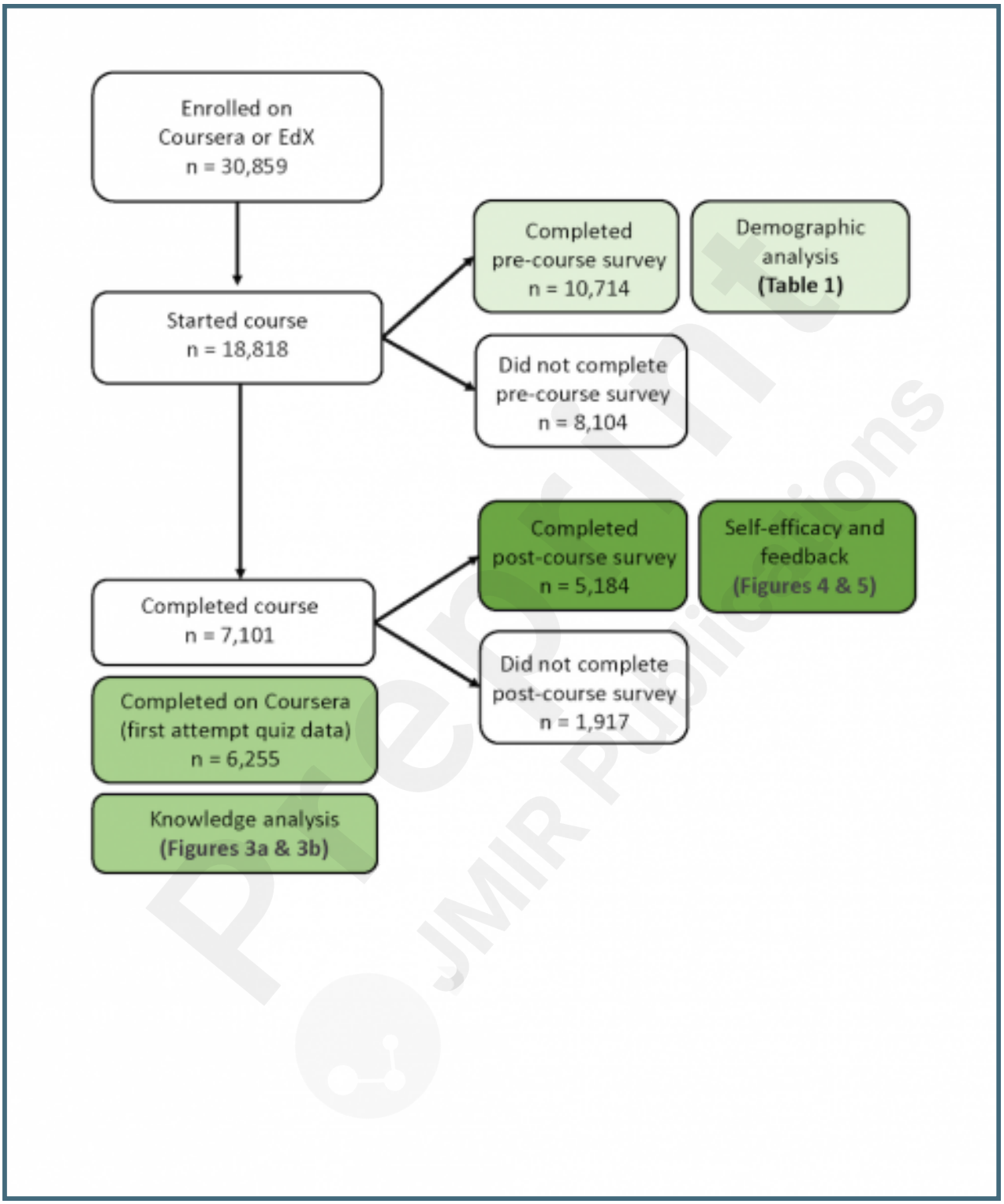
COVID-19 Course in Multiple Languages on OpenWHO in the First Quarter of 2020: Analysis of Platform Use Data. J Med Internet Res; 2020;22(4):e19076. doi:10.2196/19076 PMID: 32293580
6. Balsari S, Sange M, Udwadia Z. COVID-19 care in India: the course to self-reliance. Lancet Glob Health; 2020;8(11):e1359-e1360. doi:10.1016/S2214-109X(20)30384-3 PMID: 32853553
7. Botta M. Ventilation management and clinical outcomes in invasively ventilated patients with COVID-19 (PRoVENT-COVID): a national, multicentre, observational cohort study. Lancet Respir Med; 2020;e10. doi:10.1016/ S2213-2600(20)30459-8
8. Baker T. Essential care of critical illness must not be forgotten in the COVID-19 pandemic. The Lancet; 2020;395:1253-1254. doi:10.1016/ S0140-6736(20)30793-5 PMID: 32246914
9. Obermeyer Z, Abujaber S, Makar M, et al. Emergency care in 59 low- and middle-income countries: a systematic review. Bull World Health Organ; 2015;93(8):577-586G. doi:10.2471/BLT.14.148338 PMID: 26478615
10. Ventura C, Gibson C, Collier GD. Emergency Medical Services resource capacity and competency amid COVID-19 in the United States: preliminary findings from a national survey. Heliyon; 2020;6(5):e03900. doi:10.1016/j.heliyon.2020.e03900 PMID: 32368629
11. Çalışkan F, Mıdık Ö, Baykan Z, et al. The knowledge level and perceptions toward COVID-19 among Turkish final year medical students. Postgrad Med; Published online August 6, 2020:1-9. doi:10.1080/00325481.2020.1795486 PMID: 32657235
12. Echoru I, Kasozi KI, Usman IM, et al. University Lecturers and Students Could Help in Community Education About SARS-CoV-2 Infection in Uganda. Health Serv Insights; 2020;13:1178632920944167. doi:10.1177/1178632920944167 PMID: 32782429
13. Taghrir MH, Borazjani R, Shiraly R. COVID-19 and Iranian Medical Students; A Survey on Their Related-Knowledge, Preventive Behaviors and Risk Perception. Arch Iran Med; 2020;23(4):249-254. doi:10.34172/aim.2020.06 PMID: 32271598
14. Rowe AK, Rowe SY, Peters DH, Holloway KA, Chalker J, Ross-Degnan D. Effectiveness of strategies to improve health-care provider practices in low-income and middle-income countries: a systematic review. Lancet Glob Health; 2018;6(11):e1163-e1175. doi:10.1016/S2214-109X(18)30398-X PMID: 30309799
15. Seymour-Walsh A, Bell A, Webber A, Smith T. Adapting to a new reality: COVID-19 coronavirus and online education in the health professions. Rural Remote Health; Published online May 26, 2020. doi:10.22605/RRH6000 PMID 32456441
16. Alturkistani A, Lam C, Foley K, et al. Massive Open Online Course Evaluation Methods: Systematic Review. J Med Internet Res; 2020;22(4):e13851. doi:10.2196/13851 PMID: 32338618
17. Bozkurt A, Akgün-Özbek E, Zawacki-Richter O. Trends and Patterns in Massive Open Online Courses: Review and Content Analysis of Research on MOOCs (2008-2015). Int Rev Res Open Distrib Learn; 2017;18(5). doi:10.19173/irrodl.v18i5.3080
18. Veletsianos G, Shepherdson P. A Systematic Analysis and Synthesis of the Empirical MOOC Literature Published in 2013–2015. Int Rev Res Open Distrib Learn; 2016;17(2). doi:10.19173/ irrodl.v17i2.2448
19. Zhu M, Sari A, Lee MM. A systematic review of research methods and topics of the empirical MOOC literature (2014–2016). Internet High Educ; 2018;37:31-39. doi:10.1016/j.iheduc.2018.01.002
20. Zarocostas J. How to fight an infodemic. The Lancet; 2020;395(10225):676. doi:10.1016/S0140-6736(20)30461-X PMID: 32113495
21. Tangcharoensathien V, Calleja N, Nguyen T, et al. Framework for Managing the COVID-19 Infodemic: Methods and Results of an Online, Crowdsourced WHO Technical Consultation. J

Med Internet Res; 2020;22(6):e19659. doi:10.2196/19659 PMID: 32558655
22. Varpio L, Paradis E, Uijtdehaage S, Young M. The Distinctions Between Theory, Theoretical Framework, and Conceptual Framework. Acad Med; 2020;95(7):989-994. doi:10.1097/ACM.0000000000003075 PMID: 31725464
23. Starr N, Rebollo D, Asemu YM, et al. Pulse oximetry in low-resource settings during the COVID-19 pandemic. Lancet Glob Health; 2020;8(9):e1121-e1122. doi:10.1016/S2214-109X(20)30287-4 PMID: 32628910
24. Wahlster S, Sharma M, Lewis AK, et al. The Coronavirus Disease 2019 Pandemic's Effect on Critical Care Resources and Providers. Chest; Published online September 2020:S001236922034438X. doi:10.1016/j.chest.2020.09.070 PMID: 32926870
25. Keeley C, Jimenez J, Jackson H, et al. Staffing Up For The Surge: Expanding The New York City Public Hospital Workforce During The COVID-19 Pandemic. Health Aff (Millwood); 2020;39(8):1426-1430. doi:10.1377/hlthaff.2020.00904 PMID: 32525704
26. Cheng KJG, Sun Y, Monnat SM. COVID-19 Death Rates Are Higher in Rural Counties With Larger Shares of Blacks and Hispanics. J Rural Health; 2020;36(4):602-608. doi:https://doi.org/10.1111/jrh.12511 PMID: 32894612
27. Khalil, H. & Ebner, M. (2014). MOOCs Completion Rates and Possible Methods to Improve Retention - A Literature Review. In J. Viteli & M. Leikomaa (Eds.), Proceedings of EdMedia 2014--World Conference on Educational Media and Technology (pp. 1305-1313). Tampere, Finland: Association for the Advancement of Computing in Education (AACE). Retrieved December 28, 2020 from https://www.learntechlib.org/primary/p/147656/.
28. Contact Tracing Tools, Information, and Resources - Johns Hopkins. Johns Hopkins Coronavirus Resource Center. Accessed November 30, 2020. https://coronavirus.jhu.edu/contact-tracing
29. Government of India launches a training module for management of COVID-19 named 'Integrated Government Online training' (iGOT) portal on DIKSHA platform of MHRD. Accessed November 30, 2020. pib.gov.in/Pressreleaseshare.aspx?PRID=1612437
30. World Health Organization, ed. Monitoring the Building Blocks of Health Systems: A Handbook of Indicators and Their Measurement Strategies. World Health Organization; 2010. https://www-who-int.laneproxy.stanford.edu/healthinfo/systems/WHO_MBHSS_2010_full_web.pdf

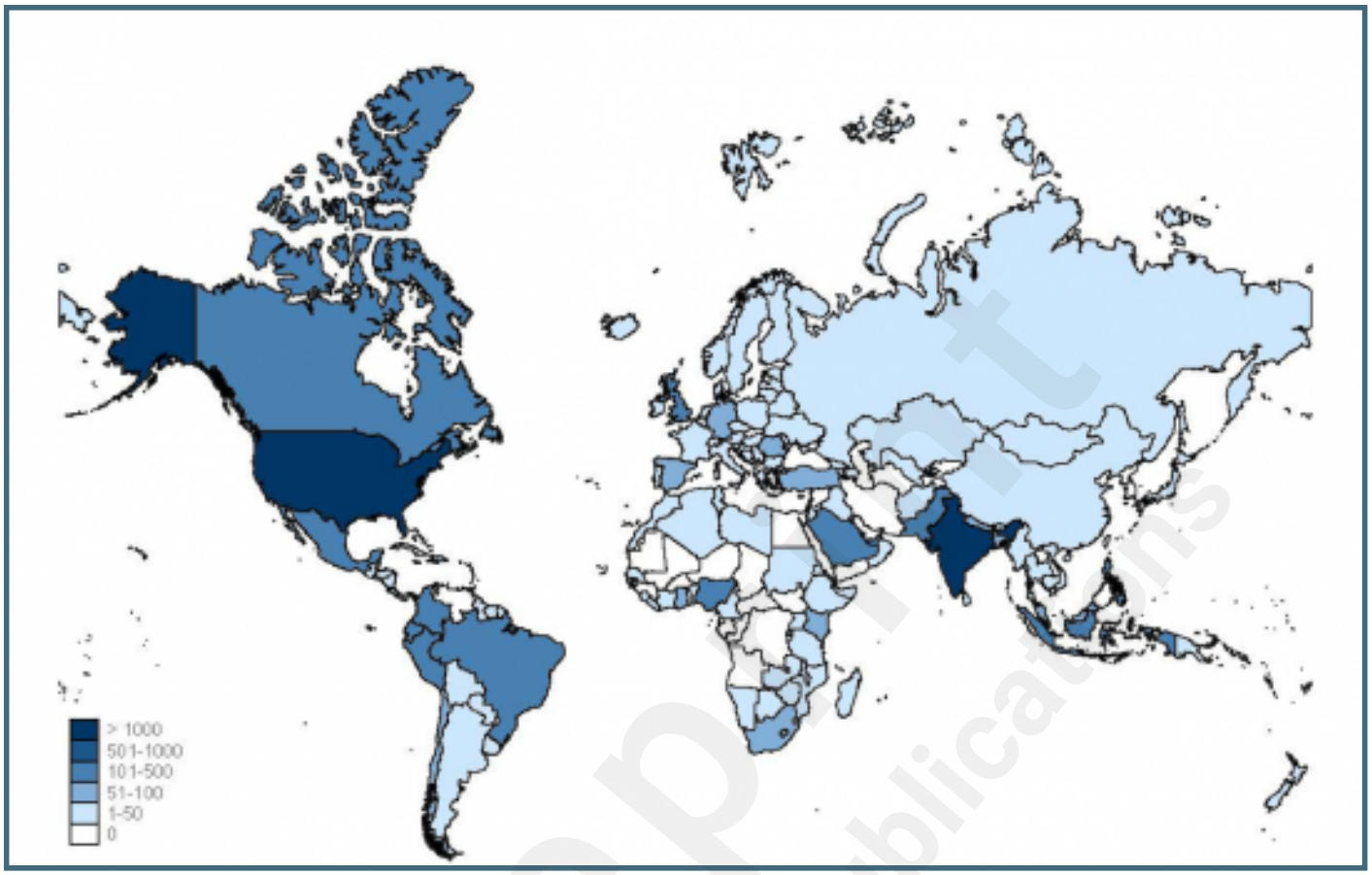
Supplementary Files

Figures

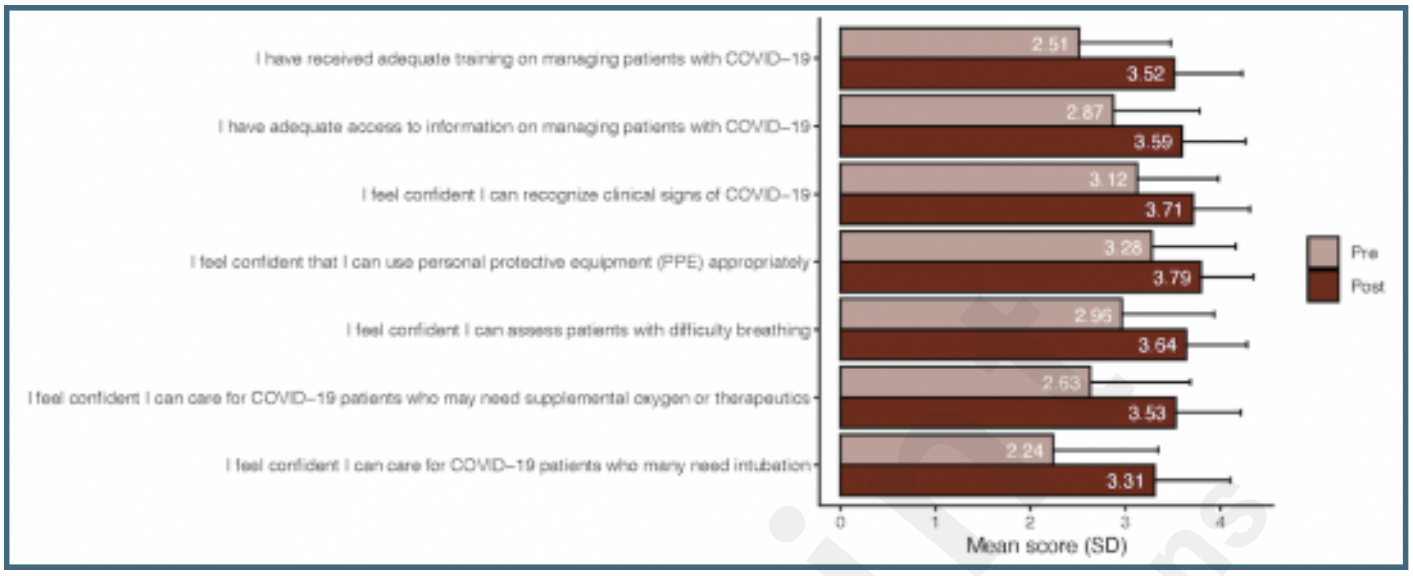
Flow diagram for study participants.



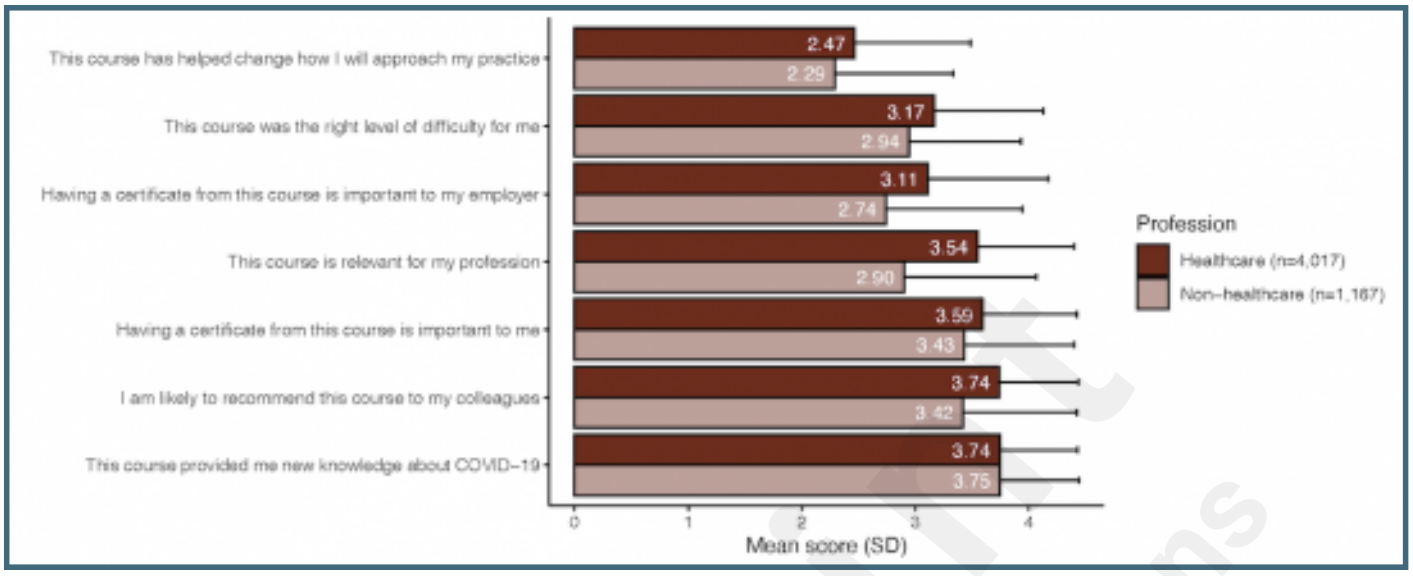
Number of learners by country.



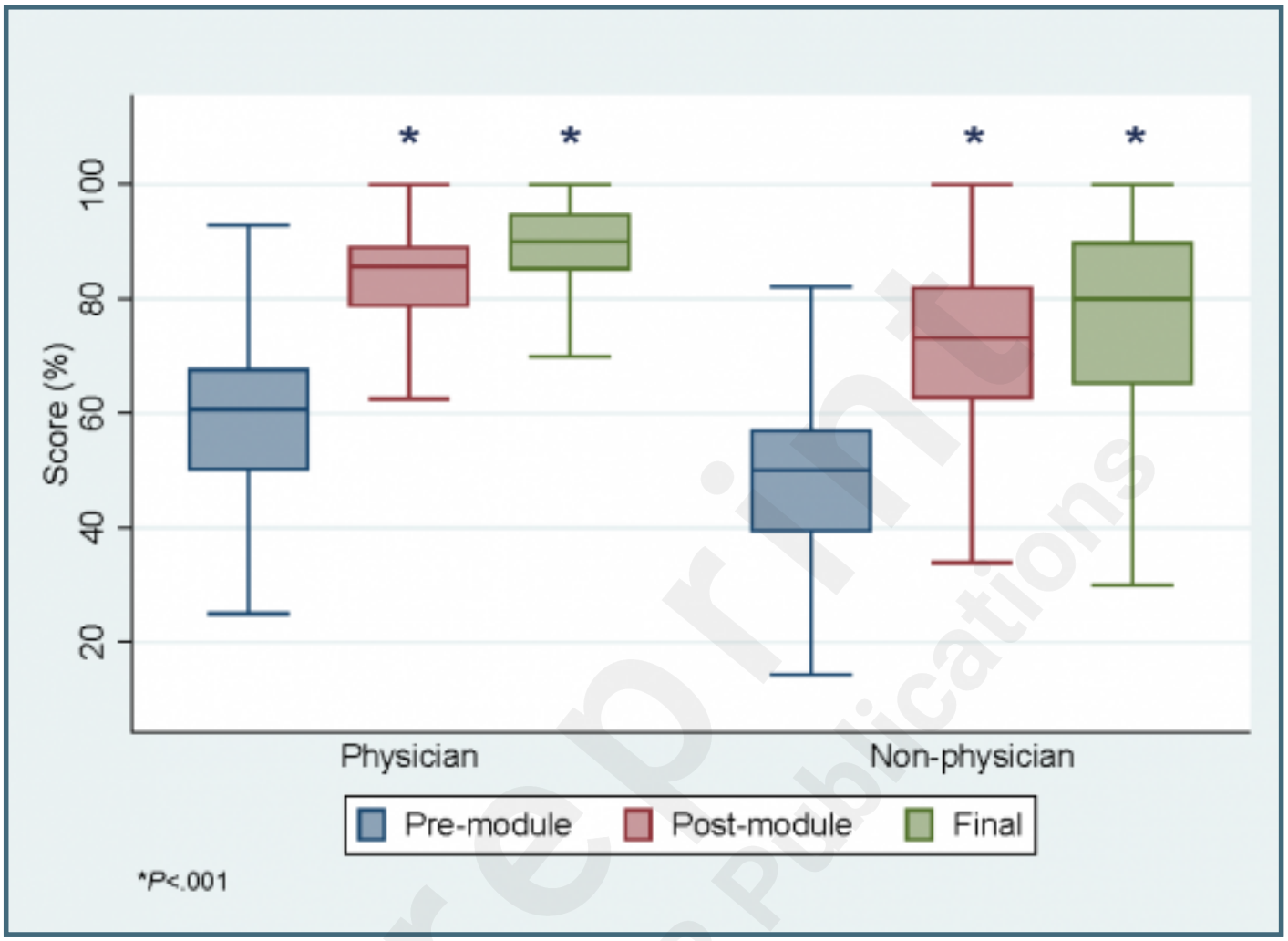
Learner self-assessment following course completion.



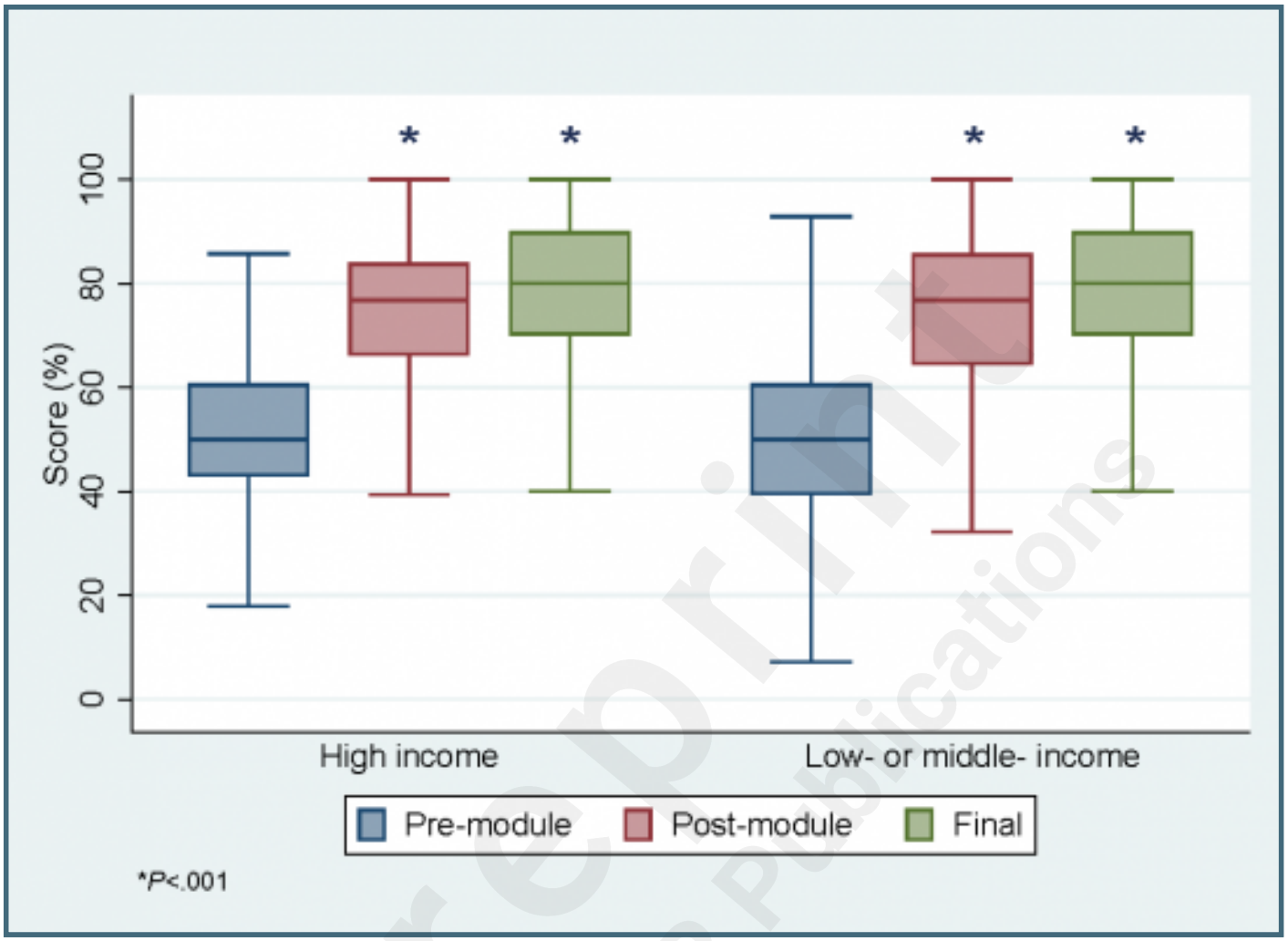
Learner course feedback following completion.



Knowledge scores by profession.



Knowledge scores by country income level.



Multimedia Appendixes

Pre and post course survey questionnaires.
URL: https://asset.jmir.pub/assets/58a25bb54ab6e75c0102d0bc47a40744.doc

Descriptive and univariate logistic regression analysis of course completion.
URL: https://asset.jmir.pub/assets/5b42f398aaaf0fbb2e27ea19fa3b183a.doc

Self efficacy by profession and World Bank income group.
URL: https://asset.jmir.pub/assets/204653d0bdd794390d40242b04e7d503.doc

Course feedback by profession and World Bank income group.
URL: https://asset.jmir.pub/assets/d16c444242c3395a658699f329a55986.doc

Knowledge scores by profession.
URL: https://asset.jmir.pub/assets/d2bd387a4247c410495a137606a62686.doc