Lessons from the Design and Implementation of a Pediatric Critical Care and Emergency Medicine Training Program in a Low Resource Country—The South American Experience

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Abstract

Keywords

- pediatric critical care training
- low resource environment
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- Advanced Pediatric Life Support
- sustainability

For more than 60 years, the world has recognized the need for pediatric critical care (PCC). Today, most low- and middle-income countries (LMICs) still lack access to pediatric intensive care units (PICUs) and specialists, resulting in high rates of morbidity and mortality. These disparities result from several infrastructure and socioeconomic factors, chief among them being the lack of trained PCC and emergency medicine (PCCEM) frontline providers. In this article, we describe a continuing medical education model to increase frontline PCC capacity in Ecuador. The Laude in PCCEM is a program created by a team of Ecuadorian physicians at the University San Francisco de Quito School of Medicine. The program is aimed at providers with no formal training in PCC and who, nonetheless, care for critically ill children. The program resulted in stronger, more cohesive PICU teams with improved resuscitation times and coordination during simulation rounds. In hospitals that implemented the program, we saw decreased PICU mortality rates. Our aim is to identify the opportunities and challenges learned and to offer lessons for other countries that use similar models to cope with the lack of local resource availability.

Introduction

In 2013, there were an estimated 6.3 million deaths of children younger than the age of 5 years worldwide with the greatest burden experienced by low-income countries.^{1,2} In low- and middle-income countries (LMICs), only 10 to 20% of critically ill children are referred to a hospital; the lack of resources and delay in recognition of illness severity make the first 24 hours of hospitalization the most vulnerable period with 30 to 50% of patient deaths occurring within the first

day.^{3,4} Most LMICs lack access to pediatric intensive care units (PICUs) and trained pediatric critical care (PCC) and emergency medicine (PCCEM) frontline providers, resulting in high rates of morbidity and mortality.^{5–9}

At its core, PCC medicine is health care for very sick children with the goal of restoring health.^{6,10,11} Practitioners of critical care have to provide appropriate patient care with the best “evidence-based, cost-effective, and resource-conserving medicine in a societally responsive manner.”¹² In their hands, relatively simple measures such as intravenous fluids for volume

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resuscitation, antibiotics for infection control, oral rehydration solutions, supplemental oxygen, and the continuous monitoring of patient vital signs are sufficient to deliver basic critical care in a majority of frontline cases. In fact, analyses have shown that the practice of critical care results in favorable cost-effectiveness profiles in dollars saved per quality-adjusted life year¹³ and disability-adjusted life year.¹⁴

Barriers to Appropriate Interventions in Resource Poor Settings

In Ecuador, there are 39 PICU beds and 30 PCC physicians¹⁵ serving a country of more than 15.5 million people, including almost 6 million younger than the age of 18 years.¹⁶ The PICU mortality in Ecuador in 2008 was 15%, higher than in European and North American countries where the rate is closer to 5%. The most common conditions that children present with and that lead to death are respiratory failure, shock, and polytrauma. Medical response systems suffer significant limitations in infrastructure and qualified staff. For example, facilities that lack dedicated pediatric units might also find it challenging to manage central lines due to the limited availability of pediatric equipment. In Ecuador, academic training programs in PCCEM are scarce. This fact combined with the small number of pediatric intensivists is the reason most critically ill children are cared for outside of a PICU by general pediatricians, emergency medicine physicians, internal medicine physicians, general (nonpediatric) surgeons, or adult intensivists. Furthermore, the quality of care is limited by the fact that these physicians work in “shifts” at multiple hospitals to maintain a minimum monthly income, which greatly reduces the continuity of care.

There is potential to improve mortality rates through relatively inexpensive interventions and systems in limited-resource settings. Well-implemented emergency triage in the field, for example, can reduce mortality by ensuring patients are properly stabilized before transport. Applying evidence-based protocols and paying attention to the *quality* of care given to pediatric patients admitted to general hospital wards can partially compensate for the absence of dedicated PCC units. Team building and training in emergency and critical care can improve response times to reduce morbidity and mortality. These specialized teams ensure continuity of care and that proper handoffs occur from initial presentation to discharge. They incorporate timely emergent interventions such as resuscitation when indicated.⁴ These solutions do not require dedicated space or investments in costly equipment. Rather, properly trained and practiced clinicians can obtain good results with basic supplies. In this article, we focus on the barriers to program design and implementation of a PCCEM training program. Furthermore, we address equipment, support services, financial and organizational sustainability, and program evaluation of this training program.

Program Design and Implementation

The Laude in PCCEM is a 10-month program created by a team of Ecuadorian physicians at the University San Francisco de

Quito School of Medicine (USFQ). The program, launched in Fall 2013, is aimed at providers with no formal training in PCCEM but who, nonetheless, have to care for critically ill children. A Delphi study used to design the program identified these elements as areas of focus. It is a certificate program, similar to other “Laude” certificate programs offered by the USFQ in various fields, intended to provide training to elevate participants’ expertise in a given specialty. The Laude in PCCEM employs a family-centered approach by integrating PCC, mental health, and palliative medicine. It is innovative in that any critically ill (not merely dying) child benefits from family involvement so that family might understand the disease process and take part in treatment decisions. The WHO supports an integrated model of care for children living with life-limiting conditions. In LMICs, other models have been used with good outcomes though few have focused on subspecialty training and palliative care as the Laude in PCCEM.^{10,16–18}

The Laude drew from the combined expertise of PCCEM-trained physicians from across the United States^a to increase a hospital’s capacity to treat critically ill children even in the absence of a PICU. At the same time, a locally designed program is sensitive to the economic factors (e.g., the way local physicians have to maintain a salary by working in multiple hospitals) and the regulatory environment (e.g., certification requirements to practice a subspecialty) in the health care system. Such a program is sophisticated about the necessary content and pedagogy that maximizes access and learning for practicing physicians, which are major considerations to accommodate complex work schedules.

A U.S.-based PCCEM specialist delivers each 2-week module with prereadings, didactics, and simulation cases to physicians whose work covers critically ill pediatric patients. The core pedagogy consists of in-class and bedside didactics combined with simulation drills in a newly constructed high-fidelity simulation center at the USFQ. Didactics during rounding, supported by prereadings, is a key part of many medical training programs as it incorporates case-based learning, system-based practices, and improves communication among nurses, respiratory therapists, and physicians. Nurses and respiratory therapists were encouraged to attend simulations to promote communication and team skills. Interprofessional instruction is uncommon in Ecuador, where physicians are typically the sole participants, necessitating a shift in learner mindset. Simulation drills incorporate topics covered during the week to reinforce didactics, build skill competency, individual confidence, and team coordination. Postmodule surveys reported participant satisfaction with the resulting improved communication and teamwork. They were particularly satisfied with bedside didactics and considered this an innovative pedagogy.

^a U.S. physicians came from such academic medical centers as Johns Hopkins University, University of Pennsylvania, University of Illinois at Chicago, University of San Francisco, University of Florida, University of Utah, George Washington University, Brown University, and Stanford University.

Curriculum Design and Development

The first step in designing a curriculum is to identify the target audience and understand their needs. In the Laude, this audience consisted of physicians who evaluate and treat critically ill children and nurses, none of whom have formal academic training in PCCEM. The goal was to enhance existing skills and knowledge of providers already involved in PCCEM. The curriculum development team employed the Delphi technique with informal focus groups to determine and prioritize the topics for the program. Contextualizing the curriculum to the local needs of each country is critical to success because of differences in resource constraints, disease prevalence, and norms of medical practice. For example, a comparison of the needs in PCC training between Ecuador and Tanzania showed that mentored leadership, guideline revision, and pre- and postqualitative mortality studies were more important in Ecuador to support continuous quality improvement, with managing shock being the only common topic of interest in the two countries.¹⁹ Providers identified ventilation management, shock, neurologic emergencies, and trauma as areas of greatest need for training. Other topics were included because of their importance to independent learning, improving one's practice, and contributing to the medical field. These included research skills, critical evaluation, application of studies, and selecting best evidence-based practices. As evidence of impact, several fellows and instructors have published or presented abstracts in PCCEM from their Laude experiences.^{20–22}

The curriculum design team left out topics that may be common in other settings, such as extracorporeal membrane oxygenation, because the technology is unavailable in Ecuador. They then built the knowledge scaffold to support learning and created learning objectives around measured learning outcomes. Emphasis was placed on didactics including bedside topical talks during rounds, real-time discussion of ventilation management, and incorporating laboratories, vital signs, and physical exam findings into a comprehensive management plan. Participants were required to present interesting or challenging patient cases or topics of interest as a means of expanding their knowledge, ability to critically evaluate and incorporate the relevant literature, and teach others.

Implementing the Program

The pilot year of the Laude included 25 participants (10 physicians—the fellows, 10 nurses, and 5 respiratory therapists) from Hospital de los Valles (HDLV) PICU. The initial goals for the pilot were twofold. The designers had to determine if the curriculum worked as expected in terms of workload, timing, and the delivery of knowledge and skills. The second was to assess whether the PICU team could be trained to function as a coordinated unit even when its members could not be uniformly involved because of schedule conflicts. Results suggest that team cohesiveness did increase, leading to improved resuscitation times and team coordination during simulations and in practice. We saw mortality rates in the HDLV PICU decline from 10 to 7% in year 1 and to 5% a year later, suggesting sustained knowledge acquisition and application.

An important goal of the Laude is to increase capacity of all hospitals in Ecuador to care for critically ill children. For this reason, the fellows were to spend a few days each month working with and teaching providers from lower resourced hospitals in the surrounding communities. However, it quickly became clear that this approach was not feasible because of the program design. Fellows commit between 10 and 30 hours per week for prereadings, didactics, and simulation drills, while maintaining a fulltime workload in the hospital. As such, they were unable to secure the needed 2 to 3 days each month for community engagement on an ongoing basis. As a result, the plan was modified at the end of the first year with fellows designing and implementing an intensive 3-day course for 20 nurses and physicians from a community hospital emergency department.

Using the same method used to design the Laude, fellows performed a needs assessment to design the training program. Topics included trauma, sepsis, neurologic emergencies, respiratory failure, arrhythmias, and megacodes. Team-based learning and communication skills were delivered using simulations. The program was well received with *all* of the participants reporting increased knowledge and confidence. They agreed that the fellows demonstrated deep understanding of the material they taught during 3 days. In fact, the 3-day program posttraining survey validated the effectiveness of the Laude. Fellows experienced positive learning outcomes (understood the material, were able to put knowledge and skills into practice, and could effectively teach the material to others). The train-the-trainer model of PCCEM capacity building worked well within a relatively short period.

During the pilot year, several logistic barriers arose, each of which was met with an innovation. Rounding, a common practice in many industrialized nations, has been difficult to implement as a standard of practice in PICUs in Ecuador. Hence, the exchange of information and knowledge occurred in other ways such as the use of “WhatsApp,” a free group-messaging platform, to discuss the evolution of each patient's clinical course, while maintaining patient confidentiality. Study results, treatments, goals of care, and status changes were communicated with this method to improve care coordination. As it turns out, while there are concerns of patient confidentiality, provider bias, and the use of information without having seen the patient, the application of information technology to reduce medical errors in PCC settings is a growing area of interest.²³ Ninety-eight percent of the participants reported satisfaction with the quality of care they provided, and most reported they continued to learn even when not at bedside.

We also encountered system-level barriers in that the hospital's organizational culture and processes limited the consistent adherence to best practices. For example, physicians and nurses did not normally interact as peers. Information on patients' status from a nursing perspective did not always enter care management plans. Combined with the lack of bedside rounds, the gaps in patient information represent a threat to patient safety. Hence, team cohesion and coordination had to be addressed as a necessary first step to achieving

competence in PCEM. To do this, nurses and respiratory therapists were included in the simulations, bedside rounds, and didactics. The results validated this decision. For example, because the hospital did not have dedicated pediatric code teams, the PICU team located individual weight-based resuscitation medication doses above each patient's bed as a way to expedite access and prevent medication errors. This innovation came from the PICU nurses who are often the first responders to a code.

Equipment and Support Services

A core component of the Laude is simulation-based training. Simulation is proven effective in improving procedural and resuscitation skills, as well as fostering knowledge integration and team building.^{24–26} At the USFQ medical school, fellows learn and practice resuscitation algorithms and protocols on high-fidelity simulation mannequins. If such a simulation facility is available, community providers can be brought to it, which was the approach by fellows in the 3-day community program described earlier. Postprogram surveys report a high level of satisfaction by the participants and the willingness to return for more training in spite of the high personal costs that include travel time, expenses for room and board, and lost income. However, high-fidelity simulation facilities are costly to use and are not usually available in LMICs. The training approach will have to be adapted. For example, the local PCEM team is considering how low-fidelity simulation equipment and supplies can be packaged into a mobile unit to bring the training to community providers. Recent studies have shown that it is possible to achieve significant improvements in clinical care with low-fidelity simulations, which are less costly to use.^{27,28}

Financial and Organizational Sustainability

The most significant barriers encountered in the Laude belong to the domains of financial and organizational sustainability. There are typically three sources of funding for such training programs. The first is philanthropy. In the Laude, philanthropy was sufficient to cover the costs of transport, room and board, and the services of a local logistics coordinator for the U.S.-based instructors. Philanthropy allows such programs to launch quickly but is unlikely to be a sustainable source of financial support. If philanthropy were to become a steady source of income, an administrative structure is needed to ensure donor acquisition and financial accountability.

Another source of funding comes from government and foundation grants. In our case, several attempts at grant writing proved unsuccessful. This was likely because the program was small and untested. Relative to the potential impact, grant-making agencies were unable to assess how the program would scale to justify their investments. Several attempts to interest the Ecuadorian Ministry of Health also failed, in part because the ministry had already declared funding priorities in neonatal health and primary care medicine. The third source of funding, and most sustainable, is from tuition paid by the participants, government, or private

industry. Tuition or program fee for service revenue models scale with increased enrollment. As well, organizations can more easily see a benefit to their employees' productivity. Here, affordability is a major consideration. Hence, a combination of philanthropy and tuition is the most likely sustainable model.

In addition to continued financial resources, program support in the form of managers, record keepers, instructional, and technical support staff are required for program sustainability. The Laude depended on a volunteer model. Instructors volunteered their time teaching in the Laude. A volunteer U.S.-based physician recruited instructors to teach in the Laude, organized reading materials, developed and analyzed evaluations, and deployed evaluations to instructors. Recruitment was by word of mouth and from the American Academy of Pediatric's Section on International Child Health (SOICH) and Child Healthcare Information for All (CHIFA).^b Word of mouth recruitment yielded the majority of participants but proved an inefficient method. A volunteer-based system without adequate follow-up left gaps in the curriculum that had to be covered by Ecuadorian instructors.

Local program administration was performed by an administrative assistant from the USFQ medical school. To comply with the U.S. tax laws related to the use of donations, an administrative assistant at the U.S. partner institution processed expense claims and wrote accountability reports. The costs of managing philanthropic donations at the U.S. partner institution amounted to approximately 20% of the support raised. The annual administrative cost of the Laude, based on a fully funded financial model, including indirect costs, would have ranged from US\$150,000 to US\$250,000. The direct expenses in a full volunteer model are about US\$40,000 per year.

Fellows used their own time to attend the Laude; many had to rearrange work schedules. They received a grant from the USFQ for the tuition but were not otherwise compensated. Related to the systems barriers discussed earlier, there was no provision at the hospital for continuous medical or nursing education. Therefore, nurses and respiratory technicians attended classes on their own time. The cost of the use of the simulation center, including personnel time, was absorbed by the USFQ.

Program Evaluation

Given the innovations in the Laude, it is imperative that program evaluation be timely and reliable. Further, it is crucial to obtain objective clinical outcomes data including morbidity and mortality rates, the rates related to specific illnesses, length of stay, and resource use. This step is critical to identifying areas for improvement and innovation.

Program evaluation can take place at two levels of analyses. The first is at the individual learner level. Learning

^b The solicitation to SOICH resulted in a 1.4% response rate while calls for volunteer instructors to CHIFA yielded a less than 1% response rate. The two organizations, collectively reaching more than 3,000 people, yielded only two volunteers to teach.

outcomes have to be pre-established during the curriculum design stage. In the Laude, learning outcomes were tied to the needs analysis conducted at the design stage. At the end of each module, instructors and participants were surveyed for their opinions regarding workload, usefulness of the prereading materials, bedside didactics, and their pre- and postsimulation confidence levels. According to the evaluations, fellows and instructors reported improvements in the practical skills of fellows during simulations. One of the barriers faced was enforcing the completion of module evaluations and collation of the subsequent data. The lack of administrative support and access to complete patient clinical information meant that outcomes data could not be collected easily. Future versions of such programs should integrate the collection of data into the curriculum itself to minimize the costs of program evaluation.

Looking Ahead: Lessons Learned for the Future

As discussed in the earlier section, the nature of the Laude, due to its volunteer structure, creates an automatic barrier to sustainability. Based on the number of physicians trained each year, the program is only able to affect an area served by two hospitals, which is approximately 400,000 adult and child lives. In a country of more than 15 million people, this means that providers from at least 37 hospitals, assuming a uniform distribution of coverage, have to be trained. Realistically, to have meaningful impact, at least 75 hospitals (using a 15-year time horizon and assuming the same rate of training) will need to be formally trained in PCCEM. The duration of the Laude is long (10 months) and does not lead to a formal academic degree, which limits its attractiveness to providers who may have been working in the field for a long time. Yet, the problem is not as bleak as the numbers suggest.

First, the power of the train-the-trainer model suggests that the actual time to national coverage could be as little as 3 years. Ten fellows were trained in the first year of the program. Although this was a small number, it represented a 30% increase in the number of formally trained PCCEM physicians nationally, in a single year. In the second year, a further 29 physicians, 21 nurses, and 5 respiratory therapists from three additional hospitals were trained. Hence, in 2 years, the Laude more than doubled the number of formally trained PCCEM providers nationally, as well as nurses and respiratory therapists. It has been difficult but not impossible for the participants to implement similar standards of practice outside of the training environment. A graduate of the program, who was appointed chief of the PICU at an area hospital, successfully trained her PICU team on communication, teamwork, patient-centered care, physiology, and evidence-based practices. Utilizing what she learned from the Laude has resulted in improvements in patient care and provider satisfaction.

Second, to overcome the time commitment barrier and to accelerate the numbers of providers trained, the USFQ medical school adopted Advanced Pediatric Life Support (APLS). This is a validated program in Spanish, developed by the

American Academy of Pediatrics and American Academy of Emergency Medicine.²⁹ The program focuses on early recognition and the first hour of stabilization and management of critically ill children. It included several topic areas that can be adapted to the specific needs of a country and is less costly than the Laude, making it more adaptable, cost effective, and impactful. APLS is now the basis of the new practice-based PCCEM training model, program in emergency and critical care in pediatrics offered to providers. Participants are required to complete a quality improvement project at their home institution and the institution must be willing to implement changes for improvements in care. So far, in 6 months, 150 health professionals from 13 provinces and 1 from Peru have completed this training.

Posttraining evaluations from the first 100 participants report that 100% of the participants were satisfied with the training and felt empowered to provide better care for their patients. More importantly, there was no statistical difference in pre- and posttest scores between pediatricians already working in PCCEM and adult critical care or emergency medicine specialists. This suggests that in LMICs, training providers from a variety of specialty backgrounds can meaningfully reduce child morbidity and mortality with APLS training. The Laude designers have already adapted the program for community hospitals, one of which is in the Ecuadorian rainforest.

If the 3-day program in APLS included a train-the-trainer component using didactics and hands-on workshops, all 75 hospitals needed to provide national coverage in PCCEM could have their own team of first responders (doctors, nurses, and technicians) within 2 weekends! If each PCCEM-trained doctor (the Laude graduated 50) trained 10 other trainers in APLS, and they, in turn, trained 10 more each, it would only take 2 weekends to train 5,000 APLS first responders. Again, this simple illustration demonstrates the power of the train-the-trainer approach for diffusing targeted medical skills in low resource environments.

Finally, we discovered in practice that team-based learning is more likely to have a larger and sustainable impact on clinical outcomes than individual physician learning. In team-based learning, providers from a specific hospital undergo interprofessional training together. Hence, they are more likely to influence an entire hospital compared with training individuals that work at different hospitals. Therefore, we recommend implementing such programs at the hospital or unit level in an interprofessional and multidisciplinary fashion, so that providers can attend as a team. More importantly, because the organizational, cultural, and systems barriers occur at the hospital level, the probability of a trained team overcoming those barriers in a coordinated fashion is more likely than for the individual physician.

In summary, the Laude, in comparison with similar training programs around the world, where the involvement of foreign experts seem permanent, has evolved, in less than 24 months, to become a truly Ecuadorian national PCCEM capacity-enhancing initiative. Localization proceeded more rapidly than anticipated, which has also led to the scaling of the program in ways that are more appropriate and useful to meet local needs.

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