Implementation of an in-patient pediatric mortality reduction intervention, Gondar University Hospital, Ethiopia

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Setting: Gondar University Hospital (GUH) is a resource-limited tertiary care hospital in northern Ethiopia.

Objective: To evaluate the aggregate effect of care standardization, institutional guidelines, and simulation-based training on pediatric mortality at a resource-limited hospital.

Design: Uncontrolled pre-post study. GUH in-patients aged from 30 days to 14 years were included in the program evaluation (baseline 11 September–18 November 2010; intervention 19 September–9 December 2011). Interns attached to the GUH pediatrics department from 6 September to 9 December 2011 were included in the training evaluation. Institution-specific management guidelines were prepared for choking, respiratory distress, dehydration, sepsis, congestive heart failure, coma, and seizure. Approval for the protocols was obtained from each pediatric faculty member. Interns received a 3.5 h simulation-based training in triage, procedural skills, and protocol usage. Primary outcome was overall deaths (%); secondary outcomes were deaths within 24 h of admission (%) and median pre/post-training emergency management test scores (%).

Results: No difference in mortality (OR 0.72, 95%CI 0.40–1.29, $P = 0.265$) or first 24 h mortality (crude OR 0.97, 95%CI 0.37–2.55) was observed. Trainee examination scores improved from 33% to 74% ($P < 0.001$).

Conclusion: Combining care standardization, management protocols, and simulation-based training did not reduce mortality among pediatric in-patients. Focused, simulation-based training improved short-term test scores among interns.

Of the 11.3 million deaths occurring in Africa each year, roughly 45% occur in children aged <14 years.¹ Available reports suggest that a third to half of these deaths occur in health care facilities.^{2,3} To improve pediatric outcomes in resource-limited hospitals, the World Health Organization (WHO) has promoted the Emergency Triage Assessment and Treatment (ETAT) program. ETAT provides a standard curriculum in triage and patient stabilization, endorses facilities renovation and materials acquisition, and emphasizes operational strategies that reduce mortality in the first 24 h of admission among children aged ≤ 5 years.⁴ Although the WHO recommends adapting ETAT to meet local needs, relatively few reports have described adapted ETAT programs.^{5–8}

Gondar University Hospital (GUH) is the only tertiary-level hospital in the Amhara Region of northern Ethiopia. It receives referrals from an area that encom-

passes 17 million people, of which 43% are aged <14 years, and 88% live in rural areas.⁹ Of all non-neonatal pediatric admissions to GUH, 20% are diagnosed with severe acute malnutrition (SAM), 9% with malaria, 8% with tuberculosis (TB), and 8% with human immunodeficiency virus (HIV) infection.¹⁰ Due to the diversity of climates in its catchment area, GUH sees considerable pathologic variety.

A review of GUH medical records in 2010¹⁰ suggested that ETAT implementation alone would insufficiently address mortality among pediatric in-patients. Most deaths were observed among children aged >5 years, and most occurred beyond the first 24 h of admission. Considerable mortality was observed among patients with congestive heart failure (CHF), which is not featured in the ETAT curriculum. To optimize resource utilization and address concerns unique to our facility, we developed an operational intervention that integrated protocol development, standardization of care, and simulation-based training. Elements of ETAT were incorporated into our protocols to ensure compliance with international standards.

In this uncontrolled pre-post study, we hypothesized that our intervention would reduce deaths among non-neonatal pediatric in-patients. A second uncontrolled pre-post study was conducted to evaluate the effect of our simulation-based training program on emergency management skills.

METHODS

Setting

Pediatric patients presenting to GUH are evaluated by interns at an out-patient clinic, and the sickest children are admitted to a critical care ward. At the time of their 3-month pediatrics attachment, interns have completed 5 years of medical school. At least one pediatrician is always available for consultation. Oxygen, intravenous/intraosseous fluids, and basic emergency medications are available intermittently. Sub-specialty services are limited. To our knowledge, no substantial changes were made to the hospital infrastructure between study periods.

Before our intervention, full histories and physical examinations were performed at the first patient encounter. Although national guidelines were available for the management of common pediatric diseases, no institutional guidelines had been developed. Little consensus existed between supervising pediatricians regarding the management of pediatric emergencies. Medical learners received little practical training in

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KEY WORDS

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TABLE 1 Contents of institution-specific bedside management protocol packet for pediatric emergencies, GUH

Table of contents
Management protocols*
Choking
Stridor
Respiratory distress
Hypovolemic shock
Septic shock
Cardiopulmonary resuscitation
Congestive heart failure
Coma
Seizure
Addenda
Normal vital signs by age
Infant and pediatric Glasgow coma scoring card
GUH-specific emergency medication formulary
WHO weight estimation charts

*Each management protocol includes an initial stabilization guideline (page 1) and a subsequent post-stabilization guideline (page 2).
GUH = Gondar University Hospital; WHO = World Health Organization.

the management of pediatric emergencies, instead learning emergency skills on the job.

Intervention

A cross-sectional record review was conducted for patients aged 30 days–14 years admitted between 19 November 2009 and 18 November 2010. Seven diagnoses were significantly associated with death: SAM, coma, meningitis, CHF, severe dehydration, aspiration pneumonia, and sepsis. Another six were encountered in ≥ 10 deaths: community-acquired pneumonia, gastroenteritis, anemia, disseminated TB, HIV, and malaria. These 13 diagnoses became targets for our mortality reduction initiative. Our methodology and results are reported elsewhere.¹⁰

The department agreed that five protocols would address the management of all priority diagnoses: respiratory distress, hypovolemic shock, septic shock, CHF, and coma. Nuances related to the management of SAM were integrated into each protocol. To ensure coverage of ETAT-recommended targets, we added protocols for the management of airway emergencies (choking and stridor) and seizure, and for appropriate cardiopulmonary resuscitation (CPR) technique. National guidelines were also integrated into each protocol. Lastly, we added four references to the protocol packet: normal vital signs by age, the Glasgow Coma Scale, an emergency medication formulary, and a weight estimation guide (Table 1).¹¹ Substantive ETAT adaptations are listed in Table 2.

Nine 2-page protocols were produced. The first page described patient stabilization, and the second described post-stabilization management. All medication recommendations were reviewed with our pharmacy to confirm availability of drugs. Areas of controversy were subjected to literature review, and evidence was graded according to the Center for Evidence-Based Medicine guidelines.¹² Faculty consensus was obtained on all revised protocols through three review meetings. The finalized product was laminated and bound.* Two copies were introduced to the pediatrics ward at the start of our intervention, to be carried to the patient's bedside during emergencies.

Each intern rotating through our department from 6 September to 9 December 2011 received simulation-based training in

*The protocol can be obtained on request from the corresponding author.

TABLE 2 ETAT adaptations designed to address institutional failures and optimize resource utilization, GUH

Adaptation	Reason
CHF protocol	CHF identified as a major cause of death at GUH*
Expanded medication formulary	GUH pharmacy offers life-saving medications not described in ETAT†
Expanded resource inclusion	GUH offers life-saving resources not described in ETAT†
Expanded differential diagnosis and treatment guidelines	GUH confronts a broader range of pathology than that described in ETAT*
Expanded recommendations for laboratory investigation	GUH offers laboratory resources not described in ETAT†
Adaptations to culture of practice	Nuances to local practice did not agree with ETAT recommendations (e.g., use of GCS rather than Blantyre coma scale, familiarity with chest compressions, etc.)‡

*Discovered through cross-sectional review of in-patient records.⁹

†Discovered through interviews with hospital administration and staff.

‡Discovered through pilot-testing of protocols with interns.

ETAT = Emergency Triage Assessment and Treatment; GUH = Gondar University Hospital; CHF = congestive heart failure; GCS = Glasgow Coma Scale.

emergency pediatrics. Participants were divided into three groups, each of which was trained within the first 2 weeks of the rotation (10, 11, and 18 September 2011). A 30 min didactic presentation was given on pattern recognition and triage. Each trainee rotated through three 30 min mannequin-based procedure skills stations: airway/bag mask ventilation, CPR, and intraosseous needle placement. The trainees then rotated through three additional 30 min stations, each offering two simulated scenarios for rehearsing emergency skills. Emphasis was placed on adhering to department protocols, using the protocols at the bedside, and communicating clearly. Debriefing was provided after each simulation.

Our evaluation used non-neonatal pediatric deaths among GUH in-patients (per cent of admissions) as a primary outcome measure. As secondary outcome measures, it used deaths in the first 24 h of admission (F24H mortality) and median pre/post-training emergency management test scores.

Patient outcome evaluation

Patient data were retrospectively abstracted from admission registers, and missing data were recovered from patient charts and archived death certificates. Because death certification is legally mandated, certification strongly reflects actual mortality. Two senior pediatricians transcribed these records into an electronic database for the baseline (11 September–18 November 2010) and intervention (19 September–9 December 2011) periods. The inclusion and exclusion criteria, definition of variables, and data collection process are described in detail elsewhere.¹⁰

GUH introduced a pediatrics residency program in late 2010. During the intervention period, residents operated functionally as general practitioners (GPs), but spent more time each day supervising interns. We reviewed the work calendars for each GP and resident and calculated the average resident/GP h/day during each patient's admission. Because four GPs were available at all times during most of the baseline period, this variable was dichotomized with a cut-off of ≥ 4 .

Baseline and intervention patient groups were compared for demographic variables. Age was dichotomized as $\leq$ or > 5 years,

TABLE 3 Characteristics of non-neonatal in-patients at Gondar University Hospital during baseline and intervention periods ($n = 906$)

Characteristic	Baseline ($n = 474$) n (%)	Intervention ($n = 432$) n (%)	P value*
Age >5 years	350 (73.8)	315 (72.9)	0.753
Male ($n = 896$)†	263 (56.7)	287 (66.4)	0.003
Origin beyond Gondar and adjacent districts ($n = 861$)†	64 (14.6)	65 (15.8)	0.513
≥4 general practitioners or residents available to supervise per admission day ($n = 812$)†	383 (91.2)	134 (34.2)	<0.001
Length of stay, days, median [IQR] ($n = 812$)†	3.0 [2.0–9.0]	4.0 [2.0–9.0]	0.492
Readmission‡ ($n = 898$)†	22 (4.7)	10 (2.3)	0.055

* Determined using Pearson's χ^2 test of independence for categorical variables and Wilcoxon rank sum test for continuous variables.

† Sample size <906 due to missing data.

‡ Number of repeat admissions/total number of patients with identification number available. Repeat admissions counted separately for second, third and fourth admissions.

IQR = interquartile range.

TABLE 4 Estimated ORs relating patient characteristics to death among non-neonatal pediatric in-patients at Gondar University Hospital during the study period; univariable logistic regression ($n = 906$)

Predictor variable	Unadjusted OR (95%CI)	P value
Male ($n = 896$)*	2.01 (1.03–3.91)	0.040
Age >5 years	1.96 (0.91–4.25)	0.086
≥4 general practitioners or residents available to supervise per admission day ($n = 812$)*	0.79 (0.44–1.42)	0.429
Length of stay, days, median ($n = 812$)*	1.01 (0.98–1.05)	0.546
Origin beyond Gondar and adjacent districts ($n = 861$)*	0.99 (0.43–2.27)	0.986

* Sample size <906 due to missing data.

OR = odds ratio; CI = confidence interval.

as age <5 years is an internationally recognized target for mortality reduction. Categorical variables were assessed using the χ^2 test. Continuous variables were assessed using the Wilcoxon rank-sum test. Admission outcomes were summarized as percentage of admissions. Univariable logistic regression was used to compare study groups for admission outcome and to analyze associations between demographic variables and death.

Training evaluation

All interns rotating through the GUH pediatrics department from 6 September to 9 December 2011 were eligible to participate in the training. Informed consent was obtained from each participant. Identical examinations were administered to each intern before and immediately after the training session. The examinations were reviewed for quality by four senior pediatricians. Emergency problem solving was tested with an 18-question multiple-choice examination (best answer of 5 options). Procedural skills were tested by direct observation. The trainees were asked to perform a variety of procedures on a pediatric mannequin, while course instructors applied a standardized, checklist-based evaluation instrument to evaluate their performance. Median trainee examination scores were calculated as percentages answered correctly, and pre- and post-training results were compared by Wilcoxon matched-pairs signed ranks test.

Statistics were generated using Stata statistical software, release 12 (StataCorp, College Station, TX, USA, 2011).

Ethics approval for this study was obtained from internal review boards at both GUH in Gondar, Ethiopia (RCS/05/83/2011), and Baylor College of Medicine in Houston, TX, USA (H-28911).

RESULTS

Of the 474 patients admitted in the baseline group, 432 were included in the intervention group. During the intervention period, more males were admitted (66.4% vs. 56.7%, $P = 0.003$) and less supervision was available (34.2% with ≥4 GPs or residents available per admission day vs. 91.2%, $P < 0.001$) (Table 3). Male sex was associated with death (odds ratio [OR] 2.01, 95% confidence interval [CI] 1.03–3.91, $P = 0.040$; Table 4). No change was observed for overall mortality (odds ratio: [OR] OR 0.72, 95%CI 0.40–1.29, $P = 0.265$) or F24H mortality (OR 0.97, 95%CI 0.37–2.55, $P = 0.959$). A significant increase in disappearance was observed (OR 1.66, 95%CI 1.05–2.62, $P = 0.031$; Table 5).

All 21 interns rotating through the GUH pediatrics department during the intervention period participated in the training program. Total examination scores improved from median 32.6% to 73.5% ($P < 0.001$), with improvements observed for all tested skills. Median scores improved from 11.1% to 77.8% on airway skills, from 11.1% to 88.9% on CPR, from 40.0% to 100% on intraosseous needle placement, and from 21.7% to 87.0% in aggregate for all procedural skills ($P < 0.001$ for all parameters) (Figure).

TABLE 5 Outcomes among non-neonatal pediatric in-patients at Gondar University Hospital during baseline and intervention periods

Outcome	Baseline (<i>n</i> = 474) <i>n</i> (%)	Intervention (<i>n</i> = 432) <i>n</i> (%)	OR (95%CI)*	<i>P</i> value
Death	30 (6.3)	20 (4.6)	0.72 (0.40–1.29)	0.265
Death in first 24 h of admission	9 (1.9)	8 (1.9)	0.97 (0.37–2.55)	0.959
Improvement at discharge	341 (71.9)	297 (68.8)	0.86 (0.64–1.14)	0.293
Unchanged at discharge†	22 (4.6)	30 (6.9)	1.53 (0.87–2.70)	0.139
Disappearance‡	34 (7.2)	49 (11.3)	1.66 (1.05–2.62)	0.031
Missing specific outcome data§	47 (9.9)	36 (8.3)	0.83 (0.52–1.30)	0.410

* Calculated using univariable logistic regression.

† Patients whose condition did not change from admission. This includes transfers and discharges against medical advice.

‡ Patients who absconded from the hospital without being formally discharged.

§ Patients for whom discharge condition is not documented. A review of death certificates confirms that these patients did not die during admission.

OR = odds ratio; CI = confidence interval.

FIGURE Examination results from a simulation-based training for pediatric interns at Gondar University Hospital, 10–18 September 2011.* *For all tested parameters, the difference between pre- and post-test results was significant with $P < 0.001$, as calculated using Wilcoxon matched-pairs signed-ranks test. Didactic total = triage score + knowledge score; procedure total = airway score + CPR score + IO score. BMV = bag mask ventilation; CPR = cardiopulmonary resuscitation, including chest compressions; IO = intraosseous needle placement.

DISCUSSION

This study describes an intervention designed to reduce non-neonatal pediatric mortality at an Ethiopian teaching hospital. We standardized emergency care through faculty consensus, created institutional guidelines, and provided simulation-based training to interns. The training program generated significant improvements in intern test performance, but no change in patient mortality was observed. Further investigation with a larger sample, longer observation periods, and more balanced study groups is required to elaborate the findings of this pilot test.

Several features distinguished our intervention. First, it was designed around the findings of a baseline audit. We developed one protocol not described in ETAT (CHF) and adapted the remaining protocols to optimize resource utilization. Second, all intervention components were built on consensus between faculty members, allowing consultants to deliver consistent recommendations to trainees. Finally, the training in our intervention provided an

opportunity to build procedural skills and rehearse emergency situations safely.

Our guidelines promoted rapid fluid resuscitation among children with septic shock, in accordance with international standards.^{4,11} After our guidelines were prepared, the Fluid Expansion as Supportive Therapy (FEAST) study demonstrated increased mortality risk with this approach.¹³ Our study neither supports nor challenges the international standard. Our study was not powered to detect mortality change among patients with septic shock and, unlike the FEAST trial, it included signs of decompensation in its case definition. Careful revision of our septic shock protocol is nevertheless warranted.

To our knowledge, only three studies exploring ETAT adaptation have reported mortality outcomes. One intervention combining operational changes with ETAT triage training significantly reduced mortality among children aged <5 years.⁶ Evaluations of another modified ETAT program⁷ and the 'ETAT plus admission' program (ETAT+, a supplemented ETAT curriculum)⁸ describe

mortality reductions but do not formally compare pre-post groups. In our study, no mortality reduction was observed. This may reflect limitations in our analysis or under-publication of similar studies with negative findings.

Our intervention's impact may have been dampened by secular differences between study groups. First, more males were admitted in the intervention group, and male sex was associated with death. To our knowledge, there is no systematic reason for the increased admission of males. Second, less supervision was provided, and supervision may conceivably reduce mortality. The paradoxical decrease in supervision is explained by the exceptionally high number of GPs and residents who took vacation or served at clinical sites outside GUH during the intervention period.

Third, the qualitative effects of our residency program may have influenced patient mortality. A recent systematic review, including mostly surgical studies from Western countries, demonstrated no added risk or benefit to care delivered by residents as a whole, but a trend toward preventable complications was noted among residents in their first year of training.¹⁴ It is conceivable that the residency program adversely affected patient outcomes, as all residents were in their first year during our intervention. As little has been published on the clinical impact of African residency programs, any comparison between Western and African residencies should be drawn with caution. Future research exploring the effect of our intervention will need to establish more balanced study groups.

Several reports have described the effect of management guidelines on pediatric outcomes, including survival¹⁵ and length of stay (LOS).¹⁶ No reduction in death was observed in our study, and we did not demonstrate any change in LOS. Few studies have described the efficacy of simulation-based training programs in African hospitals. Significant improvement was observed in our study for all tested parameters, with particular improvement in procedural skills. This finding is in agreement with a report from Taiwan demonstrating improved procedural technique after simulation-based training.¹⁷ In Western settings, simulation-based training has also been found to improve teamwork^{18–20} and to reduce medical errors,²¹ but our evaluation instrument was not designed to capture these effects.

Training in ETAT+ runs for 5 days,⁶ standard ETAT for 3.5 days,⁴ and 'Essential ETAT' (a focused ETAT program) for 1 day.²² At 3.5 h, our training is among the briefest reported, and test scores among trainees improved significantly. By allowing for focused, practical instruction, simulation-based training may increase learning efficiency. Because different evaluation methods were applied, however, direct comparisons between these training programs should be made cautiously.

More patients 'disappeared' during our intervention period. Although a causal link may conceivably exist between exposure and disappearance, this finding is more likely to be spurious due to our small sample size. Further investigation with prospectively collected outcome data is required to confirm this hypothesis. Our statistical approach (hypothesis testing) is crude compared to time-series analysis.^{23,24} We could not apply the latter because the interns targeted by our training were attached to our department for only 3 months. We attempted to address the influence of seasonality on pediatric death by drawing data from the same season in both study groups.

Due to resource limitations, we could not directly evaluate the effect of our intervention on provider behavior. Evidence from Kenya suggests that didactic training in guideline adherence gen-

erates improvement in clinical practice only when delivered jointly with job aids and longitudinal feedback.²⁵ Our approach used simulation training and job aids, but failed to provide longitudinal feedback. Further research is needed to determine if our intervention produced comparable changes in provider practice.

Parts of our training evaluation may have been biased. First, we could not apply a previously validated examination because our training program contained content tailored to our hospital. We attempted to maximize the validity of our examination by subjecting it to peer review. Second, because we administered the same examination pre- and post-training, some of the observed test score improvement may have resulted from priming. Third, because qualified third-party proctors were unavailable at the time of our training, course instructors administered all examinations directly. Their involvement may have biased the procedural examination scores.

Our locally adapted mortality reduction intervention did not lower pediatric mortality. Simulation-based training is effective and efficient in improving short-term knowledge and procedural skills among Ethiopian medical trainees. Further investigation is required to understand the link between operational change, clinical practice, and patient outcome in resource-limited hospitals.

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Contexte : Le centre hospitalier universitaire de Gondar (GUH) est un hôpital de troisième niveau ayant des ressources limitées dans le nord de l'Éthiopie.

Objectif : Évaluer l'effet cumulé de la standardisation des soins, des directives institutionnelles et de la formation basée sur la simulation sur la mortalité pédiatrique dans un hôpital aux ressources limitées.

Schéma : Étude pré/post non contrôlée. Les patients hospitalisés au GUH âgés de 30 jours à 14 ans ont été inclus dans l'évaluation du programme (avant l'intervention, 11 septembre–18 novembre 2010 ; après l'intervention, 19 septembre–9 décembre 2011). Les internes attachés au service de pédiatrie du GUH du 6 septembre au 9 décembre 2011 ont été inclus dans l'évaluation de la formation. Des directives de prise en charge spécifiques de cette institution ont été préparées pour les cas de suffocation, détresse respiratoire, déshydratation, septicémie, défaillance cardiaque, coma et convulsions. L'approbation de ces protocoles a été obtenue de chaque membre de la faculté de pédiatrie. Les internes ont bénéficié

d'une formation basée sur la simulation de 3 à 5 h en matière de triage, compétences procédurales et utilisation des protocoles. Le résultat principal était le taux global de mortalité (%). Les résultats secondaires étaient le décès dans les 24 h suivant l'admission (%), et les scores médians des tests de prise en charge des urgences avant/après la formation (%).

Résultats : Aucune différence n'a été observée en termes de mortalité globale (OR 0,72 ; IC95% 0,40–1,29 ; $P = 0,265$) ou de mortalité pendant les premières 24 h (OR brut 0,97 ; IC95% 0,37–2,55). Par contre, les scores d'examen de prise en charge des personnes formées sont passés de 33% à 74% ($P < 0,001$).

Conclusion : La combinaison de standardisation des soins, de protocoles de prise en charge et de formation basée sur la simulation n'a pas réduit la mortalité des enfants hospitalisés. Cependant, la formation ciblée et basée sur la simulation a amélioré les scores obtenus par les internes dans les tests à court terme.

Marco de referencia: El Hospital Universitario de Gondar (GUH) es un centro de atención terciaria de salud en el norte de Etiopía que cuenta con recursos limitados.

Objetivo: Evaluar el efecto agregado de la atención normalizada, la aplicación de directrices institucionales y un programa de capacitación mediante simulación, sobre la mortalidad pediátrica en un hospital de recursos limitados.

Métodos: Se llevó a cabo un estudio no comparativo antes y después de la intervención. Los pacientes entre 30 días y 14 años de edad hospitalizados en el GUH se incluyeron la evaluación del programa, cuya fase inicial se realizó entre el 19 de septiembre y el 11 de noviembre del 2010 y la intervención tuvo lugar del 19 de septiembre al 9 de diciembre del 2011. Los internos asociados al servicio de pediatría del hospital participaron en la evaluación de la capacitación del 6 de septiembre al 9 de diciembre del 2011. Se elaboraron directrices institucionales sobre el tratamiento de la asfixia, el síndrome de dificultad respiratoria, la deshidratación, la septicemia, la insuficiencia cardíaca congestiva, el coma y las convulsiones. Se obtuvo la aprobación de los protocolos por parte de

todos los miembros del departamento de pediatría. Los internos recibieron una capacitación de 3,5 h mediante técnicas de simulación sobre la selección de los pacientes, la competencia en los procedimientos y la aplicación de los protocolos. El principal criterio de evaluación del estudio fue la mortalidad global y los criterios secundarios fueron la mortalidad en las primeras 24 h de hospitalización y la mediana de la calificación del examen antes y después de la capacitación. Los resultados se expresan en porcentajes.

Resultados: No se observó ninguna diferencia en la mortalidad global (OR 0,72; IC95% 0,40–1,29; $P = 0,265$) y la mortalidad durante las primeras 24 h (OR crudo 0,97; IC95% 0,37–2,55). La puntuación del examen de los internos mejoró después de la capacitación de 33% a 74% ($P < 0,001$).

Conclusión: La intervención que consistió en una atención normalizada, la elaboración de protocolos de tratamiento y la capacitación mediante simulación no disminuyó la mortalidad hospitalaria de los pacientes pediátricos. La capacitación mediante técnicas de simulación con objetivos definidos mejoró las evaluaciones a corto plazo de los internos que participaron.