Mortality in Children Under Five Receiving Nonphysician Clinician Emergency Care in Uganda

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abstract

BACKGROUND: A nonphysician clinician (NPC) training program was started in Uganda in 2009. NPC care was initially supervised by a physician and subsequent care was independent. The mortality of children under 5 (U5) was analyzed to evaluate the impact of transitioning NPC care from physician-supervised to independent care.

METHODS: A retrospective review was performed of a quality assurance database including 3-day follow-up for all patients presenting to the emergency department (ED). Mortality rates were calculated and χ² tests used for significance of proportions. Multiple logistic regression was used to assess independent predictors of mortality.

RESULTS: Overall, 68.8% of 4985 U5 patients were admitted and 28.6% were "severely ill." The overall mortality was significantly lower in physician-supervised versus independent NPC care (2.90% vs 5.04%, P = .05). No significant mortality difference was seen between supervised and unsupervised care (2.17% vs 3.01%, P = .43) for the majority of patients that were not severely ill. Severely ill patients analyzed separately showed a significant mortality difference (4.07% vs 10.3%, P = .01). Logistic regression revealed physician supervision significantly reduced mortality for patients overall (odds ratio = 0.52, P = .03), but not for nonseverely ill patients analyzed separately (odds ratio = 0.73, P = .47).

CONCLUSIONS: Though physician supervision reduced mortality for the severely ill subset of patients, physicians are not available full-time in most EDs in Sub-Saharan Africa. Training NPCs in emergency care produced noninferior mortality outcomes for unsupervised NPC care compared with physician-supervised NPC care for the majority of U5 patients.

WHAT’S KNOWN ON THIS SUBJECT: Task-shifting is validated for many medical fields in sub-Saharan Africa to address health care staffing shortages. Task-shifting in emergency care has not been studied, though care needs remain unmet in much of sub-Saharan Africa in general and Uganda in particular.

WHAT THIS STUDY ADDS: Nonphysician clinicians trained to provide emergency care in Uganda had noninferior mortality outcomes for unsupervised care of children under 5 compared with physician-supervised care for the majority of patients. Significant benefit for supervision existed only for the severely ill subset.
Globally, the mortality rate for children under the age of 5 (U5) has been cut almost in half over the last 20 years. However, Millennium Development Goal (MDG) 4, the reduction of U5 mortality by two-thirds from 1990 to 2015, remains 1 of the targets yet to be met in Sub-Saharan Africa (SSA). Uganda saw the U5 mortality rate of 163 (per 1000 births) in 2000 reduced to 110 by 2011, but mortality still lags behind the target of 56 by 2015. The African Federation for Emergency Medicine recently released a consensus statement stating that improving emergency care could assist nations in meeting their MDG goals.

The shortage of human resources in low income countries makes the provision of health care and emergency care challenging, with the greatest challenge centered in SSA. For 50 years, leading thinkers have understood that physicians alone cannot provide all the necessary care and health systems must find ways to share responsibility and expand training. One solution to staffing that has been widely implemented in SSA is “task-shifting,” or delegating tasks to more narrowly trained cadres of new or existing providers. Though nonphysician clinicians (NPCs) have provided basic diagnosis, medical treatment, and surgical specialty care in SSA, NPC cadres have only recently begun treating undifferentiated patients in an emergency department (ED) setting.

The Global Emergency Care Collaborative (GECC) is a US-based nongovernmental organization that started the Emergency Care Practitioner (ECP) program in Uganda in 2009 to train NPCs specialized in emergency care. A detailed description of the ECP training program was previously published. In brief, Ugandan ECPs were initially paired for 9 months with a physician certified in emergency medicine (EM) by the American Board of Emergency Medicine. This physician directly supervised care provided by the ECPs and conducted bedside teaching in a model similar to US physician residency training. After this initial training period the physician departed, full-time supervision ceased, and the NPCs began to clinically practice independently, with some continued teaching by rotating volunteer physicians. Primary clinical care and decision-making were taken over by the senior ECPs who were also responsible for training and teaching junior ECPs in a “train-the-trainers” model.

To assess the impact task-shifting training had on patient outcomes, the following observational study compares the U5 mortality of the initial period of physician-supervised training to the subsequent period of independent NPC care.

**METHODS**

This study is a retrospective, observational study examining the effect of an NPC training program on the 3-day mortality rate of admitted U5 patients via review of an ongoing quality assurance database from an active rural ED at Karoli Lwanga “Nyakibale” Hospital in the Rukungiri district of Uganda. Starting in 2009, GECC created a quality assurance database of ED patient records in which demographic, clinical, and administrative information was recorded. Data collection began after 4 months of initial program development and clinical training. At the time the patient presented to the ED, a research assistant (RA) entered data into a custom-built database (Microsoft Excel from November 2009 to March 2012 and Microsoft Access from March 2012 to July 2014). For the purpose of analyzing these data for factors associated with U5 mortality, 1 blinded researcher abstracted data for all patients <60 months of age from deidentified copies of both databases into an Excel database. Sample size was based on using all available records meeting the above criterion.

Analysis focused on in-hospital mortality so all patients with an ED disposition of “discharged from the ED” were excluded. Previously admitted “back to ward” who were sent to the ED specifically for minor procedures were also excluded from analysis. The remaining patients were analyzed for this study (Fig 1). The time category “supervised” was defined as the period from November 2009 to April 2010 when the EM physician was present in the ED full-time, and “unsupervised” was defined as the period from May 2010 to July 2014.

“Severe illness” was defined by using both World Health Organization guidelines and studies of severe...
TABLE 1 Characteristics of Admitted U5 Patients (2009–2014)

<table>
<thead>
<tr>
<th></th>
<th>Supervised (n = 449)</th>
<th>Unsupervised (n = 2979)</th>
<th>P</th>
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</thead>
<tbody>
<tr>
<td>Age (95% CI), y</td>
<td>1.66 (1.56–1.77)</td>
<td>1.64 (1.60–1.69)</td>
<td>.75a</td>
</tr>
<tr>
<td>Age groups</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Neonate (&lt;1 mo), % (n)</td>
<td>4.7 (21)</td>
<td>3.1 (92)</td>
<td>.003</td>
</tr>
<tr>
<td>Infant (1–12 mo), % (n)</td>
<td>37.0 (168)</td>
<td>38.2 (1158)</td>
<td>—</td>
</tr>
<tr>
<td>Toddler (1–3 y), % (n)</td>
<td>44.8 (201)</td>
<td>38.9 (1160)</td>
<td>—</td>
</tr>
<tr>
<td>Child (3–5 y), % (n)</td>
<td>13.6 (61)</td>
<td>19.7 (588)</td>
<td>—</td>
</tr>
<tr>
<td>Male gender; % (n)</td>
<td>56.4 (253)</td>
<td>56.0 (1668)</td>
<td>.89</td>
</tr>
<tr>
<td>Parasites seen on blood smear; % (n)</td>
<td>38.8 (174)</td>
<td>32.6 (970)</td>
<td>.09</td>
</tr>
<tr>
<td>HIV-positive (known status or newly diagnosed), % (n)</td>
<td>1.58 (7)</td>
<td>3.05 (91)</td>
<td>.08</td>
</tr>
<tr>
<td>Severely malnourished, % (n)</td>
<td>10.7 (48)</td>
<td>15.2 (452)</td>
<td>.01</td>
</tr>
<tr>
<td>One or more criterion of severe illness present, % (n)</td>
<td>38.3 (172)</td>
<td>27.4 (816)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Hypoglycemic, % (n)</td>
<td>2.67 (12)</td>
<td>2.11 (63)</td>
<td>.45</td>
</tr>
<tr>
<td>Hypoxic, % (n)</td>
<td>29.8 (134)</td>
<td>23.9 (712)</td>
<td>.006</td>
</tr>
<tr>
<td>Severe anemia, % (n)</td>
<td>10.0 (45)</td>
<td>3.99 (119)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Number of criteria for severe illness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 criteria for severe illness, % (n)</td>
<td>61.7 (277)</td>
<td>72.6 (2163)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>1 criteria for severe illness, % (n)</td>
<td>34.1 (153)</td>
<td>24.4 (727)</td>
<td>—</td>
</tr>
<tr>
<td>2+ criteria for severe illness, % (n)</td>
<td>4.23 (19)</td>
<td>2.99 (69)</td>
<td>—</td>
</tr>
</tbody>
</table>

*Indicates t test used for significance, all others use χ².

malarial and nonmalarial illness. It was adapted to the laboratory resources available at Nyakibale, and yielded the following: hemoglobin <50 g/L (<5.0 g/dL), glucose <2.2 mmol/L (<39.6 mg/dL), and peripheral oxygen saturation <92%.

GECC’s follow-up protocol is described in more detail in another publication. All ED patients were followed-up at 3 days either in person on the ward or via telephone if discharged. Patients with multiple visits during the study period had each unique visit included in analysis. In all admitted patients with incomplete follow-up data, the original ward ledgers were used to confirm 3-day status if possible. Follow-up data were degraded by reduced RA staffing during 3 brief periods: March 10, 2010–July 22, 2010, August 31, 2010–September 29, 2010, and January 17, 2011–March 5, 2011. Data were entered for patients during much of this time period, but inadequate staffing meant that follow-up was not at the same rigorous standard as the remainder of the study period.

All analyses were performed by using Stata Statistical Software version 13.1 (Stata Corp, College Station, TX). χ² test was used for comparing proportions and the Student’s t test for comparing means. The level of significance for all tests was set at P = .05. Multiple logistic regression was used to analyze binary mortality outcomes. Individual variables were excluded from multiple regression analysis on the basis of univariate analysis yielding a P > .15. Crude odds ratios (ORs) were calculated with univariate analysis for individual predictors.

Initial approval for this research was made (2.0%, n = 67). The characteristics of patients seen in the 2 program phases (Table 1) were similar with respect to mean age, gender distribution, malaria prevalence, and HIV prevalence.

The unsupervised period saw more older children and more severely malnourished children. The supervised period saw significantly more severely ill patients, including more hypoxic and severely anemic children. Because the remainder of the analysis revolved around severity of illness, further analysis was performed to assess variation in severity of illness (Supplemental Information). The outcome of this analysis was that the significant difference in severe illness between time periods was unlikely to be a result of patients in the unsupervised time period being undertested or failing to have their severe illnesses identified, but instead resulted from patients in the supervised time period being more likely to present with severe illness.

The primary outcome of interest for this analysis is U5 mortality at 3 days for all admitted patients (Table 2). The overall mortality during the unsupervised period was significantly higher than during the supervised period (5.04% vs 2.90%, P = .05). This significant mortality difference persisted in the severely ill minority of patients U5 patients were admitted to Nyakibale hospital in 68.8% of visits (n = 3428). Overall, 28.6% (n = 982) of admitted patients met 1 or more criteria for severe illness; 25.7% (n = 882) met 1 criterion, and 29.1% (n = 100) had 2 or more criteria. Three-day follow-up status was confirmed in 90.5% (n = 3101) of patients, with 12.4% of patients (n = 425) having incomplete but adequate data to establish follow-up mortality. Loss to follow-up was most commonly due to invalid telephone numbers (7.6%, n = 260) and rarely due to unspecified reasons or no recorded attempt being made (2.0%, n = 67).
(4.07% vs 10.3%, *P* = .01). However, in the majority of patients ill enough to warrant admission but not meeting criteria for severe illness, the mortality difference between the physician-supervised and the unsupervised phases disappeared (2.17% vs 3.09%, *P* = .40).

To further analyze this severely ill subset, patients were stratified by the number of illness criteria met. Only 3 patients met more than 2 criteria of severe illness, so patients were categorized as having “zero,” “one,” or “two or more” criteria of severe illness. Unconsciousness or coma is commonly used as a criterion for severe illness. It was not used for this study because although unconsciousness was reported for 15 patients (0.4%), mental status recording was omitted in 95.5% (n = 3238) of patient records overall, making the data quality so poor it was rejected. Additional unpublished analysis was done by the authors of this study including unconsciousness as a criterion of severe illness and revealed no differences in significance for any of the findings reported in this article.

There was a positive relationship between an increasing number of criteria of severe illness and increasing mortality in both time periods (Table 3, Fig 2). The mortality difference met statistical significance only for patients who met 2 or more severe illness criteria (2 or more criteria: 0.00% vs 22.5%, *P* = .02).

A logistic regression model was developed to control for both disease severity and confounders (Table 4). In this model, physician supervision was independently correlated with reduced mortality (OR = 0.52, *P* = .03). The greatest predictor of increased mortality was meeting 2 or more severe illness criteria (OR = 8.94, *P* ≤ .001). Other significant predictors of mortality included neonatal age group, meeting a single criterion for severe illness, HIV seropositivity, severe malnutrition, and female gender.

### Table 2: Mortality during program periods

<table>
<thead>
<tr>
<th></th>
<th>3-Day Mortality</th>
<th>Supervised</th>
<th>Unsupervised</th>
<th><em>P</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>All patients, % (n = 3428)</td>
<td>2.90 (n = 13/449)</td>
<td>5.04 (n = 150/2979)</td>
<td>.05</td>
<td></td>
</tr>
<tr>
<td>95% CI</td>
<td>1.34–4.45</td>
<td>4.25–5.82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zero criteria for severe illness, % (n = 2446)</td>
<td>2.17 (n = 6/277)</td>
<td>3.09 (n = 67/2169)</td>
<td>.40</td>
<td></td>
</tr>
<tr>
<td>95% CI</td>
<td>0.44–3.89</td>
<td>2.36–3.62</td>
<td></td>
<td></td>
</tr>
<tr>
<td>One or more criterion for severe illness, % (n = 982)</td>
<td>4.07 (n = 7/172)</td>
<td>10.3 (n = 83/810)</td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td>95% CI</td>
<td>1.09–7.05</td>
<td>6.86–11.0</td>
<td></td>
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</tr>
</tbody>
</table>

*a* χ² test used for significance.

### Table 3: Mortality by number of illness criteria met

<table>
<thead>
<tr>
<th></th>
<th>3-Day Mortality</th>
<th>Supervised</th>
<th>Unsupervised</th>
<th><em>P</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>0 criteria for severe illness, % (n = 2448), (95% CI)</td>
<td>2.17 (n = 6/277), (0.44–3.88)</td>
<td>3.09 (n = 67/2169), (2.36–3.62)</td>
<td>.40</td>
<td></td>
</tr>
<tr>
<td>1 criterion for severe illness, % (n = 882), (95% CI)</td>
<td>4.58 (n = 7/153), (1.09–7.05)</td>
<td>8.64 (n = 63/729), (6.86–11.0)</td>
<td>.09</td>
<td></td>
</tr>
<tr>
<td>2+ criterion for severe illness, % (n = 100), (95% CI)</td>
<td>0.00 (n = 0/19), (0.00–0.00)</td>
<td>24.7 (n = 20/81), (15.1–34.3)</td>
<td>.02</td>
<td></td>
</tr>
</tbody>
</table>

*a* χ² test used for significance.

![FIGURE 2](http://pediatrics.aappublications.org/) Mortality by number of illness criteria met.
A second logistic regression model was used to exclusively review patients warranting admission but without criteria for severe illness (Table 5). Using an otherwise identical model, physician supervision was not associated with decreased mortality (OR = 0.73, \( P = .47 \)), but neonates, girls, and severely malnourished patients were still at increased risk of death.

**DISCUSSION**

Although NPC care has been studied for a variety of medical and surgical fields,\(^5\)\(^6\)\(^7\)\(^8\)\(^9\)\(^17\)\(^18\) and is widely accepted in SSA, evaluation of the effectiveness of NPCs in an undifferentiated ED environment is just beginning.\(^10\)\(^19\) Because baseline mortality data for this region of Uganda are not available, this study evaluated the effectiveness of independent NPC care by comparing the mortality of supervised care with unsupervised care.

EM specialist physician care or supervision is an ideal but currently unrealistic goal in rural Uganda where health care staffing is extremely limited. In Rukungiri, the population of 321,000 is served by only 12 physicians and 117 nurses.\(^20\) Only 3 to 5 physicians have been on staff at Nyakibale from 2009 to the present day. Before the development of the ECP program, Nyakibale hospital had a “standard of care” for undifferentiated patients presenting to the hospital that was similar to most hospitals within Uganda; no formal triage or resuscitation was offered, treatment was given by nonemergency trained providers (usually clinical officers) during outpatient department hours, ad hoc treatment was offered during off hours, and nonambulatory or seriously ill trauma patients were sent to minor theater when staff was present. The initial phase of continuous, US board-certified, EM specialist physician supervision provided by GECC for the ECP program gave a level of care that is currently irreproducible from within the Ugandan system, but which served as both a target for program development and a standard for internal and external comparison.

It was reasonable to expect that mortality would be lower during the supervised phase due to the positive effect specialist expertise would have on patient outcomes, especially considering the EM physician had extensive local clinical experience and cultural fluency within this region of Uganda. This expected mortality benefit of physician
supervision for NPC care was seen (2.90% vs 5.04%, $P = .05$), but the benefit was restricted to the subset of severely ill patients (4.07% vs 10.3%, $P = .01$). When these mortality data were further stratified by the number of illness criteria each patient met, the mortality benefit was statistically significant only for patients who met 2 or more severity criteria. The mortality benefit for physician supervision of patients meeting a single criterion for severe illness was clinically significant (4.58% vs 8.64%) but only approached statistical significance ($P = .09$).

A mortality benefit of physician supervision for NPC care that existed for all severely ill patients was more exaggerated (statistically and clinically) as the severity of illness increased. Underlying trends toward reduced U5 mortality overall in Uganda from 2009 to 2014 would have reduced mortality during the unsupervised period, and biased data away from finding mortality differences. The persistence of a mortality benefit despite this shift in background mortality further supports the likelihood the above findings are not due to chance. The expertise and supervision of an EM subspecialist could be seen to disproportionately benefit the critically ill, but not to necessarily affect outcomes for the nonseverely ill majority of U5 admitted patients cared for by NPCs.

The logistic regression analysis for all patients reinforced physician supervision as a protective factor for reducing 3-day mortality (OR = 0.52, $P = .03$), when reviewing the overall population that included the severely ill. Notably, female gender independently predicted excess mortality, even when controlling for nutritional status, comorbidities, and disease severity. Further study is required to identify other physiologic factors (eg, disease or vaccine prevalence) or social factors (eg, timing or pattern of health care seeking behavior) contributing to the disparity.

When reviewing only admitted patients who did not meet any criteria for severe illness, no mortality benefit was revealed for physician supervision (OR = 0.73, $P = .47$) after controlling for gender, nutritional status, age, and comorbidities. Overall, this majority of nonseverely ill U5 patients received care from unsupervised NPCs that led to outcomes that were noninferior to outcomes from EM physician-supervised care.

**Limitations**

Several limitations existed for this study. From a programmatic standpoint, no preintervention studies for mortality in the Nyakibale ED exist that would have provided a baseline for program impact evaluation. Also, NPC training and formal triage were implemented simultaneously and their independent effects are not evaluated in this article. Physician supervision ceased in April 2010, but physician presence has been ongoing in the ED to supervise teaching and data collection issues. These physicians did not supervise cases, review cases, or see patients primarily. However, these physicians were intermittently physically present in the ED and available for consult if the ECPs had questions they were unable to answer with the guidelines and texts they had available. This variable involvement was not captured in the database.

From the standpoint of data integrity, despite the consistent presence of RAs to capture follow-up data, 9.5% ($n = 324$) of patients were lost to follow-up. Also, the inadequate charting of height, weight, middle-upper arm circumference, and mental status may have systematically underrepresented malnutrition and the presence of severe illness. Our data do not allow us to determine day of death or control for differences in inpatient care provided during the 2 periods.

Finally, admitted patients had their care taken over by an inpatient team, and the quality of their care contributed to overall 3-day mortality independent of ED management. The inpatient team had control over changes made to the initial diagnosis, ongoing medical and surgical management, and any additional workup or consultation. These and other variations in the care received on the ward could not be measured with this study and are not addressed in this article.

**Generalizability**

External validation between studies and heterogeneous care environments is challenging, and no similar studies incorporate data from a rural district hospital ED in Uganda, nor have any previously included clinical care from NPCs. Emergency care needs are not uniquely Ugandan, and thus it is reasonable to review other data from SSA. For admitted patients, Nadjm et al reviewed febrile patients in Tanzania and did not specify severe illness criteria. That study's overall mortality of 5.1% (95% confidence interval [CI]: 4.35–5.84) under non-EM physician care is almost identical to the 5.04% (95% CI: 4.25–5.82) seen during independent NPC care, and higher than the 2.90% (95% CI: 1.34–4.45) seen during EM physician-supervised NPC care.

Using severe illness criteria allows for more representative comparisons between studies. Reyburn et al reviewed admitted patients meeting at least 1 criteria for severe illness (by using similar criteria). Though these data exclusively revealed patients with suspected malaria, the U5 subset of their published data revealed a mortality of 7.15% ($n = 204/2851$, 95% CI: 6.21–8.21) under non-EM physician care. This was higher than observed for physician-supervised NPC care (4.07%, 95%
CI: 1.09–7.05) and lower than observed for independent NPC care (10.3%, 95% CI: 6.86–11.0).

CONCLUSIONS

These external data reinforced the trend seen in the internal data; unsupervised NPCs delivered quality care in an ED setting. Their outcomes were similar to physician-supervised care for the uncomplicated majority of patients, and physician supervision provided a mortality benefit only in the severely ill subset of patients. Additionally, though comparisons across studies are difficult, it appears that the mortality outcomes of unsupervised NPC care approximated the outcomes from non-EM physicians caring for acutely ill children in resource-limited settings. In most of rural SSA, similar to the setting of this study, general physician care is difficult to obtain, and emergency physician care is nonexistent.

Having seen that unsupervised NPCs can provide quality care in an area when physician emergency care is unobtainable, these results must be validated before any impact on local or regional policy is possible. The next step in validating this staffing model is currently being undertaken by GECC in Uganda. This subsequent project will obtain pre-and postimplementation mortality data from a different Ugandan ED and assess the mortality impact of introducing the NPC-care model. As the benefits of improving emergency care are unlikely to be restricted to Uganda, a cluster-randomized trial across multiple countries would provide the highest quality possible data about the impact of improving emergency care in SSA. These studies together will inform the conversation that strengthening ED care within health systems can reduce mortality and demonstrate how task-shifting may help save U5 lives in Uganda and SSA, helping countries meet their MDG goals.

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ABBREVIATIONS

CI: confidence interval
ECP: Emergency Care Practitioner
ED: emergency department
EM: emergency medicine
GECC: Global Emergency Care Collaborative
MDG: Millennium Development Goal
NPC: nonphysician clinician
OR: odds ratio
RA: research assistant
SSA: Sub-Saharan Africa
U5: under 5

REFERENCES


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