

Interhospital Transfer of Critically Ill and Injured Children: An Evaluation of Transfer Patterns, Resource Utilization, and Clinical Outcomes

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OBJECTIVE: To describe patterns of transfer, resource utilization, and clinical outcomes associated with interhospital transfer of critically ill and injured children.

DESIGN: Secondary analysis of administrative claims data.

PARTICIPANTS: Children 0 to 18 years in the Michigan Medicaid program who underwent interhospital transfer for intensive care from January 1, 2002 to December 31, 2004. The 3 sources of transfer from referring hospitals were: emergency department (ED), ward, or intensive care unit (ICU).

MEASUREMENTS: Mortality and duration of hospital stay at the receiving hospitals.

RESULTS: Of 1643 interhospital transfer admissions to intensive care at receiving hospitals, 62%, 31%, and 7% were from the ED, ward, and ICU of referring hospitals, respectively. Nineteen percent had comorbid illness, while 11% had organ dysfunction at the referring hospital. After controlling for comorbid illness, patient age, and pretransfer organ dysfunction, compared with ED transfers, mortality in the receiving hospital was higher for ward transfers (odds ratio [OR], 1.76; 95% confidence interval [CI], 1.02–3.03) but not for ICU transfers. Also, compared with ED transfers, hospital stay was longer by 1.5 days for ward transfers and by 13.5 days for ICU transfers.

CONCLUSION: In this multiyear, statewide sample, mortality and resource utilization were higher among children who underwent interhospital transfer to intensive care after initial hospitalization, compared with those transferred directly from emergency to intensive care. Decision-making underlying initial triage and subsequent interhospital transfer of critically ill children warrants further study. *Journal of Hospital Medicine* 2009;4:164–170. © 2009 Society of Hospital Medicine.

KEYWORDS: health resources, hospitalized children, length of stay, mortality, triage.

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Interhospital transfer of critically ill and injured children is necessitated by variation in resource availability between hospitals. Critically ill children judged in need of clinical services or expertise not locally available undergo transfer to hospitals with more appropriate resource capabilities and expertise, with the expectation that clinical outcomes of transfer will be better than nontransfer.

Significant variation both in the availability of pediatric critical care services across US hospitals¹ and in child mortality among hospitals without pediatric critical care services² suggests

that interhospital transfer will remain an integral part of healthcare delivery for critically ill and injured children. Timely provision of definitive care for acute life-threatening disease is associated with good clinical outcomes.^{3,4} While prior studies have examined clinical outcomes and resource consumption among critically ill adults who underwent interhospital transfer for intensive care,⁵⁻⁹ there is scarce information regarding clinical characteristics and outcomes of interhospital transfer for critically ill and injured children.

This study was conducted to test the hypothesis that, among critically ill and injured children who undergo interhospital transfer for intensive care, children transferred after an initial hospitalization at the referring facility will have higher mortality, longer length of stay (LOS), and higher resource consumption than children transferred directly from the emergency department (ED) of the referring hospitals.

METHODS

Study Design

We conducted a secondary analysis of administrative claims data from the Michigan Medicaid program for the period January 1, 2002, to December 31, 2004. The data included all paid claims for health services rendered to enrollees in the Medicaid program. The Institutional Review Board of the University of Michigan Medical School approved the study.

Study Sample and Variable Identification

A 3-step approach was employed to identify interhospital transfer admissions for intensive care of children. Initially, the Medicaid claims were queried to identify all hospitalizations for children 0-18 years who received intensive care services, using Medicare revenue codes.¹⁰ Admissions for neonatal intensive care were excluded from the analysis. The *American Hospital Association Guide to the Health Care Field*, a compendium of US healthcare facilities, was used to verify the presence of intensive care facilities.^{11,12} Subsequently, to identify the subset of children who underwent interhospital transfer, data were queried for the presence of claims from another hospital, and the date of discharge from the referring hospital had to be the same as the date of admission to the receiving hospital intensive care unit (ICU). Finally, to ascertain the source of interhospital transfer, Medicare revenue codes and current procedural terminology (CPT) codes were used to

identify claims for receipt of services at specific sites within the referring hospital; namely, the ED, ward, or the ICU. This information was used to categorize admissions into 1 of 3 pathways of interhospital transfer:

- ED transfer—From the ED of the referring hospital to the ICU of the receiving hospital.
- Ward transfer—From the wards of the referring hospital to the ICU of the receiving hospital.
- Inter-ICU transfer—From the ICU of the referring hospital to the ICU of the receiving hospital.

Dependent Variables

Mortality at the Receiving Hospital. This is determined by linkage to vital statistics records maintained by the Michigan Department of Community Health, Division of Vital Records and Health Statistics.

LOS at the Receiving Hospital. This is determined as the count of days of hospitalization at the receiving hospital. Of note, this includes ICU days and non-ICU days at the receiving hospital.

Independent Variables

Source of Interhospital Transfer. The main (exposure) independent variable. Categorized into ED, ward, or inter-ICU transfers, as described.

Patient Demographics. Age and gender.

Comorbid Illness. Determined using International Classification of Diseases, ninth revision (ICD-9) diagnosis codes, applying methodology as described.¹³

Organ Dysfunction at the Referring and Receiving Hospitals. Determined using ICD-9 diagnosis codes, applying methodology as described.¹⁴

Patient Diagnostic Categories. Eleven diagnostic categories were created based on primary admission diagnoses (Appendix A).

LOS at the Referring Hospital. Determined as the count of days of hospitalization at the referring hospital.

Receipt of Cardiopulmonary Resuscitation (CPR) on the Date of Interhospital Transfer. Determined using procedure codes.

Receipt of Medical-Surgical Procedures at the Receiving Hospital. Identified through the use of ICD-9 procedure codes, CPT codes, and Healthcare Common Procedure Coding System codes. The procedures are listed in Appendix B.

Statistical Analysis

Descriptive statistics were used to characterize the study sample. According to the 3 sources of inter-

TABLE 1
Patient Characteristics at the Referring Hospital According to Transfer Source

Characteristics	Transfer Source			P
	ED (n = 1022)	Ward (n = 512)	Inter-ICU (n = 109)	
Median age in years (IQR)	2 (0-9)	1 (0-7)	1 (0-10)	<0.01
Male (%)	57.8	56.2	47.6	0.13
Comorbid illness (%)	13.1	25.0	50.5	<0.01
Pretransfer hospital length of stay (days)				
Median (IQR)	0	1 (0-2)	3 (1-8)	<0.01
Mean (SD)	0.2 (5.2)	1.6 (4.8)	9.7 (18.0)	<0.01
Pretransfer organ dysfunction (%)	5.5	14.5	40.4	<0.01

NOTE: Transfer source: ED, transfer admission from the emergency department of the referring hospital to the intensive care unit of the receiving hospital. Ward, transfer admission from the ward of the referring hospital to the intensive care unit of the receiving hospital. Inter-ICU, transfer admission from the intensive care unit of the referring hospital to the intensive care unit of the receiving hospital.

Abbreviations: ED, emergency department; ICU, intensive care unit; IQR, interquartile range; SD, standard deviation.

hospital transfer, patient characteristics (age, gender, presence of organ dysfunction, and comorbid illness), median LOS at the referring hospital, and receipt of CPR on the date of interhospital transfer were compared using chi-square tests for categorical variables, and Kruskal-Wallis tests for continuous variables. Similarly, outcome variables of in-hospital mortality and median LOS at the receiving hospital were compared across the 3 sources of interhospital transfer. Analysis of variance was used to compare mean LOS at the receiving hospital across the 3 sources of interhospital transfer. Median (with interquartile range [IQR]) and mean (with standard deviation [SD]) values are presented to describe LOS, given skew in LOS data.

To account for potential confounding of LOS and mortality at the receiving hospital by the presence of organ dysfunction and comorbid illness¹³⁻¹⁶ at the referring hospital, multivariate logistic regression and multiple linear regression analyses were conducted to estimate the odds of in-hospital mortality and the incremental LOS, respectively, for ward and inter-ICU transfers, compared with ED transfers. Statistical analyses were conducted using Stata 8 for windows (Stata Corporation, College Station, TX). A 2-tailed α level of 0.05 was used as the threshold for statistical significance.

TABLE 2
Primary Diagnostic Categories According to Transfer Source

Diagnostic Category (%)	Overall* (n = 1639)	Transfer Source		
		ED* (n = 1018)	Ward (n = 512)	Inter-ICU (n = 109)
Respiratory disease	35.1	32.8	41.0	28.4
Trauma	16.2	20.5	9.2	9.1
Neurological disease	12.4	12.5	12.3	11.9
Gastrointestinal disease	6.7	5.4	7.4	11.9
Infectious disease	5.8	4.0	8.4	10.0
Endocrine disease	5.5	7.9	1.8	0
Drug overdose/poisoning	5.0	6.4	2.9	1.8
Cardiovascular disease	4.8	2.8	6.3	16.5
Hematologic/oncologic disease	2.0	1.6	2.9	1.8
Cardiac arrest	0.2	0	0.6	0.9
Other diagnoses	6.2	5.4	7.2	7.7

*Diagnoses were missing in 4 admissions.

RESULTS

Patient Characteristics

Of 1,643 transfer admissions for intensive care during the study period, 1022 (62%) were ED transfers, 512 (31%) were ward transfers, and 109 (7%) were inter-ICU transfers. The average age was 2 years, with male gender (57%) predominance. Comorbid illness was present in 19% of admissions, while 11% had evidence of organ dysfunction at the referring hospital. Table 1 presents key patient demographic and clinical characteristics at the referring hospitals, by transfer source. Inter-ICU and ward transfers were younger than ED transfers, and had a higher preponderance of comorbid illness and organ dysfunction. At the time of interhospital transfer, compared with ED transfers, the proportion of admissions with organ dysfunction (a marker of illness severity) was 3-fold and 8-fold higher among ward and inter-ICU transfers, respectively.

Patterns of Transfer

The leading diagnoses among all children were respiratory disease, trauma, and neurological disease (Table 2), with some variation in diagnoses by source of interhospital transfer. For example, cardiovascular disease was the second leading diagnosis after respiratory disease among the inter-ICU transfers, while more children with endocrine disease (predominantly diabetic ketoacidosis), traumatic injury, or drug poisoning were transferred directly from the ED, than from the ward or

TABLE 3
Ten Leading Medical-Surgical Procedures and Services Rendered at the Receiving Hospital According to Transfer Source

Characteristics (%)	Overall (n = 1643)	Transfer Source			P
		ED (n = 1022)	Ward (n = 512)	Inter-ICU (n = 109)	
Respiratory	26.8	19.0	36.7	54.1	<0.01
Radiological	21.2	19.5	20.5	41.3	<0.01
Vascular access	20.0	15.2	27.0	33.0	<0.01
Gastrointestinal	3.9	3.0	3.7	12.8	<0.01
Neurological	3.8	3.2	3.7	10.1	<0.01
Cardiovascular	3.6	1.8	4.1	18.4	<0.01
Burn care	3.4	4.5	2.0	0	<0.01
General surgery	3.2	2.1	4.3	8.3	<0.01
Dialysis	2.6	2.0	2.5	8.3	<0.01
ECMO	2.1	1.3	2.2	9.2	<0.01

the ICU settings. For burn care, 80% (45/56) of all transfer admissions were direct from the ED (Table 3). The majority (78%) of children with traumatic injuries were directly transferred from the ED to the ICU, while the remainder were transferred after initial care delivered on the ward (18%) or ICU (4%) settings prior to interhospital transfer for definitive intensive trauma care. Importantly, among the inter-ICU transfers, 104 (95%) were transferred to pediatric ICUs from referring hospitals with adult and pediatric ICU facilities, suggesting uptransfer for specialized care. Five children were transferred between hospitals with adult ICU facilities.

CPR was performed on the date of interhospital transfer for 23 patients (1.4% of the sample), of whom 13 (56.5%) were ward transfers, 8 (34.8%) were inter-ICU transfers, and 2 (8.7%) were ED transfers ($P < 0.02$). Two-thirds of these children did not survive subsequent hospitalization at the receiving hospitals.

Clinical Outcomes and Resource Utilization at the Receiving Hospitals

At the receiving hospitals, other than burn care, medical-surgical procedures were performed most often among the inter-ICU transfers. Ward transfers also had higher receipt of procedures compared with ED transfers (Table 3). The inter-ICU and ward transfers had a higher preponderance of organ dysfunction at the receiving hospitals, compared to the ED transfers (38.5% and 29.3% versus 20.8%, $P < 0.01$).

TABLE 4
Patient Unadjusted Outcomes at the Receiving Hospital According to Transfer Source

Characteristics	Transfer Source			P
	ED (n = 1022)	Ward (n = 512)	Inter-ICU (n = 109)	
Mortality (%)	2.8	5.5	8.3	<0.01
Length of stay (days)				
Median (IQR)	3 (2–7)	5 (3–12)	13 (7–24)	<0.01
Mean (SD)	6.7 (10.4)	8.5 (9.2)	21.4 (22.9)	<0.01

Abbreviations: IQR, interquartile range; SD, standard deviation.

Clinical outcomes at the receiving hospitals varied significantly according to the source of interhospital transfer (Table 4). Sixty-six (4%) of patients died at the receiving hospitals. In comparison with ED transfers, unadjusted in-hospital mortality was 2-fold and 3-fold higher among the ward and inter-ICU transfers, respectively. Also, hospital LOS was significantly longer among the ward and inter-ICU transfers than for the ED transfers.

In multivariate analyses adjusting for patient age, and the presence of comorbid illness and organ dysfunction at the referring hospital, compared with ED transfers, odds of mortality were significantly higher (odds ratio [OR], 1.76; 95% confidence interval [CI], 1.02–3.03) for ward transfers. Inter-ICU transfers also had higher odds of mortality (OR, 2.07; 95% CI, 0.88–4.86), without achieving statistical significance. Similarly, compared with ED transfers, LOS at the receiving hospital was longer by 1.5 days (95% CI, 0.3–2.7 days) for ward transfers, and by 13.5 days (95% CI, 11.1–15.8 days) for inter-ICU transfers.

DISCUSSION

This study is the first to highlight significant variation in clinical outcomes and resource consumption after interhospital transfer of critically ill and injured children, depending on the source of transfer. In comparison with children transferred directly from the referring hospitals' ED settings, children transferred from the referring hospitals' wards had higher mortality, while those who underwent inter-ICU transfer had significantly higher resource consumption. In addition, ward transfers had the highest proportion of children who underwent CPR on the date of interhospital transfer, highlighting elevated severity of disease

prior to transfer and an urgent need for improved understanding of pretransfer clinical care and medical decision-making. The findings raise the possibility that more timely transfer of some patients directly from community hospital EDs to regional ICUs might improve survival and reduce resource consumption.

Although interhospital transfers are common in everyday clinical practice, there has been a knowledge gap in pediatric acute and critical care medicine regarding the clinical outcomes and resource consumption among children who undergo such transfers. Findings from the current study narrow this gap by relating triage at the referring hospitals to clinical outcomes and resource utilization at the receiving hospitals.

Certain distinct transfer patterns were observed. Most children with burn injury underwent direct transfer from the ED to the ICU; this transfer pattern may be related both to the limited availability of ICUs with burn care capability in Michigan and to the acuity of burn injuries, which often mandates immediate triage to hospitals with intensive burn care facilities. Conversely, while the majority of children with traumatic injuries were directly transferred from emergency to intensive care, over one-fifth were transferred after initial care delivered on the ward or ICU settings prior to interhospital transfer for definitive intensive trauma care. Such imperfect regionalization of trauma care suggests further study of clinical outcomes and resource utilization among injured children is warranted. Likewise, cardiovascular disease was prominent among the inter-ICU transfers, suggesting a clinical practice pattern of stabilization and resuscitation at the initial ICU prior to interhospital vertical or uptransfer for definitive cardiac care at the receiving hospitals.

It remains unknown whether the timing of interhospital transfer of critically ill children is a determinant of clinical outcomes. Prior studies among adults have reported higher mortality with prolonged duration of pre-ICU care on the ward.^{4,17} In the current study, ward and inter-ICU transfers were initially hospitalized for a median of 1 and 3 days, respectively, prior to transfer. While we could not determine from administrative data what the precise triggers for interhospital transfer in this study were, it is instructive to note that ward transfers comprised more than one-half of all children who received CPR on the date of transfer. For children who received CPR, severe

clinical deterioration likely triggered transfer to hospitals with ICU facilities, but because only a minority of children received CPR overall, other triggers of transfer warrant investigation. For most of the children transferred, it seems plausible that the precipitant of transfer was likely a mismatch of their clinical status with the clinical capacities of the facilities where they were initially hospitalized. Future work should investigate if there is an association between clinical outcomes at the receiving hospitals, and both the timing of interhospital transfer and the clinical status of patients at transfer.

Importantly, compared with ED transfers, ward transfers demonstrated elevated odds of mortality after adjustment for coexisting comorbid illness, patient age, and pretransfer organ dysfunction at the referring hospital. Some possible explanations for this finding include the progression of disease while receiving care on the ward, or suboptimal access to ICU facilities due to barriers to transfer at either the referring or receiving hospitals. Importantly, progression of disease in ward settings may be detected by early identification of children at high risk of clinical deterioration on the wards of hospitals without ICU facilities, prior to cardiopulmonary arrest, because death after CPR may not be averted with subsequent ICU care.¹⁸

Various approaches to facilitate rapid and appropriate triage and reassessment of children in hospitals without ICU facilities, prior to severe clinical deterioration or need for CPR, must be investigated. These approaches might include in-hospital measures such as the establishment of medical emergency teams to respond to clinical deterioration on the wards¹⁹ or collaborative interhospital measures such as the use of telemedicine²⁰ or similar remote communication/triage systems to enhance communication between clinical caregivers at hospitals with ICU facilities and those in hospitals without ICU facilities. Furthermore, interhospital transfer agreements may facilitate expeditious and appropriate transfer of severely ill patients to hospitals with ICU facilities.

Access to hospitals with ICU facilities might also influence outcomes for critically ill children admitted initially to wards of hospitals without ICU facilities. Kanter² reported significant variation in mortality among children who received care at New York hospitals without ICU facilities. Of note, 27% of statewide pediatric inpatient deaths occurred in those hospitals without ICU

facilities. It appeared that, while some pediatric deaths in hospitals without ICU facilities were expected, regional variation in such mortality might have been associated with reduced access to, or poor utilization of, hospitals with ICU facilities. Barriers to interhospital transfers might include underrecognition of mismatch between patient illness severity and hospital capability at referring hospitals, or lack of capacity to accept transfers at the receiving hospitals. Further study is warranted to investigate clinical decision-making underlying the initiation of the interhospital transfer processes, and procedural or institutional barriers that might hinder the transfer of critically ill children from hospitals without ICU facilities.

Resource consumption at the receiving hospitals, measured by hospital LOS and receipt of medical-surgical procedures, was highest among the inter-ICU transfers. This was an expected finding, given the high frequency of organ dysfunction among the inter-ICU transfers, before and after interhospital transfer. These patients had the highest use of advanced and resource-intensive technology, including continuous renal replacement therapy, extracorporeal membrane oxygenation, and cardiovascular procedures such as open-heart surgery. In addition, the duration of hospitalization at the receiving hospital was 2 weeks longer among the inter-ICU transfers when compared with the ED transfers. Such prolonged hospitalization has been previously associated with significantly increased resource consumption.^{4,6} In the absence of physiologic data pertaining to illness severity, however, it is unknown whether this observed differential LOS by source of interhospital transfer might be attributable to both unobserved illness severity and/or extensive in-hospital post-ICU multidisciplinary rehabilitative care for inter-ICU transfer patients, compared with ED transfer patients.

Our study findings need to be interpreted in light of certain limitations. Administrative claims data do not allow for assessment of the quality of hospital care, a factor that might play an important role in patient clinical outcomes. The data lacked any physiologic information that might enhance the ability to estimate patient severity of illness; the analysis used the presence of organ dysfunction at the referring hospitals as a proxy for illness severity. The use of diagnosis code-based measures of severity adjustment, as employed in the current study, however, has been reported to be comparable with clinical severity measures

because of the relatively complete capture of diagnosis codes for life-threatening conditions occurring late in the hospitalization, such as prior to interhospital transfer in the current study.^{21–23}

The absence of clinical information prevented assessment of the likelihood of in-hospital morbidity, transport complications, and need for various therapeutic interventions after ICU care, which are also highly relevant outcomes of interhospital transfers. It is unknown if the small sample size among inter-ICU transfers limited the ability to demonstrate a statistically significant difference in odds of mortality among inter-ICU transfers compared with ED transfers.

Also, the identification of diagnoses and procedures was made using multiple coding instruments and is therefore susceptible to inaccuracies of detection and attribution that may have biased the findings. Study findings did not include cost, because cost data were not available for children enrolled in Medicaid managed care plans under capitated arrangements. Finally, it is unknown how generalizable the current study findings might be to children with private insurance, or to children who are uninsured.

The study findings highlight potential opportunities for future research. Further studies are warranted to identify key characteristics that differentiate children admitted to nonpediatric hospitals who are subsequently transferred to pediatric hospitals with ICU facilities versus the children who are not transferred. Also, in-depth study of the decision-making that underlies interhospital transfer of critically ill or injured children to hospitals with ICU facilities for advanced care after initial hospitalization is vital to improved understanding of factors that might contribute to the extensive resource consumption and mortality burden borne by these children. The existence and effectiveness of interhospital transfer agreements at the state level needs to be examined specifically as it relates to patterns and clinical outcomes of interhospital transfer of critically ill and injured children in the US.

In conclusion, in this multiyear, statewide sample among critically ill and injured children enrolled by a statewide public payer, clinical outcomes were worse and resource consumption higher, among children who underwent interhospital transfer after initial hospitalization compared with those transferred directly from referring EDs. The findings raise the possibility that more timely transfer of some patients directly from community

hospital EDs to regional ICUs might improve survival and reduce resource consumption.

Efforts to improve the care of critically ill and injured children may be enhanced by improved understanding of the medical decision-making underlying interhospital transfer; application of innovative methods to identify and ensure rapid access to clinical expertise for children initially admitted to hospitals without pediatric intensive care facilities who might subsequently require intensive care; and routine reassessment of hospitalized children to ensure effective and efficient triage and re-triage at the ED, ward, and ICU levels of referring hospitals.

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