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Mass Transfer of Pediatric Tertiary Care Hospital Inpatients to a New Location in Under 12 Hours: Lessons Learned and Implications for Disaster Preparedness

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Objective To report an experience with large-scale rapid transportation of hospitalized children, highlighting elements applicable to a disaster event.

Study design This was a retrospective study of the relocation of an entire pediatric inpatient population. Mitigation steps included postponement of elective procedures, implementation of planned discharges, and transfer of selected patients to satellite hospitals. Drills and simulations were used to estimate travel times and develop contingency plans. A transfer queue was modified as necessary to account for changing acuity. The Hospital Incident Command System was used.

Results Thirteen critical care teams, 5 general crews, 2 vans, and 4 other vehicles transferred a total of 111 patients 8.5 miles in 11.6 hours. Patients were transferred along parallel (vs series) circuits, allowing simultaneous movement of patients from different areas. Sixty-four patients (including 32 infants) were considered critically ill; 24 of these patients required ventilator support, 3 required inhaled nitric oxide, 30 required continuous infusions, and 4 had an external ventricular drain. There were no adverse outcomes.

Conclusions Mass inpatient pediatric transfers can be managed rapidly and safely with parallel transfers. Preexisting agreements with regional pediatric teams are imperative. Disaster preparedness concepts, including preplanning, evacuation priorities, recovery analysis, and prevention/mitigation, can be applied to this event. *(J Pediatr 2010;157:138-43)*.

The large-scale rapid transfer of pediatric patients is challenging. Infants and children involved in a mass casualty incident (MCI) have a high risk of toxic exposure and hypothermia and limited ability to care for themselves during a crisis. Pediatric patients require different medical care than adults involved in the same disaster event.[1-6]

The American Academy of Pediatrics and American College of Emergency Physicians have published shared guidelines for pediatric preparedness in the emergency department (ED).[7] Unfortunately, many providers feel inadequately trained in pediatrics, and only 6% of EDs in the United States have all necessary supplies for pediatric emergencies.[3,4,6,8-13] Accordingly, severely injured children have improved outcomes when transported by pediatric-trained teams and treated at specialized pediatric centers.[12,14] Despite these issues, however, most disaster plans do not differentiate between adult and pediatric patients.[15]

The Hurricane Katrina rescue effort raised the question of whether adult hospitals should be bypassed for more distant pediatric facilities when moving pediatric patients.[16] Evacuation of pediatric patients from New Orleans was not coordinated centrally. Instead, multiple pediatric centers organized transportation of individuals to their respective institutions. This resulted in a random pattern of transportation and a limited scope of pediatric care. A regional model would facilitate more comprehensive and organized care.[17] In this model, each pediatric institution must be prepared to evacuate its own facility and also to assist with evacuation of other facilities.[4,18]

In 2007, our tertiary care children's hospital moved its inpatient census 8.5 miles from the existing 262-bed location to a new 270-bed facility with an additional 25-bed psychiatric unit.

AC	Acute care
CC	Critical care
CCT	Critical care transport
ED	Emergency department
EHR	Electronic health record
FFL	Flight for Life
HICS	Hospital Incident Command System
MCI	Mass casualty incident

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The authors declare no conflicts of interest.

 10.1016/j.jpeds.2010.01.047

Methods

This was a retrospective study of the relocation of an entire pediatric inpatient population. Planning for this event included development of the first known pediatric-specific hospital movement plan. Moving documents and electronic health records (EHRs) for patients moved were reviewed. Extracted data included patient age, gestational age, pertinent medical history, critical care (CC) status, and any necessary pediatric medical devices. Data recorded included medications given during transportation, unanticipated treatments, and any adverse events. EHRs were also reviewed for any associated adverse events occurring between 7 am and 12 am (a minimum of 4.5 hours posttransfer) on the day of the move. The After Action Report was reviewed as a postmove assessment. Key administrators were interviewed (with informed consent) regarding unanticipated problems and MCI-relevant lessons learned.

Drills and Simulations

A mock transfer of 7 patients was performed to estimate transportation times and equipment needs, compare driving routes, and test the communication system. A 2-loop system with separate routes for ambulance and other traffic was used. After this exercise, city officials agreed to adjust the traffic lights to improve flow along the ambulance path, but could not guarantee security support.

A computer simulation model was developed using Flexsim 4.0 software (Flexsim Software Products, Inc., Orem, Utah). Time distributions were tabulated from the mock move and educated assumptions. The simulation included 3 transport options (CC ambulance, non-CC ambulance, and van) and 4 patient types (critically ill infants requiring isolettes, critically ill noninfants, non-critically ill ambulance patients, and low-acuity van patients). Variance was built into the model. Initial simulations estimated 36 hours for the transfer of 175 patients. The model was refined until an estimate of 11.7 hours was attained, to minimize the overuse of staff and resources, cost, and patient risk associated with prolonged operation of 2 facilities. The final configuration involved 18 ambulances with 7 loading zones and 10 unloading zones. In this model, CC ambulances moved all CC patients before assisting with the transfer of any remaining non-CC patients. Non-CC ambulances moved only the noncritical acute care (AC) patients, and vans moved only low-acuity and psychiatric patients. Computer simulations identified a limited availability of pediatric CC transport (CCT) teams and isolettes as rate-limiting factors in rapid pediatric patient movement.

Implementation of MCI Transport and Rescue Principle

The Noria principle of MCI transport and rescue supports unidirectional patient movement. Routes should not cross other paths or impact zones, and the efficiency of transfer is maximized by a conveyor-belt formation.[19] We created 6 continuous and independent circuits: packing and unpacking teams, distinct AC and CC populations, and separate routes for ambulance and equipment traffic (Figure 1). Patients were moved along parallel circuits rather than in series (or full unit by unit), so that patients from different areas of the hospital could be moved simultaneously without overloading any single unit. This gave the staff adequate time to safely pack and unpack each patient. At the new facility, care was transferred to an unpacking team, and the ambulance was cleaned by a separate crew. The transport team then collected a clean stretcher from a surplus supply before returning to the old facility.

Transport Agreements

A memorandum of understanding was developed with Flight for Life (FFL), our hospital's primary pediatric CCT service for the transportation of CC patients during the move. AC patient transfer agreements were arranged with a local advanced life support-equipped private ambulance service. Additional memorandums of understanding were arranged with 3 pediatric CCT teams from regional subspecialty centers. These visiting CCT teams provided 1 additional ambulance and 3 isolettes. All transportation providers attended a 1-day training session that covered communication protocols; training on car seats, isolettes, and a new stretcher restraint system; orientation to facilities; command cells; check-in/checkout procedures; pack-up checklists; and move routes.

Pediatric-Specific Considerations and Equipment

A 5-level patient classification system was developed based on patient acuity and equipment needs (Table I). Infection

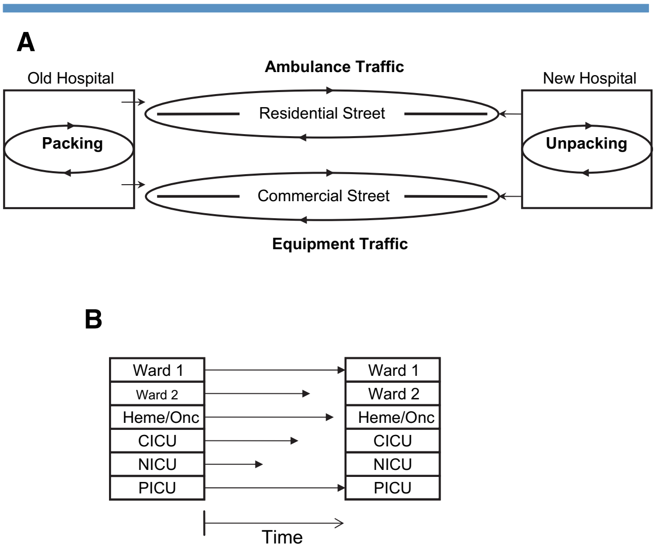

Figure 1. **A,** Four continuous, unidirectional, and independently functioning circuits, including patient packing and unpacking and the separate driving routes for ambulance and equipment traffic. **B,** Transfer in parallel allowed each unit to move patients at an appropriate pace. Arrows of different sizes represent patients at various stages of transport.