

# Ambulance stretcher adverse events

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## ABSTRACT

**Introduction:** Ambulance personnel use wheeled stretchers for moving patients in the out-of-hospital setting. The nature of adverse events and associated injuries occurring during ambulance stretcher operation was characterised.

**Methods:** Data from the United States Food and Drug Administration's Manufacturer and User Facility Device Experience Database (MAUDE) were used. All adverse events involving ambulance stretchers during the years 1996–2005 were identified. The nature of the event, the method of stretcher handling, the individuals injured and the nature of the resulting injuries were identified.

**Results:** There were 671 reported adverse events. The most common adverse events were stretcher collapse (54%; 95% CI 50 to 57%), broken, missing or malfunctioning part (28%; 95% CI 25 to 32%) and dropped stretcher (7%; 95% CI 5 to 9%). Adverse events most commonly occurred during unloading of the stretcher from the ambulance (16%; 13 to 19%). Injuries occurred in 121 events (18%; 95% CI 15 to 21%), most often involving sprains/strains (29%), fractures (16%) and lacerations/avulsions (13%). There were three traumatic brain injuries and three deaths. Patients sustained injuries in 52 events (43%), and ambulance personnel sustained injuries in 64 events (53%). More than one individual sustained injuries in 12 events.

**Conclusion:** Adverse events may occur during ambulance stretcher operation and can result in significant injury to patients and ambulance personnel.

Emergency Medical Services (EMS) ambulance personnel provide medical care to out-of-hospital patients. The important roles of EMS include response to requests for 911 emergency help, rapid assessment and on-scene treatment of patients, and triage and transport of patients to appropriate receiving hospital facilities. Each year in the United States, EMS ambulances transport over 16 million patients to hospital emergency departments.<sup>1</sup>

A unique task in EMS ambulance care is the physical handling and movement of out-of-hospital patients. These essential functions include extrication of the patient, movement of the patient to the ambulance, transport of the patient to the receiving hospital and transfer of the patient from the ambulance to the receiving hospital bed or stretcher. These tasks may occur in cramped or unsafe locations such as the third floor of patients' homes, shopping malls or even the wreck of a motor vehicle collision. The primary device used by rescuers for mobilising patients in the out-of-hospital environment is the wheeled ambulance stretcher.

Ambulance stretchers must be light (to facilitate field portability), strong (to handle large patient loads) and compact (to allow movement through

cramped spaces). Modern ambulance stretchers contain mechanisms to facilitate a variety of key tasks such as movement, changing of stretcher height, and loading into and unloading from the ambulance patient compartment (figs 1, 2). A specialised fastening system secures the stretcher to the ambulance floor during transportation (fig 3).

While individual reports highlight adverse events associated with ambulance stretcher operation, there are presently no systematic descriptions of these incidents.<sup>2,3</sup> In this study, we characterise the nature of adverse events and associated injuries occurring during the operation of EMS ambulance stretchers.

## METHODS

This study was approved by the Institutional Review Board of the University of Pittsburgh.

We used data from the United States Food and Drug Administration's Manufacturer and User Facility Device Experience database (MAUDE), which contains information regarding adverse events involving medical devices. FDA regulations require medical device manufacturers to provide written reports regarding deaths, serious injuries or malfunctions resulting from medical device use. In addition, user facilities and manufacturers may submit voluntary reports. The data are collected using standard reporting forms (Form FDA 3500A) and entered into a publicly accessible database.<sup>4</sup> The MAUDE database describes each event, detailing the reporting source, the date, location and type of event, manufacturer's information and resulting injuries. The database also contains a narrative summarising the pertinent details of the event.

For this analysis, we searched the MAUDE online database for all incidents from 1 January 1996 through 31 December 2005 involving wheeled stretchers (product code FPO). We excluded incidents involving hospital stretchers or other transportation devices, determined by examining the stretcher manufacturer name and model. Because the MAUDE database distinguishes multiple reports for the same incident, we were able to identify and exclude any duplicates from the final data set.

We reviewed the narrative of each report, identifying the nature of the adverse event, the method of stretcher handling at the time of the incident, the individuals injured during the event, if any, and the associated injuries. Two members of the study team independently reviewed all cases, and a third member of the study team adjudicated any discordances. We abstracted the data using standard data collection forms and entered the information on a computer database.

## Error management



**Figure 1** Adjusting ambulance stretcher height. Ambulance personnel must simultaneously activate mechanical triggers at each end of the stretcher, coordinate manual stretcher lifting or lowering, then re-actuate the mechanism to lock the wheeled undercarriage in place.

We broadly classified the adverse events as (1) collapsed stretcher, (2) broken, missing or malfunctioning part, (3) stretcher drop or fall not otherwise specified, (4) tipped stretcher, (5) isolated rescuer injury during stretcher operation, and (6) failure of stretcher fastening system. “Collapsed stretcher” referred to instances where the wheel carriage failed, allowing the stretcher to suddenly fall from a raised position to the ground. “Broken, missing or malfunctioning part” referred to isolated stretcher component failures; for example, frame or side bar fracture. “Stretcher drop or fall” referred to instances where the stretcher was dropped or the patient fell without any additional explanation. “Tipped stretcher” included instances where the stretcher tilted over from a vertical position; for example, if a wheel struck a ground object, causing the stretcher to tip over. Examples of “isolated rescuer injury” included injuries (for example, back strains, pinched extremities, etc) occurring during stretcher operation. The last adverse event category referred to physical or operational failure of the mechanism fastening the stretcher to the ambulance (fig 3).

We classified the method of stretcher handling as: (1) unloading stretcher from ambulance, (2) moving (ie, pushing/pulling) stretcher, (3) adjusting stretcher height, (4) transferring patient on/off stretcher, (5) loading stretcher onto ambulance, (6) lifting stretcher and (7) transporting stretcher in moving ambulance.

We identified the types (patient, ambulance personnel or other) and number of individuals injured in each adverse event. We classified the injuries as: (1) strain/sprain, (2) fracture, (3) laceration or avulsion, (4) contusion or abrasion, (5) death, (6) traumatic brain injury or (7) other injuries. If there was more than one potential adverse event, stretcher handling or injury classifications, we identified the most prominent categories by study team consensus.

We analysed the data using descriptive statistics, identifying the appropriate 95% CIs. We analysed the data using Microsoft Access and Excel (Microsoft Corp. Redmond, WA) and STATA version 9.2 (Stata, College Station, TX).

## RESULTS

Of 863 unique reports involving wheeled stretchers, we excluded 192 hospital stretcher incidents, resulting in a final



**Figure 2** Unloading stretcher from ambulance. One operator lifts the foot of the stretcher out of the ambulance while the other operators guides the wheeled undercarriage until it locks in place. A safety catch bar prevents the head of the stretcher from rolling out of the ambulance.

dataset of 671 ambulance stretcher adverse events. Of the 671 reports, 630 (94%) were manufacturer reports, 14 (2%) were voluntary reports, and 27 (4%) were user facility reports.

Over half of the reported events involved a stretcher collapse (table 1). Broken, missing or malfunctioning parts comprised an additional one-fourth of the adverse events.

The method of stretcher handling was unknown for most of the incidents (table 2). Of the remaining events, the most common tasks were unloading of the stretcher from an ambulance, moving the stretcher and adjusting the height of the stretcher.

Injuries occurred to 130 individuals in 121 (18%; 95% CI 15 to 21%) adverse events (table 3). Stretcher collapses and tips caused most (54%) of the injuries. While most of the injured individuals were ambulance personnel, substantial numbers of patients also sustained injury. Other injured individuals included nurses (not part of the ambulance crew) and patient family members. In nine events, more than one rescuer was injured, and in three instances the patient and at least one ambulance personnel was injured. Traumatic brain injuries occurred in three events, and death occurred in three instances.

The three traumatic brain injuries included: (1) a bystander assisting with stretcher unloading fell off the ambulance when the stretcher collapsed; (2) a patient struck his head on the ground after the stretcher collapsed during unloading from the ambulance; and (3) an ambulance attendant sustained injuries in a rollover ambulance accident where the stretcher disengaged

**Table 1** Nature of reported adverse events

Adverse event	Frequency (percentage; 95% CI)
Collapsed stretcher	360 (54%; 50 to 57%)
Broken, missing or malfunctioning part	189 (28%; 25 to 32%)
Dropped stretcher or patient fall not otherwise specified	48 (7%; 5 to 9%)
Tipped stretcher	30 (4%; 3 to 6%)
Isolated rescuer injury during stretcher operation	13 (2%; 1 to 3%)
Failure of stretcher fastening system	4 (1%; 0 to 2%)
Unknown	27 (4%; 2 to 5%)

Total of 671 events.

from the fastening system. The three deaths included: (1) a patient died from injuries sustained in an ambulance accident where the stretcher fastening system fractured; (2) a patient died from injuries sustained after the stretcher tipped over; and (3) a patient died from complications from a stretcher skin pinch injury.

## DISCUSSION

The physical extrication, movement and transportation of out-of-hospital patients are integral components of EMS care. The ambulance stretcher plays an essential role in these tasks, facilitating the movement of ill or injured patients who are often incapacitated and unable to walk, sit or stand. The stretcher is also the primary device for securing the patient in the moving ambulance.

Our study identifies numerous adverse events associated with ambulance stretcher operation. Of the 671 adverse events, over one in five were associated with injury to the patient, ambulance personnel or other individuals. In several instances, more than one individual was injured. Many of the resulting injuries were serious, including fractures, traumatic brain injury and even death. Mandatory and voluntary reporting systems, including those involving medical devices, often underestimate the frequency and/or severity of adverse events.<sup>5-6</sup> Thus, our series likely provides only a glimpse at the nature and potential extent of these incidents.

Our current effort offers one of the first perspectives of the range and results of adverse events occurring during ambulance stretcher operation. Prior efforts describe the ergonomics but not the epidemiology of stretcher movement and operation.<sup>7-8</sup> Other efforts highlight the prominence of EMS personnel occupational injuries, which include disabling back injuries as observed in this series.<sup>9-10</sup> Government advisories have alluded to ambulance stretcher adverse events, underscoring their operational complexities and the need for adequate maintenance and

**Table 2** Method of stretcher handling at time of adverse event

Method of stretcher handling	Frequency (percentage; 95% CI)
Unloading stretcher from ambulance	108 (16%; 13 to 19%)
Moving stretcher	28 (4%; 3 to 6%)
Adjusting stretcher height	21 (3%; 2 to 5%)
Transferring patient on/off stretcher	18 (3%; 2 to 4%)
Loading stretcher onto ambulance	17 (3%; 1 to 4%)
Lifting stretcher	7 (1%; 0 to 2%)
Transporting stretcher in ambulance	5 (1%; 0 to 2%)
Unknown	467 (70%; 66 to 73%)

Total of 671 events.

operator training.<sup>2-3</sup> In an analysis of EMS tort insurance claims data, we found that patient-handling adverse events (including those involving stretchers) comprised the second largest portion of EMS tort claims.<sup>11</sup>

In this series, there were inadequate data to determine causality. However, many of the narratives may have mis-attributed individual adverse events to operator error. The human factors engineering safety literature distinguishes between "user error" and "use error." User error (sometimes called operator error) refers to isolated lapses in human-device interaction. In contrast, use errors denote *systematic patterns* of error, often attributable to inadequate design.<sup>12</sup> Device usability can directly influence the frequency of use error.<sup>13-14</sup> Our series highlights the prominence of several specific categories of events, suggesting the presence of underlying use errors amenable to design improvements.

For example, over half of the adverse events and most of the injuries involved stretcher collapse. Ambulance stretchers contain a wheeled undercarriage coupled by complex mechanisms to allow positioning of the stretcher at different heights (figs 1, 2). To change the height of the stretcher, two operators must simultaneously squeeze levers at the head and foot of the stretcher while manually raising or lowering the stretcher and feeling for the actuation of the locking mechanism. Improved audible, visual or other feedback systems could help to verify actuation of the locking mechanism. The most innovative stretchers contain hydraulic lifting mechanisms, but these systems are not widely used due to their cost and weight.

The same mechanisms also facilitate stretcher loading onto and unloading from the ambulance patient compartment, which may be situated 2-3 feet over the ground surface. During unloading, one operator holds the foot of the stretcher, while the other operator guides the undercarriage downwards (fig 2). If the undercarriage lock does not actuate, the stretcher will collapse as it is unloaded from the ambulance. Once again,

**Table 3** Injuries from ambulance stretcher adverse events

Type of injury	Individual injured			Frequency (percentage; 95% CI)
	Patients	Ambulance personnel	Other	
Strain/sprain	3	35	0	38 (29%; 22 to 38%)
Fracture	12	9	0	21 (16%; 10 to 24%)
Laceration/avulsion	12	4	1	17 (13%; 8 to 20%)
Contusion/abrasion	2	2	0	4 (4%; 1 to 8%)
Death	3	0	0	3 (3%; 1 to 7%)
Traumatic brain injury	1	1	1	3 (3%; 1 to 7%)
Other injury	5	4	0	9 (7%; 3 to 13%)
Unknown	12	16	7	35 (27%; 20 to 35%)
Total	50 (38%; 30 to 47%)	71 (54%; 46 to 63%)	9 (7%; 3 to 13%)	130

Total of 121 injury events. More than one individual may have sustained injury from a single adverse event. Percentages and confidence intervals reflect a total of 130 injured individuals.

improved feedback systems could help to verify this key step. Stretcher loading ramps exist but are not commonly used due to their space requirements.

While patient safety principles emphasise system- or design-level improvements, our observations also underscore the ingrained role of user-device interaction in ambulance stretcher operation. The Emergency Medical Technician curriculum in the United States covers basic patient movement and handling techniques but does not address more complex situations; for example, the movement of a morbidly obese patient.<sup>15</sup> Few formal curricula cover the ergonomics of patient lifting and moving. Increased training and emphasis in these areas could help to improve the safety of both patients and ambulance personnel.

This study contains important limitations. Our analysis describes a series of ambulance stretcher adverse events but does not indicate their prevalence or incidence, figures that would require prospective data collection. Our analysis included only adverse events reported to the MAUDE database and may underestimate the true frequency of these incidents. Since it is compulsory for manufacturers to report events involving device failures to the MAUDE database, events perceived as involving operator error may be disproportionately under-reported.

The design of the MAUDE database provided only limited perspectives of each adverse event. For example, we were able to identify the nature of handling for only 30% of the events, and we were not able to ascertain causality. Also, we could not

characterise the affected patients or ambulance personnel. While we were able to ascertain the types of injuries resulting from stretcher adverse events, we were unable to determine long-term outcomes. While we used common terminology to characterise the stretcher incidents, standard definitions and terms for these events presently do not exist.

While we did not stratify the adverse events by the manufacturer or stretcher model, most of the incidents involved products manufactured by the two leading manufacturers in the United States (Ferno-Washington, Wilmington, Ohio, and Stryker, Kalamazoo, Michigan). Our findings may not be generalizable to brands and designs of other countries.

In conclusion, we found that adverse events may occur during ambulance stretcher operations, and can result in significant patient and/or ambulance personnel injury. Additional design and educational advancements may improve this important aspect of EMS patient and provider safety.

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**Figure 3** Stretcher-fastening system. The mechanism secures the stretcher to the ambulance floor during transportation.