Published in final edited form as:

Plast Reconstr Surg. 2016 January ; 137(1): 100e–111e. doi:10.1097/PRS.0000000000001879.

Hand Trauma Care in the United States: A Literature Review

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Abstract

BACKGROUND—Hand trauma is one of the most complex injuries treated in the emergency department. They are time sensitive and require highly specialized care. Patients may have difficulty accessing appropriate hand trauma care due to a variety of factors. We aimed to evaluate the state of the hand trauma system by examining articles that reported on access to hand trauma care.

METHODS—We conducted a literature review on hand trauma care using PubMed, Ovid MEDLINE, and EMBASE databases. We included English language articles from the U.S. that described access to hand trauma care in the emergency health system.

RESULTS—Fourteen studies met our inclusion criteria. Ten studies evaluated access to hand trauma care on a patient level. Of these 10 studies, five reported on access to care for transferred patients and five reported on access to care for patients with amputation injuries. The other four studies evaluated access to hand trauma care at a hospital level.

CONCLUSIONS—Lack of hand trauma guidelines at emergency departments and a severe shortage of on-call hand specialists at community hospitals and trauma centers have created a suboptimal system of hand emergency care in the U.S. The current system of hand trauma care in the U.S. may not only drive up the cost of care but may also adversely affect patients' health and well-beings.

Introduction

The hand is the most common body part to be injured.^{1,2} Hand injuries can have devastating and long-term social and economic consequences, affecting not only an injured individual's

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Financial disclosure: None of the authors has a financial interest in any of the products, devices, or drugs mentioned in this manuscript. This work was supported by the Midcareer Investigator Award in Patient-Oriented Research (2 K24-AR053120-06) (to Dr. Kevin C. Chung).

health and functioning, but also hindering his/her family's livelihood and society as a whole.³ Severe hand trauma cases are complex and their optimal treatments are time sensitive.⁴ Often, patients have to drive for hours to different locations in search of a trauma center with a specialized hand surgeon.^{5,6} Although there are numerous instances of transferred cases that do not need hand specialists and whose transfers are mainly driven by insurance status or off-hours patient presentations,⁷ there are also many preventable amputations, leading to substantial disabilities that could have been prevented had patients been efficiently transported to an appropriate trauma center.^{5,8} This suboptimal system of hand trauma care in the U.S. may not only drive up the cost of trauma care but may also prevent the healthcare system from equitable improvement in patients' health-related quality of life.⁸

Economically vulnerable populations such as minorities, uninsured or underinsured individuals, and people living in rural areas often face numerous barriers to accessing an appropriate level of hand trauma care.⁹⁻¹² Despite an extensive body of literature regarding emergency, trauma, and regionalization of care in general, there is a paucity of evidence regarding best practices for hand trauma care in the U.S. The Institute of Medicine (IOM) emphasized the need for an accountable and equitable emergency care system in the U.S. in its 2006 report.¹³ The purpose of this study is to conduct a literature review of the hand trauma system in the U.S. This study has two specific aims: (1) evaluate studies of hand trauma injuries that examine access to care, and (2) evaluate how barriers in access to care influence outcomes of hand trauma injuries.

Materials and Methods

Literature search

We conducted a search of the available English language literature using the PubMed, Ovid MEDLINE, and EMBASE databases (Figure 1). The search was conducted on March 3, 2015. We searched the databases using variations of the following key words: "hand injuries" AND "trauma centers" AND "outcome" or "access." We expanded these terms to include the corresponding MeSH and Emtree subject headings. We then limited the search to human subjects. Details of the search terminology can be found in Table 1. After duplicates were eliminated, two reviewers separately screened the studies by reviewing the titles and abstracts to eliminate articles unrelated to our topic. The same two reviewers then reviewed the full text of the remaining studies for inclusion and exclusion criteria. Citations in the remaining studies were manually screened to identify relevant studies not found through the initial search.

Study criteria

We included articles that met the following criteria: data from the U.S., English language full-text, reported traumatic injury to the hand, wrist, fingers, and/or thumb treated in the emergency room, and examined access to appropriate hand trauma care. We excluded articles not relevant to our topic, commentaries, surgical technique descriptions, general trauma transfer and treatment, non-emergent hand injuries, articles with data from countries other than the U.S., and articles not available in the full-text format.

Data abstraction

Two of the investigators independently abstracted data from the eligible articles. Data included total number of subjects, study setting and dataset used, transfer method, hospital level, specialist involved, time to treatment, type of injury, barriers to access, and overall findings. We considered barriers to access to include anything that affected the time it took to receive appropriate treatment of the hand injury.

Results

A total of 14 studies met our inclusion criterion. Because of the heterogeneity of findings, we divided the results into two categories: (1) studies examining access to hand trauma care on a patient level (Table 2), and (2) studies that performed hospital level analysis (Table 3).

In the first category, five studies focused on access to hand trauma care by way of transfer. Three studies reported patient-level information for a total of 1,476 non-transferred (1,229, 83%) and transferred (247, 17%) upper extremity emergency cases.^{6,7,14} Two studies reported patient-level information for a total of 349 transferred hand injuries.^{9,15}

Three studies emphasized differences between transferred versus non-transferred patients.^{6,7,14} The mean patient age was 39 and there was no significant difference between transferred (mean of 32) and non-transferred individuals (mean of 40). Although the majority of transferred and non-transferred patients were male, the percentage of males in the transferred group was higher (75% vs. 63%, $p < 0.05$). Melkun et al.¹⁴ compared the racial/ethnic mix between transferred and non-transferred groups and found no statistical differences between transferred and non-transferred groups (Whites: 53%, African-Americans: 5%, Hispanic: 37%, other races: 5%). Melkun and colleagues¹⁴ measured the difference in length of stay (LOS) in the hospital between the transferred and non-transferred groups. The percentage of patients discharged in less than 24 hours was 11% higher among the transferred group than the non-transferred group (61% vs. 50%, $p = 0.031$). Although neither study found significant differences between the two groups in insurance status, there was a substantial difference between the studies in each category. Melkun et al.¹⁴ reported that 66% of all patients were insured (with no significant difference between the transferred and non-transferred groups). The other two studies (using the same data over the same time period)^{6,7} reported a higher percentage of patients in the transferred group compared with the non-transferred group to be uninsured or underinsured (30% vs. 23%, $p < 0.05$). There were 77 (31%) amputations/devascularizations in the transferred group compared to 53 (4%) in the non-transferred group ($p < 0.05$). In summary, although patients in the transferred group had relatively more complicated hand injuries, they also had a higher percentage of underinsured or uninsured patients. These patients were twice as likely to be unnecessarily transferred.

Two studies examined transferred patients, with no reference to non-transferred patients.^{9,15} Bauer et al.¹⁵ examined the characteristics of 296 patients with hand emergencies transferred from an outside ED. The majority of patients were white males with a mean age of 45 years; 73% of patients had higher reimbursing insurance (private insurance, worker's compensation, or Medicare), and 23% of patients had lower reimbursing insurance

(Medicaid, charity and welfare, or self-pay). However, there was no difference in the likelihood of having surgery within 24 hours or seeing a hand surgeon on the day of transfer between these two insurance groups. For patients transferred on weekdays compared to patients transferred on weekends, the weekdays group was more likely to see a hand surgeon on the day of transfer (61% vs. 48%) and be taken to the OR within 24 hours (51% vs. 38%). Patterson et al.⁹ prospectively assessed 53 patients transferred for acute hand injury. The insurance status of these patients was 32% private, 21% worker's compensation, 17% Medicare, 15% Medicaid, and 15% uninsured. A hand surgeon was on call at the transferring facility for 15 (28%) cases, however only examined 3 of those patients before transfer and did not examine the other 12 cases. Twenty-two patients were transferred from hospitals with 2 or more orthopedic surgeons on staff and 2 or more hand surgeons on staff. Fourteen of these patients had Medicaid, Medicare, or were uninsured (64%) with the remaining 8 patients having private insurance or worker's compensation (4 each, 18%). At the receiving facility, it was determined that 13 (25%) of patients could have been treated at the initial facility or be seen as outpatients.

Also in the first category examining access to care at a patient level, five studies examined where and how patients with amputation injuries received care.^{16–20} Three of the studies focused on epidemiological aspects of amputation injuries and reported a total of 15,360 hand amputation injuries.^{18–20} The average rate of replantation was 18% (40% among children only).²⁰ Out of 2776 attempted replantations of fingers, thumbs, and wrists, 1774 (64%) were finger replantations. Individuals who had replantation were younger, with an average age of 36 compared with 44 among those who had revision amputation. Patients treated at teaching hospitals were more likely to undergo replantation than those treated at non-teaching hospitals (80% vs. 20%, $p < 0.001$). Individuals who had no insurance or who had Medicaid had lower replantation rates compared with patients with other insurance.

Shale et al.¹⁷ described 3341 patients with thumb amputations treated at 474 hospitals. Nonteaching hospitals treated 37% (1238/3341) of patients and attempted replantations for 10% (123/1238) of those patients with an 81% success rate. Teaching hospitals treated 63% (2103/3341) of patients and attempted replantations for 20% (427/2103) of those patients with an 86% success rate. Patients treated at teaching hospitals were 3.1 times more likely to undergo an attempted replantation than those at nonteaching hospitals. Patients at high-volume centers were 3.4 times more likely to undergo an attempted replantation than those at low-volume centers. Patients who smoked were significantly more likely to have a failed replantation attempt.

Ozer et al.¹⁶ reported on replantation and revision of amputated fingers for 40 patients who were air-transported to a level I trauma center. Out of 40 patients transferred only 15 underwent a replantation procedure (23 out of 70 digits). After physicians discussed issues such as survival rate, functionality of the injured digit, cost, and time to recover with the patients, six patients chose not to undergo a replantation procedure (although they were suitable for replantation). 19 patients (39 digits) were not suitable for replantation.

The second category consists of four studies that provide hospital-level information regarding availability of hospital hand emergency care for a total of 509 hospitals.^{12,21–23}

Two of these studies^{12,23} surveyed 124 hospitals; 56% of these hospitals provided basic emergency hand care. Only 13 out of 124 hospitals (10%) had on-call hand specialists available at all times; 47 hospitals (42%) had no emergency hand coverage, 46 hospitals had hand specialists, but 17 of them had no on-call coverage. Only 12 hospitals (10%) had full on-call hand emergency coverage. Peterson et al.²² surveyed all level I and II trauma centers. They found that out of 249 level I and II trauma centers only 93 covered hand surgery and microvascular replantation. Interestingly, out of 117 level I and 132 level II trauma centers, only 55% and 36% had hand surgeons on call, respectively. Chung et al.²¹ reported characteristics of the hospitals for the total of 304 finger and thumb replantations. Out of 906 hospitals in 1996 only 136 (15%) performed finger replantations. 60% of the 136 hospitals had only performed one finger replantation per year, 8% performed 5–9 cases, and merely 2% performed 10 or more of such procedures.

Discussion

Hand injuries represent more than 12% of all trauma cases in the U.S. and are the most common type of injuries treated in emergency departments (EDs). Although usually non-fatal, they are costly and may lead to lifelong disability and morbidity. Despite high demand, research suggests a substantial on-call coverage gap for surgeons. Thus, a high percentage of hand trauma patients must be transferred to level I or II trauma centers or academic hospitals. The 1986 Emergency Medical Treatment and Active Labor Act (EMTALA) requires hospitals that are unable to treat a trauma patient to stabilize and transfer the patient to a level I trauma center.⁷ Owing to the shortage of hand surgeons taking emergency calls and lack of national guidelines for transferring patients with acute hand trauma, the management of hand trauma care in the U.S. may not be efficient. This suboptimal system of care may not only increase healthcare costs by overusing the trauma system, it cannot provide the best health outcomes.²³ The goal of this study was to broadly examine the current literature on barriers to access to hand trauma care in the U.S. Our literature review indicates that there are system- and patient-level factors affecting access to hand trauma care.

At the system-level, factors such as the availability of hand specialists, lack of transfer guidelines at the local emergency department, location, teaching status, and volume of the hospitals that handle emergent trauma cases affect how hand trauma patients are treated. Our findings indicate that patients with amputation injuries who are admitted to larger (versus smaller), urban (versus rural), and academic teaching (versus non-teaching) hospitals have a higher likelihood of undergoing replantation compared to revision amputation. Lack of guidelines on hand trauma transfer and a severe shortage of on-call hand specialists in community hospitals make the proper diagnosis and transfer of hand trauma patients impossible.^{12,21} As a result, there are many hand trauma cases that could have been treated locally instead of being transferred to level I or II trauma centers and many cases that should have been transferred but were treated locally.¹⁶

At the patient level, age, smoking habits, race and ethnicity, and insurance status influence the treatment of emergent hand trauma.^{18,20} Controlling for other confounders, patients with hand amputation injuries who are African-Americans, Hispanics, uninsured, or underinsured

are less likely to receive attempted replantation (versus revision amputation).²⁰ Additionally, health factors such as age and smoking habits influence the success or failure of optimal treatment of hand trauma.¹⁶

This study has a few limitations. First, owing to the heterogeneity of the studies reviewed, we were unable to conduct a meta-analysis. However, the broad range of studies offered a holistic and complete view of both system and personal factors affecting hand trauma care. Second, because the majority of the studies were based on findings from one or two trauma centers or based on hand trauma cases from specific states, the results were not nationally generalizable. There were only a few nationally representative studies that compared epidemiological aspects of hand trauma patients, stratified by the treatment procedures provided. Further nationally representative studies of hand trauma care in the U.S. are required. Third, except in a few studies,¹⁷ severity of hand injuries were not reported, which made comparisons of the findings difficult. Despite these limitations, this study provides a comprehensive view of challenges facing the hand trauma care in the U.S.

IOM advocates for a reliable and equitable emergency care system.¹³ Research suggests that the current hand trauma system in the U.S. is far from being reliable and equitable. Although there is no shortage of elective hand surgery in the U.S., most hand surgeons are not willing to be on call for emergency hand care.^{6,7,14} Our literature review indicates that only a small fraction of level I trauma centers have full coverage and on-call hand surgeons. Second, lack of hand trauma guidelines in community hospitals and emergency departments, along with lack of on call emergency hand specialists, makes proper diagnosis and decisions regarding transferring or treating the patient locally almost impossible. Validated triage systems are already in place for burn and general trauma patients.^{6,7,16} Using these systems as a starting point, particularly the burn triage system because burn injuries are similar to hand injuries in that both are fairly specialized, would aid policymakers in this important task. Amputation injuries are one of the most common hand traumas. Proper transfer guidelines for amputation injuries could pave the way for future transfer guidelines for general or less common hand trauma cases. Third, research suggests that the majority of emergency transferred cases could have been treated locally had they been diagnosed properly by a hand specialist/surgeon at an emergency department. Policies for training and adequate numbers of hand specialists in community hospitals should also be considered. Another avenue might be consideration of telemedicine in hand trauma care, particularly in remote rural areas.²⁴

Furthermore, in the case of complex emergency hand trauma, research indicates that higher volume teaching hospitals with adequate equipment and experienced hand surgeons on call would provide higher quality hand trauma care. The concept of regionalization of care has been debated in many critical trauma cases. Considering the shortage of hand trauma surgeons in rural areas and certain states, regionalization of hand trauma care may be an option that needs further investigation.

To summarize, our literature review indicates that both system- (transfer guidelines, availability of hand specialist, hospital resources) and patient-level (insurance status, geographic location of residence, and race/ethnicity) factors influence timely access to

quality hand trauma care and therefore hand trauma outcomes. Considering that emergency hand traumas are the most prevalent emergency cases, hand surgery organizations and policy makers should invest in optimizing the system.

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Figure 1.
Flow chart describing review of literature

Table 1

Search terminology

PubMed (133 results)	Ovid MEDLINE (143 results)	EMBASE (159 results)
<p> ("hand injuries"[mh] OR "wrist injuries"[mh] OR "hand injury"[tiab] OR "hand injuries"[tiab] OR "hand accident"[tiab] OR "hand accidents"[tiab] OR "hand emergency"[tiab] OR "hand emergencies"[tiab] OR "hand trauma"[tiab] OR "hand lesion"[tiab] OR "hand lesions"[tiab] OR "hand wound"[tiab] OR "hand wounds"[tiab] OR "finger injury"[tiab] OR "finger injuries"[tiab] OR "finger wounds"[tiab] OR "finger lesions"[tiab] OR "finger amputations"[tiab] OR "finger amputations"[tiab] OR "thumb injury"[tiab] OR "thumb injuries"[tiab] OR "thumb wound"[tiab] OR "thumb wounds"[tiab] OR "thumb lesion"[tiab] OR "thumb lesions"[tiab] OR "wrist injury"[tiab] OR "wrist injuries"[tiab] OR "wrist wound"[tiab] OR "wrist wounds"[tiab] OR "wrist lesion"[tiab] OR "wrist lesions"[tiab] OR "finger amputation"[tiab] OR "finger amputations"[tiab] OR "thumb amputation"[tiab] OR "thumb amputations"[tiab] OR "hand amputation"[tiab] OR "hand amputations"[tiab] OR "wrist amputation"[tiab] OR "wrist amputations"[tiab] OR "trauma centers"[tiab] OR "trauma centers"[tiab] OR "trauma units"[tiab] OR "trauma units"[tiab] OR "trauma department"[tiab] OR "trauma departments"[tiab] OR "regionalization"[tiab] OR "volume"[tiab] AND ("outcome assessment"[mh] OR "outcome and process assessment"[mh] OR "health services accessibility"[mh] OR "outcome"[tiab] OR "outcomes"[tiab] OR "access"[tiab]) AND english[la] NOT (animals[mh] NOT humans[mh]) </p>	<p> 1 exp Hand Injuries/ or exp Wrist Injuries/ or ((hand* or wrist* or finger* or thumb* or digital) adj3 (trauma* or injur* or emergenc* or amputat* or accident* or lesion* or wound*)) .mp. 2 exp Trauma Centers/ or exp Regional Health Planning/ or exp Emergency Service, Hospital/ or (regionalization or regionalisation or volume).mp. or ((emergenc* or trauma*) adj3 (center* or unit* or department* or hospital*) .mp. 3 exp health services accessibility/ or exp "outcome assessment (health care)"/ or exp "outcome and process assessment (health care)"/ or ((outcome* or access* or availability*) adj3 (care* or trauma* or emergenc* or treatment or healthcare)) .mp. 4 (and/1-3) not (exp animals/ not exp humans/) </p>	<p> ('hand injury'/exp OR 'wrist injury'/exp OR (hand* OR wrist* OR thumb* OR finger* OR digital) NEAR/3 (trauma* OR injur* OR emergenc* OR amputat* OR accident* OR wound* OR lesion*)) .ab,ti AND ('emergency health service'/exp OR 'emergency ward'/exp OR 'regionalization'/exp OR regionalisation:ab,ti OR regionalization:ab,ti OR volume*:ab,ti OR ((emergenc* OR trauma*) NEAR/3 (center* OR unit* OR department* OR hospital*)) .ab,ti AND ('health care access'/exp OR 'outcome assessment'/exp OR 'treatment outcome'/exp OR ((outcome* OR access* OR availability*) NEAR/3 (care* OR healthcare OR trauma* OR emergenc* OR treatment)) .ab,ti) AND [english]/lim NOT ([animals]/lim NOT [humans]/lim) </p>

Table 2

Studies describing access to hand trauma care on a patient level

Author (year)	Total No. Subjects	Study Setting/Dataset	Access/ Treatment Details (Hospital Level, Transfer Method, Time to Treatment)	Type of Injury	Barriers to Access of Appropriate Care	Authors' Findings
Patient Level Analysis (examined transfers)						
Bauer 2013	296 patients transferred from outside emergency departments (EDs)	Retrospective – hospital records	Two level I trauma centers. Transfer methods: 73% by ambulance, 5% by private car, 2% by helicopter, 20% unknown.	Hand-related emergency	Transfer guidelines, hand surgeon availability at receiving ED, day of transfer (weekday versus weekend)	92% of patients received a consultation from a hand surgery resident, and 48% of patients saw an attending hand surgeon. 39% of patients were taken to the operating room (OR) within 24 hours, and 16% were taken to the OR nonemergently (within a week or so). 45% of patients never underwent an operation in the OR, however 53% of patients had a procedure done in the ED. Patients who were transferred on weekdays were more likely to see a hand surgeon than those transferred on weekends. The authors found that insurance status did not alter the likelihood of seeing a hand surgeon or having emergent surgery. They suggest alternative methods of consultation, such as telemedicine, to reduce the number of unnecessary transfers.
Eberlin 2013	1172 patients (155 transferred, 1017 presented directly to ED)	Retrospective – hospital records (same data as Hartzell 2013)	Two level I trauma centers	Primary hand or upper extremity abnormality	No guidelines for transfer for hand surgery patients	The authors compared patients with upper extremity injuries that presented directly to the ED with patients transferred from outside EDs. 50% of transfers to tertiary centers for emergency hand evaluation were unnecessary (the injuries did not need hand surgeon or were not urgent). Patients who were transferred were more likely to have no insurance, Medicaid, or state-provided insurance and were less likely to be employed. The authors suggest stricter transfer guidelines for hand surgery evaluation.
Hartzell 2013	1172 patients (155 transferred, 1017 presented directly to ED)	Retrospective – hospital records (same data as Eberlin 2013)	Two level I trauma centers with year-round upper	Upper extremity injuries – bone and ligament trauma to distal third of forearm, soft	No guidelines for transfer for hand surgery patients	The authors specifically evaluated the demographics and insurance status of patients transferred for hand surgery evaluation. The number of uninsured

Author (year)	Total No. Subjects	Study Setting/Dataset	Access/ Treatment Details (Hospital Level, Transfer Method, Time to Treatment)	Type of Injury	Barriers to Access of Appropriate Care	Authors' Findings
			extremity coverage Transfer methods: 4% by air, 43% by ambulance. Average transfer time was 42 minutes (5 minutes to 2 hours 50 minutes).	tissue and infections for entire upper extremity		patients was higher among transferred patients than among non-transferred patients. 53% of transfers did not need emergent transfer to a level I center. Transferred patients had more complex injuries, but 90% of transferred patients did not require more emergency surgery.
Melkun 2010	212 patients presented directly to ED, 92 patients transferred from outside hospitals	Retrospective – hospital records	Level I trauma center	Hand emergencies	Specialist unavailability	Transferred patients had more complex injuries. Patient insurance was similar between those transferred and those that presented directly to the ED. The authors found that patients were transferred mostly due to high complexity of the injury and specialist unavailability at the transferring ED. The authors suggest creating regional hand trauma centers and develop criteria for hand trauma transfers.
Patterson 2010	53 patients transferred from outside ED	Prospective- hospital records	Level I trauma center, teaching hospital. Transfer method: 44 by ambulance, 8 by car, 1 by airplane.	Hand injury	Unwillingness or unavailability of hand surgeon at referring hospital	Patients were prospectively evaluated before transfer via a referral line specifically for communication regarding transfers, and reevaluated after transfer by the same surgeon. The receiving hospital determined that 75% of transferred patients needed a hand surgeon consultation and the remaining 25% could have been treated by the transferring physician or be seen as outpatients. However, they found that the majority of transfers did not require level I resources. The authors found that insurance status was not a significant factor in when or how patients were transferred, or the injury severity. A hand surgeon was on call at the initial facility for 15 cases, however only 3 patients were evaluated. The authors speculate that the reason for transfer was because surgeon at the initial hospital

Author (year)	Total No. Subjects	Study Setting/Dataset	Access/ Treatment Details (Hospital Level, Transfer Method, Time to Treatment)	Type of Injury	Barriers to Access of Appropriate Care	Authors' Findings
						was unable to or did not want to treat the patient.
Patient Level Analysis (examined amputation injuries)						
Friedrich 2011	9407 patients	Retrospective cohort study – SID of HCUP	N/A	Upper extremity amputation	Characteristics of hospital where care was received (size, teaching status), patient insurance	1361 patients (14%) underwent replantation. Large teaching hospitals in urban areas were more likely to perform replantations. Patients with Medicaid, Medicare or were self-pay were less likely to receive replantation than patients with private insurance. The authors suggest regionalization for hand trauma, possibly using telemedicine to facilitate the process.
Ozer 2010	40 patients (70 digits)	Prospective	Level I trauma center. Transport method: air.	Amputations distal to MCP joint (excluding thumb). Patients with additional injuries were excluded from the study.	Patient concerns over return to work and cost of operation (lack of health insurance). Initial assessment of injury and poor communication prior to transfer	The decision to transfer hand trauma patients may not always be justified if a hand surgeon at the original hospital does not evaluate patients. 62.5% of patients transferred did not have replantation (15% were appropriate cases for replantation but chose not to undergo operation (needed to get back to work, concerned about cost and health insurance)). 47.5% of transferred patients had injuries that were unsuitable for replantation (severe crush injury with significant health risks). The authors concluded that most patients did not need to be air transferred. They state that the most common reason for unnecessary transfer was poor initial assessment and suggest telemedicine as an option to improve communication.
Richards 2010	3650 finger amputations, 1112 thumb amputations, 246 hand or wrist amputations at 193 hospitals	Retrospective – AHCA database (FL)	N/A	Upper extremity amputation	Determining where to transfer patient	6% of hospitals accounted for 68% of replantations, and 5% of hospitals accounted for 45% of patients treated for amputation. The process of determining where to transfer a patient was time consuming. There needs to be a triage system to streamline this process and reduce unnecessary transfers. The authors suggest that since there seem to be centers where the majority of hand trauma is treated, these

Author (year)	Total No. Subjects	Study Setting/Dataset	Access/ Treatment Details (Hospital Level, Transfer Method, Time to Treatment)	Type of Injury	Barriers to Access of Appropriate Care	Authors' Findings
						centers should be identified to create coordinated care.
Shale 2013	3341 patients at 474 hospitals	Retrospective – NTDB	N/A	Traumatic thumb amputation	Characteristics of hospital where care was received (teaching or nonteaching, high volume or low volume)	Teaching and high-volume hospitals attempt to replant a higher percentage of amputated thumbs. There are similar success rates across all hospital settings. The only patient level factor that decreased replantation success rate was if the patient was a smoker. The rate of replantation attempts was the highest for patients with private insurance, worker's compensation, and Medicaid.
Squittier 2011	1321 patients	Retrospective cohort study – HCUP KID	N/A	Pediatric amputation	Racial and insurance disparities, treatment at low-volume hospitals	There was a 40% replant attempt in pediatric patients. Surgical management (revision amputation versus replantation) did not vary by hospital type or region. African Americans, Hispanics, and patients with no insurance were less likely to undergo replantation. Younger patients were more likely to undergo replantation. 52% of replantations were done at centers that only did 1 to 2 replantations per year. The authors suggested that referring amputation patients to a high volume center with a hand surgeon and more resources would be more efficient.

Table 3

Studies describing access to hand trauma care on a hospital level

Author (year)	Total No. Subjects	Study Setting/Dataset	Access/ Treatment Details (Hospital Level, Transfer Method, Time to Treatment)	Type of Injury	Barriers to Access of Appropriate Care	Authors' Findings
Hospital Level Analysis						
Caffee 2007	31 self-designated hand surgeons, 13 hospitals (with full emergency services)	Retrospective – surveys sent to hospitals in north Florida	N/A	N/A	Limited number of hand surgeons on call	Three out of 13 hospitals had no hand surgeons on call, and 5 out of 13 hospitals had hand surgeons on call but not every day. The remaining 5 hospitals always had a hand surgeon on call. Out of 31 hand surgeons, 21 did not take calls or took calls less than 4 days per month. Most hand surgeons had no or limited on-call hours and devoted most of their time to ambulatory centers.
Chung 2000	304 patients at 136 hospitals	Retrospective -HCUP database	N/A	Finger and/or thumb amputations with replantation		University hospitals performed 24% of the replantation procedures, while non-university hospitals performed 76%. 90% of hospitals performed 4 or fewer replantations, while 10% of hospitals performed 5 or more replantations. A large number of replant patients were transferred to a small number of replantation hospitals. The majority of finger replants happened in hospitals with only one replantation per year.
Mueller 2012	111 hospitals	Prospective-telephone survey	All licensed hospitals in TN with an emergency department or operating facility	N/A	Availability of hand surgery specialist coverage	18% of hospitals had a hand specialist on call occasionally, while 42% of hospitals had no coverage for hand emergencies at all. Only 2% of hospitals could accommodate all hand trauma cases. 58% of hospitals offered basic emergency hand coverage. The authors believe that this lack of coverage for hand emergencies stems from an inadequate number of hand surgeons and unwillingness to be on call.
Peterson 2012	249 hospitals	Prospective – telephone survey	Level I and level II trauma centers	N/A	Number of hospitals offering specific services, number of hand surgeons providing coverage	For level I trauma centers, 47% had continuous and immediate access to hand surgery and microvascular replantation service and 56% had access to these services at some point during the month. For level II trauma centers, 29% had continuous and immediate access to hand surgery and microvascular replantation service and 36% had access to these services at some point during the month. The authors found that the availability of subspecialty hand and microvascular replantation emergency is inconsistent, and the number of hand surgeons providing trauma care is decreasing. They suggest created a more coordinated system for emergency hand injuries requiring microvascular care.