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Original Research

Critical Care Helicopter Overtriage: A Failure Mode and Effects Analysis

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A B S T R A C T

Objective: Overtriage (OT) of helicopter emergency medical services (HEMS) poses significant burden to multiple stakeholders. The project aims were to identify the following: 1) associated factors, 2) downstream effects, and 3) focus areas for change.

Methods: We undertook a failure mode and effects analysis (FMEA) to evaluate our HEMS interfacility transport process. Data were collected from organizational finances and 3 key stakeholder groups: 1) interfacility patients transferred by HEMS in 2017 who were discharged from the receiving facility within 24 hours (n = 149), 2) flight registered nurses (n = 19), and 3) referring emergency medicine providers (EMPs) (n = 30) from the top HEMS users of 2017. The completed FMEA identified failure modes, the frequency and severity of effects, and unique risk profile numbers (RPNs).

Results: Twelve failure modes were identified with 30 potential causes. Leading failure modes included inappropriate HEMS requests by EMPs (RPN = 343), inappropriate activation by EMS for interfacility transport (RPN = 343), and minimizing patient/family involvement in decision making (RPN = 315). Significant burdens to organizational finances and flight registered nurse satisfaction were identified.

Conclusion: Associated factors for interfacility HEMS OT, downstream effects, and areas for change were identified. EMP and emergency medical services practices, HEMS processes, and shared decision making may affect regional OT rates.

Overtriage (OT), as it pertains to helicopter emergency medical services (HEMS), is the inappropriate use of medical helicopters for the transport of low-acuity patients not in clinical need of HEMS benefit. The Ground and Air Medical qUality in Transport (GAMUT) Quality Improvement Collaborative defines HEMS OT as the "percent of the HEMS patient transport contacts discharged without hospital admission."[1] OT poses significant burden to HEMS providers, health care systems, government and private medical funds, and patients.[2-7] OT does not significantly improve the outcome of low-acuity patients and may inappropriately ration a scarce resource away from a potential patient in need.[8] An increased workload of flight registered nurses (RNs) by inappropriate use of their time and resources has anecdotally been seen to lead to decreased job satisfaction, increased burnout, and increased turnover. Injudicious use of government funds such as Medicare or Medicaid represents poor fiduciary responsibility that can have far-reaching implications for the country or state. Lastly, patients billed for overtriaged HEMS transports may have their claims denied by third-party payers and bear responsibility for part or all of this expense.

Rates of OT vary significantly among HEMS programs and are difficult to validate and compare. Published OT rates were found from a multitude of perspectives including HEMS providers, receiving trauma centers, and state/national databases. The heterogeneity of data collectors, data sources, and specific populations resulted in a wide variance in reported scene transport, interfacility transport, and

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combined OT rates (ie, 3%-85.2%, 6.6%-26%, and 1.3%-70%, respectively).[2,9-26] The GAMUT database where HEMS providers may voluntarily submit blinded quality metric data to compare themselves with national averages reported an average HEMS OT rate of 2.6% in 2017.[27]

Our HEMS program is 1 of few not-for-profit HEMS providers in our region and assumes much of the uninsured costs for care. We identified that the frequency of patients transported by critical care helicopter and subsequently discharged home from the receiving emergency department (ED) nearly doubled from 7% in 2016 to 13% in 2017, well above the GAMUT benchmark. The financial burden of OT to the institution was unknown. However, HEMS operations have been shown to be most cost-effective when significant reductions in OT are made.[3,5] Using an estimated 50% insurer denial rate for the volume of 2017 OT HEMS transports because of the lack of medical necessity, we approximated the organization incurred $1,440,000 in bad debt and over $100,000 in variable costs. We identified literature that reported patient, provider, or system factors associated with HEMS OT[5,11,14,16,20,23-26,28-38]; however, little could be applied to our population or setting, impeding planning efforts to reduce OT. Given the rise in HEMS OT, potential costs to the program, and minimal applicability of the literature, we undertook a failure mode and effects analysis (FMEA) to identify the following: 1) associated factors for OT, 2) severity and likelihood of downstream effects of OT, and 3) focus areas for impactful change. Our goal was to use this information to improve processes that would reduce HEMS OT.

Methods

Design

We undertook a quality improvement initiative using the FMEA approach to evaluate the helicopter transport request process, identifying which steps in the process a failure (deviation from desired process) might occur, causative factors for the failure, and the severity of their impact(s).[39] The FMEA was conducted following the Institute for Healthcare Improvement's FMEA tool (Fig. 1).[39] A FMEA template was created with interdisciplinary validation, outlining the known steps of an interfacility HEMS transport request as well as identifying the possible failures of these steps, leading to OT. Known downstream effects were added to the template, and placeholders were given to presumed or unsure effects. Data were used to inform incomplete FMEA items, such as potential causes of process failures, severity of outcomes, and likelihood of occurrence. Data were obtained from surveys and discussions performed with flight RNs and emergency medicine providers (EMPs) (emergency medicine physicians, advanced practice RNs, and physician assistants) as well as from organizational databases. These data were input into the FMEA tool for completion and analysis of failure modes, effects, and risk priority. Because the majority of OT at this HEMS program occurred from interfacility transport requests, this FMEA was designed for interfacility requests only. The study protocol was approved by The Ohio State University Institutional Review Board and this health system's institutional review board.

Setting

The FMEA was conducted at a not-for-profit, hospital-based, helicopter and ground ambulance critical care transport program; a division of a large, urban academic health system that serves as the public safety net health system for the region. This program is the oldest HEMS program in the region (established in 1982) and operates 3 helicopters and 3 ground ambulances with satellite basing across Northeast Ohio. Traditionally, this program has promoted a unique helicopter crew configuration, 2 Instrument flight rules −operating pilots and an advanced practice medical crew consisting of a physician and RN or an acute care nurse practitioner and RN. These crew configurations garner a higher operational cost but increase safety and the level of care provided. The flagship facility of this program's health system is the longest standing level 1 trauma center in Northeast Ohio, and, as such, this HEMS program and its health system are well established as the experienced tertiary trauma care providers in the region. In 2017, over 1,600 trauma patients were transported by this program. Oversaturation of HEMS programs and "helicopter shopping" have been witnessed in this region, as well as a relative scarcity of ground critical care transport services, likely increasing the potential for HEMS OT and the financial risk for patients.[35,40-42] As a not-for-profit program, this organization has made a stance to not operate with practices commonly seen with for-profit HEMS programs, such as producing liens and lawsuits against patients who are uninsured or cannot pay.[40,42] Also, this program charges approximately half the cost of its for-profit competitors, coupled with advanced crew configurations, increasing OT's margin for burden at this program.[40,42]

Sample

Data were gathered from 3 key stakeholder groups to inform the FMEA: 1) patients transported by this HEMS program in 2017, who were discharged from the receiving facility within 24 hours after interfacility transport (medical record audit) (n = 149); 2) all actively employed flight RNs from this HEMS program (n = 22); and 3) referring EMPs and their emergency medicine directors, who were employed by the top 15 HEMS-utilizing facilities of 2017 (n = 76). Facilities were ranked in order of total HEMS transport requests. Facilities were further described by the percentage of transport requests that were considered OT. Eligibility criteria for EMPs were those who worked at 1 of the top 15 requesters for HEMS and represented high (≥25%), moderate (10%-24%), or low (<10%) OT proportion. Exclusion criteria included students, residents, or providers who did not have the position or authority to request HEMS transport.

Variables and Data Collection Procedures

Data were collected from 4 data sources to complete the FMEA template. The outcome of interest, HEMS OT, was defined as patients transported by HEMS and discharged from the receiving facility in < 24 hours.

Patient Variables

Unidentified, aggregate data were gathered from the internal electronic medical record database (emsCharts® Warrendale, PA) to identify characteristics and themes among 2017 OT patients, which included interfacility or scene transport, transport distance, diagnoses, injury versus non-injury, mechanism of injury, Glasgow Coma Scale score, drug/alcohol indicators, vital signs, as well as demographics (age, sex, race, and referral location).

Financial Variables

Unidentified financial data were obtained via organizational database and flight log software (Flight Vector® Softtech Inc. (Henderson, NV)), providing amounts billed/received, adjustments, payer type, account status, and bad debt.

Flight RN Variables

Staff flight RNs were sent an electronic, anonymous survey hyperlink via company e-mail forwarded by the chief flight nurse. The flight RN survey was adapted from multiple nursing job satisfaction studies as well as turnover intention and burnout tools.[43-48] Job satisfaction was operationally defined as "the feeling of pleasantness when occupational desires or needs have been fulfilled."[48] Survey items were validated by interdisciplinary members of this program's Quality Improvement Committee. Items were submitted to a panel of 8 content experts to ensure content validity >0.78 for each item using

Step Number	Steps to Interfacility Transport	Failure Mode	Failure Causes	Failure Effects	Likelihood of Occurrence (1-10)	Likelihood of Detection (1-10)	Severity (1-10)	Risk Priority Number (RPN)	Actions to Reduce Occurrence of Failure

Failure Mode: What could go wrong?
Failure Cause: Why would the failure happen?
Failure Effects: What would be the consequences of the failure?
Likelihood of Occurrence: 1–10 [10 = very likely to occur]
Likelihood of Detection: 1–10 [10 = very unlikely to detect]
Severity: 1–10 [10 = most severe effect]
Risk Priority Number (RPN): Likelihood of Occurrence × Likelihood of Detection × Severity

Figure 1. Institute of Healthcare Improvement FMEA tool. (Reprinted with permission from the Institute for Healthcare Improvement).

the content validity index (CVI) method per Lynn.[49] The final survey consisted of 20 items, with CVIs ranging from 0.88 to 1.0. The survey obtained flight RN perceptions related to job satisfaction, burnout, and intention to leave as affected by OT. In addition, the following demographic content was requested: age, sex, certification status, years of experience as a flight RN, and employment status (full-time, part-time, or as needed). Survey data were collected and managed using REDCap Powered by Vanderbilt University (Nashville, TN), electronic data capture tools hosted at Case Western Reserve University (Cleveland, OH).[50]

EMP Variables

Data were gathered from the electronic medical record database to identify 2017 referring EDs. An investigator-designed survey was used to elicit EMPs' perceptions and practices of HEMS use. The survey was designed using a 3-step process. Domains of interest were identified and mapped from the Systems Engineering Initiative for Patient Safety (SEIPS 2.0) framework (Fig. 2).[51] Instrument items were created and validated by interdisciplinary members of this program's Quality Improvement Committee. Items were revised and submitted to a panel of 8 content experts to ensure CVI >0.78 for each item. The final survey consisted of 37 items, with CVIs ranging from 0.88 to 1.0. The final survey content included EMPs' knowledge of transport modes, system, and process factors that could influence HEMS requests; EMP judgment on helicopter requests; and demographic information (age, sex, level of education, years of experience as an EMP, and employment status). The quality initiative overview and introduction were sent to EMP directors. If the directors agreed, he or she forwarded the e-mail/survey to his or her EMPs. Second, group and individual discussions were held at sites electing to have the lead author further clarify influential factors, allowing the EMPs to expound on potential concepts not mentioned in the survey. Survey and discussion data were collected and managed using REDCap electronic data capture tools hosted at Case Western Reserve University.

Analyses

Descriptive statistics were conducted on all variables. Notes from discussions were reviewed for recurring themes. Data triangulation was performed to inform FMEA components and for quantification of the likelihood of occurrences, severity of outcomes, detectability of failures, and the risk priority number (RPN). The RPN was established to rank failures for interventional priority. RPNs were calculated for each step as the likelihood of occurrence (1-10) multiplied by the likelihood of detection (1-10) multiplied by the severity (1-10). Associated factors for the FMEA analysis were considered clinically meaningful if reported in ≥25% of participants.

Results

Patient Participant Profile

One hundred ninety-three patients were initially identified as HEMS OT from 2017. Forty-four patients were excluded for scene response. OT cases resultant of interfacility transport were examined (n = 149).

Characteristics of the patients included 67% males and 88% adults (>18 years). The average age of these patients was 38 years old, ranging from 1 year to 90 years old (median = 37 years old). The racial distribution was 52% white; 30% black, non-Hispanic; 5% white, Hispanic; 1% black, Hispanic; and 12% unknown or unidentified. The majority of patients (87%) were insured.

Nearly half (46%) of the OT patients were transported from 1 county. Most patients (90%) were transported to this program's flagship hospital. The majority of patients (91%) were transferred for traumatic injuries. Nearly all (97%) patients were transported to an ED. Three patients were transported to a cardiac catheterization suite, 1 patient was transferred to a medical intensive care unit, and 1 patient was transferred to a pediatric intensive care unit.

EMP Participant Profile

Referring EMPs and their directors were surveyed to identify the decision-making and human systems factors affecting EMPs' use of HEMS for interfacility transport. Post-survey discussions were also conducted. From the top 15 HEMS-utilizing EDs, 10 EMP directors were sent recruitment e-mails regarding the study; 3 to 5 attempts were made for each EMP director. Six directors responded as willing to participate in the study (7 EDs, 1 director responsible for 2 EDs). Recruitment e-mails were sent to an additional 3 EMP directors, with 1 additional director agreeing to participate. Of these 7 directors agreeing to participate, 1 dropped out (ie, ceased communication). Of the 6 directors who did not participate, 2 stated they required organizational permission, and 4 never responded to the e-mail

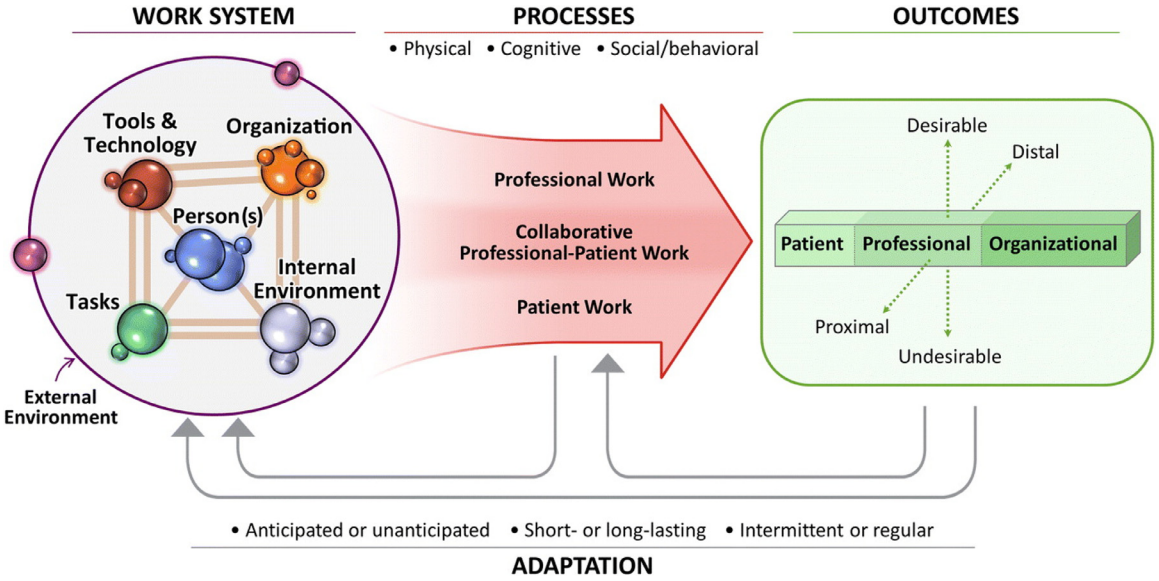

Figure 2. The Systems Engineering Initiative for Patient Safety (SEIPS) Model 2.0. (Reprinted with permission from Holden et al.[51])

invitations. After e-mail correspondence with the directors willing to participate, follow-up phone conversations were conducted to provide further information regarding the study. EMP directors sent their EMPs the study information and the anonymous electronic surveys via an e-mailed hyperlink. In addition, EMP directors also notified EMPs of the opportunity to meet with the lead author in person or by phone for more in-depth discussions regarding HEMS transport.

Thirty surveys were completed by EMP respondents: 19 physicians, 8 physician assistants, and 3 nurse practitioners. EMP respondents were 73% male and varied in age (25-35 years old [37%], 36-50 years old [33%], and >51 years old [30%]). Two thirds of EMPs had between 4 and 15 years of experience, and 37% of respondents noted experience functioning as a flight physician, flight nurse, or flight paramedic. Most (90%) were board certified in emergency medicine/acute care, and 90% were full-time EMPs. High, moderate, and low OT EDs were represented by 33%, 47%, and 20% of respondents, respectively. After survey completion, confidential discussions were held with 10 EMPs.

Flight RN Profile

An electronic survey was sent to 22 flight RNs from their chief flight nurse. Nineteen surveys were completed. All but 1 respondent were full-time flight RNs. Two thirds were male. Almost half were 30 to 40 years old, 42% were 41 to 50 years old, and 10% were 51 to 60 years old. Approximately one third of flight RNs had <6 years of experience, one third had 7 to 10 years of experience, and one third had 11 to 30 years of experience. Almost half of the respondents held secondary employment outside of this HEMS program.

FMEA Process Steps, Failure Modes, and Failure Causes

The interdisciplinary Quality Improvement Committee created a 12-step process for HEMS interfacility transport requests with corresponding failure modes (Fig. 3). Survey and discussion content was used to validate the identified failure modes and their causes. No new failure modes were discovered from the EMP data. Failure modes identified with RPN >140, and considered most amenable to intervention, included 1) inaccurate determination of the patient as critically ill or exceeding resources, 2) inappropriate EMS activation of HEMS for ED rendezvous, 3) inappropriate request for helicopter transport by EMP, 4) EMP determines noncritical patient needs to be transferred by HEMS for services not available at their facility, 5) patient/family not informed on mode of transport selection by EMP, and 6) patient follow-up information not given to EMP.

Inaccurate determination of the patient as critically ill or exceeding ED resources (step 4a, RPN 140), although potentially severe, had a low likelihood of occurrence. EMPs reported following current evidence-based guidelines, with few exceptions. HEMS use due to a lack of ED resources was infrequently cited; 30% of EMPs noted limited or inefficient technologic resources, and 23% noted scarce resources (such as blood products). Most (87%) stated nurse staffing had no effect on their decision to use HEMS; 77% reported that high provider-to-patient ratios had no impact on their use of HEMS.

Inappropriate EMS activation of HEMS for ED rendezvous (step 4b, RPN 343) was noted frequently in discussions and survey content. When presented with a non-critical patient, with HEMS en route per EMS activation, 20% of EMPs would not cancel HEMS, and 27% were unsure. Most discussion participants repeated these 2 responses. EMPs revealed they were weary to change the initial clinical decision made by EMS. The most common themes mentioned were a lack of time to truly determine whether the patient was critically ill before HEMS arrival, not wanting to contradict another healthcare provider's judgment, potential liability of canceling HEMS, and not wanting to delay non-critical but necessary transfer.

Inappropriate requests for helicopter transport by EMPs (step 8, RPN 343) and transfers by HEMS for services not available (step 5a, RPN 224) had several contributing factors, including EMP education, cost concern, input on decision making, and ground ambulance delays. Most EMPs had little or no formal training regarding the types and abilities of the various levels of transport care. EMPs on average overestimated the cost of this program's patient transport modalities (179% of charges for critical care ground transport and 133% for HEMS charges). Half (53%) reported that neither cost of transport nor HEMS program billing practices (ie. billing the patient directly for unreimbursed charges, "balance billing") were impactful to their HEMS use. EMPs from high OT EDs were least likely to report a perceived cost impact on decision-making (20%), compared with middle (36%) and low OT ED EMPs (86%). Only one third of EMPs reported frequently or almost always receiving input from the receiving physician on the most appropriate mode of transport. Most (87%) said they would be open to a flight acute care nurse practitioner's input on a patient's mode of transport. A minority of EMPs (37%) stated they were not in favor of dispatch center personnel questioning their mode of transport decision. EMPs from high OT EDs were significantly more likely to welcome questioning of their mode of transport choice (70%) compared with middle OT ED EMPs (21%) and low OT ED EMPs (17%). When facing prolonged ground transport response times, 27% of EMPs responded that they would up-triage a non-critical patient to HEMS if estimated response times were >90 minutes, and 27% reported a 15- to 90-minute threshold to up-triage to HEMS. Twenty-seven percent noted that they would up-triage to a higher level of service if it provided an easier acceptance/transfer process.

Regarding patient/family not informed on the mode of transport selection by EMP (step 9, RPN 315), over three quarters of EMPs noted that they almost always inform the patient/family on the clinical need of HEMS transport. However, nearly three quarters (73%) noted that they inform and consent the patient to HEMS transport after they have already called to dispatch the helicopter. Nearly half (47%) of EMPs noted that they used a specific health system's transport service because of organizational affiliations. Discovered during EMP discussion, patients semi-frequently ask EMPs the potential cost and insurer coverage of HEMS transport before transfer, and EMPs reported having no information to provide. It was not identified if patients were provided information on the options and differences in regional HEMS service providers.

Regarding patient follow-up information not given to EMP (step 12, RPN 224), 17% of EMPs noted their facility reviews HEMS use for appropriateness and provides them feedback. This HEMS program strives to conduct follow-up calls to referring EMPs regarding the patient's status/findings 24 hours after transfer. Nearly half of the EMPs responded that these follow-up calls have been impactful on their future decisions to use HEMS. Internal feedback noted semi-frequent difficulty in obtaining follow-up data, reported primarily because of bedside nurse refusal to provide information, citing Health Insurance Portability and Accountability Act concerns. This occurred nearly exclusively at outside health systems, which represented 40% of this program's HEMS destinations.

FMEA Failure Effects

The failure effects (ie, downstream consequences) identified in this FMEA impact 3 common stakeholders: patients (both actual and potential), flight RNs, and health systems.

For OT interfacility HEMS patients, potential consequences are financial burden, risk exposure, loss of autonomy, and missed care. Few patients were exposed to financial burden here. Most (87%) were insured, although lower than national reports,[52] and only 4% received insurer denials. Increased risk exposure consists of HEMS accidents (3.2/100,000 flight hours in the United States).[53] Loss of autonomy and control in healthcare decision-making is noted when

Step Number	Steps to Interfacility Transport	Failure Mode	Failure Causes	Failure Effects	Likelihood of Occurrence (1-10)	Likelihood of Detection (1-10)	Severity (1-10)	Risk Priority Number (RPN)
1	Patient presents to EMS (or direct to ED, see #3)							
2a	EMS transports patient to ED	EMS provider calls inaccurate patient report to ED.	EMS provider knowledge/experience deficit	ED MD preemptively calls for HEMS, when not needed, based on EMS provider's radio report	3	2	5	30
2b	EMS transports patient to ED	Patient is transported to a hospital without necessary evaluation/treatment resources, when better resourced facilities are within reasonable distance for transport.	-Closest Facility -No other facility present or open -Patient preference	Non-trauma center ED MD tasks HEMS for transport to tertiary trauma center, potentially overburdening Level One resources, when definitive treatment could have been performed at a community Level 2 or 3 ED	2	4	2	16
3	Patient presents to ED EMP							
4a	ED EMP assess/treats patient	EMP inappropriately determines the patient as critically ill or exceeding the resources of their facility	-Education deficit -Low volume of moderate-severe trauma case exposure -Poor resources or staffing	-Patient is over-triaged to HEMS: -Non-payment/reimbursement; financial burden to patient and HEMS program -Flight nurse burden; satisfaction, burnout, turnover -Removal of public service asset for someone else in need -Increased risk exposure for patient and crew	4	5	7	140

Rationale
2a. Occurrence - 23% of EMPs noted that inaccurate communications at least sometimes results in inappropriate HEMS request. **Detection** - This should be identifiable after patient presents to the EMP. **Severity** - Severity is low, as EMP should still have opportunity to cancel HEMS if deemed unnecessary after patient arrives.
2b. Occurrence - Highest OT facilities are not in close proximity to Level 2 or 3 trauma centers; EMS generally appears to be transporting to the closest appropriate facility. If patients arrive to a rural/community ED without necessary resources to treat the patient, the appropriate measure is to transfer the patient out. Given the distance from tertiary care, these rural facilities most prudent action may be to request HEMS for transport. **Detection** - Detection is plausible, but thorough detection would be labor intensive. **Severity** - impact is limited to a theoretical overburdening to a tertiary health system, and the missed opportunity for the HEMS system to provide care for another patient, potentially in greater need of HEMS care/benefit.
4a. Occurrence - The majority of EMPs surveyed noted they received very little or no formal training regarding the types and abilities of the various levels of transport care (ALS, critical care ground, HEMS). Impact of this education deficit appears generally low however, as OT represents 13% of HEMS requests, and EMPs responded to clinical survey items mostly following current evidence-based guidelines. Also, this does not appear to be a system-wide issue since 41% of all interfacility OT occurred between 2 facilities. Minimal exposure to moderate-severe trauma patients has been noted to influence secondary over-triage however, and may contribute to HEMS utilization in these rural facilities.* 30% of EMPs noted that limited/inefficient technologic resources increased their use of HEMS. 23% of EMPs responded that they request HEMS transport because of the ease of accessing scare resources (such as blood products, medications, additional advanced providers, etc.). 87% of EMPs reported that ED Nurse staffing issues had no affect on their decision to utilize HEMS, and 77% reported that high provider to patient ratios, or “pull to full” strategies, had not impacted their use of HEMS. **Detection** - the effect of an individual EMP's education or exposure is unrealistic to track with OT occurrences, as is real-time resources and staffing at each facility. However, the ability to track the OT occurrence remains consistent. Additionally, the ability to determine an EMP's clinical judgment or concern for a patient's clinical stability as unwarranted or inappropriate is an exceedingly difficult task, with infrequently any inarguable verdict on medical appropriateness. **Severity** - 61% of charges were recouped from OT cases. 47% of Flight RNs noted that they were less satisfied with their job when they were called to transport OT patients; risk statements for burnout were occurred generally in 1/3 to 1/2 of Flight RNs; and 16% reported they often think about quitting their job, 16% were actively looking at other jobs, and 32% noted OT causes them to consider leaving this HEMS program. Finally, though HEMS crashes have decreased over the last few years, HEMS accident rates remain above 3 accidents per 100,00 flight hours.** A theoretical risk for missed opportunity costs exists for a HEMS asset to be tasked to an OT trip, being unable to execute a true critical care transport, with or without payment. This risk has clinical outcome implications for the patient if transport is delayed/unavailable, as well as financial implications for the HEMS program.

Figure 3. FMEA: OT of critical care transport helicopters for interfacility transport. (Adapted with permission from Institute for Healthcare Improvement.[39])

Step Number	Steps to Interfacility Transport	Failure Mode	Failure Causes	Failure Effects	Likelihood of Occurrence (1-10)	Likelihood of Detection (1-10)	Severity (1-10)	Risk Priority Number (RPN)
4b	ED EMP assess/treats patient	EMS activated HEMS enroute to ED inappropriately; ED EMP does not cancel HEMS	-EMP does not assess patient -EMP does not want to cancel transport already started if needed -EMP does not want to reverse another providers judgment	-Patient is over-triaged to HEMS: outcomes as above	7	7	7	343
5a	ED EMP determines need for transport to another facility	EMP determines non-critical patient needs to be transferred by HEMS for services not available at facility, or for services able to be received on outpatient basis.	-Lack of specialty services at referring facility -Prolonged Advanced Life Support or Critical Care Ground Ambulance estimated time of arrival - Advanced Life Support or Critical Care Ground Ambulance mode not recommended by receiving physician or HEMS program	-Burden on receiving ED to await evaluation by specialty service -Burden on patient to arrange transport home after brief ED visit -Patient is over-triaged to HEMS: outcomes as above	8	4	7	224
5b	ED EMP determines need for transport to another facility	ED EMP decides to transfer to higher level care than needed with HEMS, or passing a capable specialty resource facility. (i.e. transferring to a level 1 trauma center, passing a capable level 3 trauma center, per patient needs, which could have been transferred safely by Critical Care Ground Ambulance.)	-Lack of familiarity with trauma triage criteria/HEMS benefit -Lack of input from receiving physician	-Overburdening of Level One/tertiary resources -Diversion of care/activation from an appropriate Level 2 or 3 trauma center -Patient transferred by HEMS because of distance to tertiary center, instead of by clinical need -Patient is over-triaged to HEMS: outcomes as noted above	3	3	7	63

Rationale
4b. Occurrence - The likelihood of an EMP not assessing a patient entering their ED that has been earmarked for HEMS transport is unlikely. When asked if they would cancel an EMS-HEMS activation, if the patient arrives prior to the HEMS crew and the patient is determined to not be critically ill, 47% of EMP respondents were noted to be at least somewhat likely to cancel HEMS. Discussions with EMPs noted increased incidence of EMS activations for "ED rendezvous." EMPs noted this to occasionally be problematic, with experience in the scenario of non-critically ill patients having been requested for HEMS transport by EMS. The most common themes mentioned were a lack of time to truly determine the patient is not critically ill before HEMS arrival, not wanting to contradict another healthcare provider's concern for the patient, the liability of canceling HEMS due to an inaccurate perception for lack of necessity, and not wanting to delay eventual transport of the patient for non-critical, specialty care. **Detection** - Detecting the cause for this failure to be hesitance of an EMP to reverse EMS decision-making, agreeing to continue transport for non-critical needs, or lack of assessment are unrealistic. Post-hoc analysis will continue to identify the occurrence of OT, however, currently, if EMS activates HEMS for an ED rendezvous and patient enters the ED, the trip is marked as interfacility from that ED, and not otherwise noted as an EMS activation. This potentially will affect the accurate detection and area of impactful focus. **Severity** - see 4a severity.
5a. Occurrence - Nearly all EMP discussions noted a lack of specialty service availability, such an otolaryngology and interventional radiology, contributed to transfer of patients to their tertiary referral center, though not mentioned as a frequent occurrence. When facing prolonged ground transport response times, 27% of EMPs responded that they would up-triage to HEMS if estimated response times would be >90 minutes, 27% reported a 15-90 minute threshold to up-triage to HEMS, and the remainder responded that no time threshold would cause them to up-triage to HEMS. Given the frequently rural nature of this region, and the relative scarcity of ground critical care availability, this high volume of up-triaging related to ETAs for transport of non-critical patients is significant. When evaluating outside provider influence on EMPs decision-making, it was found that 37% of EMPs responded that they frequently or almost always received input from the accepting physician. **Detection** - Though the nature of these transports should be evident to the accepting physician and the HEMS dispatch personnel, mode of transport is ultimately at the discretion of the referring provider. Also, HEMS programs may be hesitant to question the judgment of referring EMPs, out of fear for them to take their business elsewhere, given the oversaturated, competitive markets and incidence of "helicopter shopping. **Severity** as noted above. Additional potential burden to the receiving ED and specialty services, though not direct burden to this HEMS program.
5b. Occurrence - Only 1/3 of EMPs reported frequently or almost always receiving input from the receiving physician. However, EMPs were able to identify the evidence-based clinical conditions receiving benefit from HEMS transport, except for a perceived benefit with intubated neonate patients, and perceived lack of benefit for patients with hemothoraces/pneumothoraces and patients with Injury Severity Scores of >15. Currently, there are few Level 2 or 3 trauma centers within this region. A trauma consortium exists in the region, coordinating appropriate trauma transfers, which has its own internal QI/PI committee, tracking appropriateness of facility transfer. However, it is unknown if appropriateness of mode of transport is tracked there as well. **Detection** - In addition to consistent HEMS OT detection after transport, HEMS dispatch personnel could log whether recommendations were offered by the receiving physician. Lack of knowledge detection is limited to infrequent study measures, such as this survey. This program also coordinates transfers for the regional trauma consortium and would likely receive this information, unless normal procedures are not followed for transfer. **Severity** - As above, in addition to potential burdens to the receiving tertiary center, not directly affecting this HEMS program.

Figure 3 Continued.

Step Number	Steps to Interfacility Transport	Failure Mode	Failure Causes	Failure Effects	Likelihood of Occurrence (1-10)	Likelihood of Detection (1-10)	Severity (1-10)	Risk Priority Number (RPN)
6a	ED EMP calls for patient transport	Dispatch center does not assist referring EMP with identifying most appropriate mode of transport	-Lack of dispatcher knowledge/comfort with identifying appropriateness of vehicles per clinical need -Dispatcher attempting to not question EMP's judgment; out of respect or fear of EMP going to another HEMS service with request -HEMS program culture looking to accept HEMS requests whenever possible	-Patient is over-triaged to HEMS: outcomes as noted above	7	2	7	98
6b	ED EMP calls for patient transport	EMP demands helicopter when not needed, even against dispatcher suggestion for ground transport, and helicopter is dispatched	-HEMS program culture willing to accept HEMS requests whenever possible	-Patient is over-triaged to HEMS: outcomes as noted above	4	1	7	28
7	Acceptance for patient sought at receiving facility	Accepting physician does not influence appropriate transport mode choice	-Accepting physician offers no input -Referring provider does not take accepting physician's input	-Patient is over-triaged to HEMS: outcomes as noted above	5	2	7	70

6a. Occurrence - Most HEMS dispatchers at this program are medically trained to the EMT - Basic or Paramedic level, but it would be understandable for them to not feel comfortable with questioning the judgment of an EMP. Helicopter shopping has been witnessed in this region, and oversaturation and competition can lead to desire to accept any HEMS request that can be completed safely. Active measures at this program attempt to mitigate and prevent helicopter shopping, however this HEMS program may limit question of EMPs' judgment of mode of transport requests due to increasing competition and the program's position as a public utility model of emergency transport services. **Detection** - In addition to standard HEMS OT identification, these scenarios can easily be detected by review of dispatch center call recordings. **Severity** - As noted above.

6b. Occurrence - 37% of EMPs stated they were against a dispatch center questioning their mode of transport decision. However, amongst their groups, EMPs from high OT EDs were significantly more likely to want questioning of their mode of transport choice (70%), compared to middle OT ED EMPs (21%) and low OT ED EMPs (17%). Anecdotal observation of this phenomena has occurred, but infrequently. **Detection** - This phenomenon would be easily detectable and reportable by HEMS dispatchers. **Severity** - As noted above.

7. Occurrence - Most EMPs report not frequently receiving input from the receiving physician. However, 87% reported that they would be open to input on appropriate mode of transport from a HEMS Flight RN or ACNP. EMPs would likely extend this acceptance to physician input. **Detection** - This scenario could be detected by dispatcher reporting, or by review of dispatch center phone recordings (though this would be labor intensive). **Severity** - As noted above.

Figure 3. Continued.

Step Number	Steps to Interfacility Transport	Failure Mode	Failure Causes	Failure Effects	Likelihood of Occurrence (1-10)	Likelihood of Detection (1-10)	Severity (1-10)	Risk Priority Number (RPN)
8	Mode of transport decided	Referring provider inappropriately requests helicopter and one is sent	-Education deficit of scope of transport modes by EMP -EMP does not consider cost of HEMS with non-critically ill patient -Dispatch agrees to send helicopter	-Patient is over-triaged to HEMS: outcomes as noted above	7	7	7	343
9	Patient updated on condition/need of transport	Patient/family is not informed on mode of transport, and/or the need for transport, eliminating the patient/family as a potential barrier to OT.	-EMP does not inform patient/family on need for HEMS transport, because of personal preference, lack of time, or assumed criticality of the situation	-Patient does not get choice of mode/company until helicopter arrives -Prevents non-critically ill patients from assisting as second barrier by self-selecting against OT -Patient is over-triaged to HEMS: outcomes as noted above	5	9	7	315
10	Transport crew dispatched to transport patient							

Rationale
8. Occurrence - Over half (57%) of EMP respondents noted very little (i.e. 1 lecture) or no formal training on the types and levels of transport care. Despite this, EMPs were mostly correct in responding to scope of abilities per transport mode. Very few EMPs identified advanced practice modalities for local ALS (such as carrying PRBCs onboard, transporting temporary transvenous pacemakers, and placing chest tubes), and few under identified abilities for critical care ground ambulance (Such as performing eFAST ultrasound exams, placing chest tubes, carrying PRBCs). EMPs on average overestimated the average cost of patient transport modalities, most notably for critical care ground transport. EMPs' estimation of this program's critical care ground transport fees were reported an average of 179% of the actual average charge; median response was 191% actual average charge. Estimations for HEMS transport were closer, but remained higher than actual average charges. Average EMP response was 133% actual average HEMS charge. 53% of EMPs reported that cost of transport to the patient or HEMS program billing practices were not impactful to their decision to utilize HEMS for transport. Of EMPs reporting cost of HEMS as impactful to their decision-making, EMPs from high OT EDs were less likely to report perceived impact (20%), compared to middle (36%) and low OT EDs (86%). There could be an impact from EMPs' comfort level with certain patient populations, i.e. trauma, and requesting HEMS to be "safe rather than sorry." Almost half (47%) of EMPs noted that they request HEMS from this program because they felt more at ease that another advanced practice provider would be coming to transport their patient. As noted above, dispatchers may be weary of questioning the referring EMP's judgment. In addition, 27% of EMPs noted that they would call for a higher level of service, i.e. HEMS, because of an easier acceptance and transfer process. There may also be a component of OT imposed by other HEMS programs. Nearly half (47%) of EMPs noted that they used a specific health system/transport service because of organizational affiliations. If the another HEMS program is called first for a transport, and that HEMS program suggests helicopter transport when not needed, but then cannot complete the transfer (i.e. because of weather conditions), this helicopter transport request will be passed to another program, without the benefit of participating in the original referral conversation and transport decision process. Also, as noted above, over 1/4 of EMPs noted they would up-triage to HEMS in non-critical patients if ground ambulance ETAs exceed 15-90 minutes. **Detection** - Detection for most of these factors are exceedingly difficult. Education level and cost consideration are limited to intermittent surveying such as this study. Dispatch call logs can be reviewed to determine if dispatchers did not intervene when desired, but this would prove labor intensive to scan dispatch call recordings. Prospective tracking of up-triage to HEMS when EMPs originally request ground transport is feasible. Some transports may have been safe and feasible by ground transport, but if patient is admitted to a non-critical unit, they will not be identified as OT because they were not discharged in <24 hours. Furthermore, if patients are transported to other health systems, patient follow-up data may not be provided to crews, and OT patients may not be identified. **Severity** - As noted above.
9. Occurrence - Over 3/4 of EMPs noted that they almost always inform the patient/family on the clinical need of HEMS transport. And nearly 3/4 (73%) noted that they inform and consent the patient to HEMS transport, but only after they have already called to dispatch the helicopter. The amount to which OT patients may question EMP's judgment and refuse HEMS transport if informed early in the process is unknown. Patients wishing to refuse HEMS transport can still do so after HEMS arrives, but may be less likely to refuse after HEMS has already arrived at bedside. **Detection** - This is nearly undetectable on a case by case basis, unless patients report to HEMS crews that they were not consented or informed on impending HEMS transport. **Severity** - As noted above. In addition, patient/family autonomy and participation in healthcare decisions is limited.

Figure 3 Continued.

Step Number	Steps to Interfacility Transport	Failure Mode	Failure Causes	Failure Effects	Likelihood of Occurrence (1-10)	Likelihood of Detection (1-10)	Severity (1-10)	Risk Priority Number (RPN)
11	Transport crew arrives to patient; receives report and assesses patient	Transport crew continues with inappropriate helicopter transport request	-Customer service/public relations for EMP -Patient likely still needs transport, by some form -Not wanting to delay transfer, abandon patient, or wait in ED until a ground unit is available	-Patient is over-triaged to HEMS: outcomes as noted above	5	3	7	135
12	Patient is transported to receiving facility	No follow up to ED EMP; no utilization review discussion	-No follow-up information provided -No ED provider tasked to monitor EMPs' appropriateness of HEMS utilization	HEMS OT continues	4	8	7	224

Rationale
11. Occurrence - It is generally out of the scope of standard practice for HEMS transport crews to refuse interfacility transport requests of EMPs due to crew judgment for medical necessity of transport. Program culture of public utility model likely plays a roll. Performing good customer service (servicing the EMP) for repeat business is a strong organizational value. The frequency to which the HEMS physician/acute care nurse practitioner would feel comfortable reversing the EMP's decision for HEMS need following a first-time bedside assessment is likely infrequent. However, if the HEMS provider noted a patient not in need of HEMS transport, anecdotally, the failure causes identified are present to at least a moderate degree. **Detection** - Detection of the failure would rely solely on reporting from HEMS crew members, which is feasible, but would be difficult to validate their accuracy without investigation to determine HEMS providers' accuracy in identifying OT prospectively. **Severity** - As noted above. Of note, a HEMS provider refusing a transport because of perceived lack of medical necessity, followed by deterioration and poor clinical outcome of that patient, would likely result in an outcome with a severity greater than that of HEMS OT.
12. Occurrence - Follow-up calls to referring EMPs regarding the patient's status/findings after 24 hours is an expected staff function for each transport. Nearly half of EMPs responded that these follow-up calls have been impactful on their future decisions to utilize HEMS. However, at least 10% of transports did not receive follow-up patient information by staff. Nearly all instances cited "HIPPA" as their explanation for no follow-up; when calling the transported patient's current unit, the bedside nurse refuses to give patient information over the phone. This occurred near-exclusively at outside health systems, which represent 40% of HEMS destinations. Also, half of EMPs noted there was no one at their facility who reviews HEMS utilizations for appropriateness, and 1/3 answered neutrally. **Detection** - Lack of follow-up information is detectable by the quality committee when searching the follow-up logs in the electronic medical record database. However, committee members cannot track whether that information was actually delivered to the refferring EMP. The lack of ED personnel to review EMPs appropriateness is likely a static concept, with ~20% of EMPs receiving internal feedback; of which is a non-detectible occurence for this program. **Severity** - As noted above.
Failure Mode: What could go wrong? **Failure Cause:** Why would the failure happen? **Failure Effects:** What would be the consequences of the failure? **Likelihood of Occurrence:** 1–10 [10 = very likely to occur] **Likelihood of Detection:** 1–10 [10 = very unlikely to detect] **Severity:** 1–10 [10 = most severe effect] **Risk Priority Number (RPN):** Likelihood of Occurrence × Likelihood of Detection × Severity

Figure 3. Continued.

EMPs choose helicopter transport and the HEMS provider before informing the patient of the benefits and differences in transport modes or HEMS providers. Using a critical care transport helicopter for a non-critical patient may result in missed care for another patient in greater need.

Flight RNs are at risk for decreased job satisfaction, increased risk of burnout, and increased intention to leave related to OT. Most (95%) flight RNs were satisfied with their jobs, and all were motivated by their work when challenged. However, when overtriaged, 47% noted they were less satisfied, and only 16% found their work desirably challenging. Between 33% to 50% of RNs reported transporting OT patients causes them to doubt the significance of their work, makes their work feel less meaningful or rewarding, and emotionally drains them. Nearly one third stated OT causes them to consider leaving this HEMS job. Negative findings were especially represented in the 7 to 10 years of experience group.

This health system assumed a significant amount of financial burden for OT interfacility HEMS transport; 39% of charges to this patient group were not recouped. Of the 13% uninsured patients, 95% received charitable reductions, reducing charges by half on average. About one quarter of OT cases resulted in bad debt assumption. Over a third of OT patients received Medicaid benefits, which is higher than the national average,[52] and 13% received Medicare. Missed opportunity losses, when revenue-generating flights are missed because helicopters are unavailable because of an OT transport, were unable to be calculated.

Discussion

We undertook a FMEA to identify associated factors or causes for HEMS OT in our program, its impact to financial and personnel resources, and areas in need of further investigation for impactful change. We found the following issues, some aligning with the literature, that could contribute to this problem: regional oversaturation of HEMS programs,[40,52] frequency of EMS activation for ED rendezvouses, scarce ground transport resources,[54] lack of follow-up information or utilization review with EMPs, and minimal patient/family involvement in HEMS use. The 3 highest risk priorities identified in the FMEA were inappropriate requests from EMPs for HEMS, inappropriate EMS activation for HEMS transport, and patients and their families not involved in HEMS decision-making.

Potential Plans for Actions to Reduce Failure Occurrence

Inappropriate Requests From EMPs

Inappropriate requests may be resultant of varying definitions or perceptions of OT; regional systems issues (such as HEMS oversaturation, ground ambulance scarcity, or dispatch process variations); and EMPs' knowledge, practices, or available support. We found no studies validating the sensitivity or specificity of the GAMUT operational definition of OT as it relates to medical necessity nor any related metrics for interfacility transport OT. This is likely due in part to the variance in subjective opinions on what dictates medical need for helicopter transport. The GAMUT definition is quantifiable and reproducible but likely includes some portion of patients who required prompt medical evaluation or intervention. Attempts should be made to identify patient characteristics or situations for prospective analysis of interfacility HEMS requests for OT.

The majority of HEMS literature discusses benefit of scene response; further investigation is needed in isolating benefit from HEMS interfacility transport. Such research and OT patient characteristics could be used to create an interfacility triage tool for mode of transport. Targeted education should be provided to referring EMPs on the scope and capabilities of transport modalities along with relative costs.[29,40] Outreach education, such as providing exposure to moderate to severely injured trauma patients may be impactful, because a lack of exposure has been seen to increase secondary OT rates.[5,8,55] Considerations to expand ground critical care services in scarce regions should also be considered, given the significant response to up-triaging non-critical patients related to moderate ground response times.

It is unclear if HEMS dispatchers, who are mostly trained to the emergency medical technician–basic level, do not feel comfortable questioning a referring EMP's judgment or if organizational culture impedes this. Involvement of an experienced advanced practice provider, such as a flight acute care nurse practitioner, in the HEMS dispatch process could provide decision-making support for EMPs.[5,56] Innovative uses of telehealth for critical care transport consultation could also be considered with this advanced practice model HEMS program.[5,57] Additionally, because of our increased capabilities, transport requests received from other HEMS programs (ie, weather turndowns) currently remove this program from the HEMS utilization discussion with the referring EMP, and this may increase OT passed to this program. Further investigation and process change is warranted.

Inappropriate EMS Activation for HEMS

The proportion of OT caused by EMS activation of HEMS with ED rendezvous is unknown. Current processes in transport recording cause HEMS activations by EMS to be listed as requested by an ED if the patient enters the ED. This may be falsely elevating some EDs' OT rates. Changes in dispatch documentation will more accurately track the origination of OT requests. Education initiatives can be provided to EMS agencies with significant OT activations.[26] Triage tools and unique guidance can be provided to individual agencies based on available regional resources and transport distances. Current developments at community EDs (ie, increasing resources and establishing level 3 trauma centers) may impact this phenomenon.

Patients and Their Families' Decision-Making

HEMS is 1 of the few healthcare interventions in which patients frequently have no input on when they receive it or which provider is performing it[40]; often patients cannot be informed how much the service will cost them before they agree. Assuring patient/family involvement before HEMS arrival would be difficult. Likely, the best course for this program is to provide EMPs with resources (ie, a brochure), removing some burden from their process and prospectively providing accurate information to patients and their families regarding this HEMS program's capabilities, insurance affiliations, and billing practices.[40]

Limitations

Limitations of this quality improvement initiative include time limitations, a small sample size, lack of randomization, and participation bias. Changes in organizational alliances prevented the participation of some referring EDs. A lack of a validated OT definition and measure may not be accurately portraying the proportion of low-acuity patients being transferred emergently by HEMS (ie, a stable patient admitted for medical management >24 hours). Gaps in the literature, lack of HEMS programs' participation in data sharing, and varying definitions of OT creates difficulty in identifying average or acceptable levels of OT. GAMUT data are used for comparison with other programs; however, self-reported data and reporting biases may impair the accuracy of reported averages. Also, HEMS programs not affiliated with their receiving facilities may not be supplying complete data to GAMUT for OT averages. There are several strengths to this quality improvement study. We examined the issue from a number of stakeholders, including those external to our institution. Our findings revealed a number of facets for which further investigation would elucidate. These facets, such as OT definition, EMP and

emergency medical services practices, and shared decision-making, are applicable across multiple settings.

Conclusion

This FMEA helped to uncover associated factors for interfacility HEMS OT, downstream effects, and potential actions for impactful change. OT impacts patients, HEMS programs, and health systems. Decreased job satisfaction and increased burnout risk were noted when flight RNs were exposed to OT. Changes to job satisfaction and burnout could lead to staff turnover. Although OT has been cited as a financial burden to patients and health systems, we found limited financial burden for patients compared with this organization. However, OT practices within the region may cause such burden to other HEMS patients, particularly from for-profit billing practices. Further work is needed to validate industry and organizational definitions of OT and to create prospective identifiers, which can be applied to create an HEMS interfacility transport triage tool. Constraints of referring practices and regional oversaturation of HEMS continue to affect HEMS OT, but several mitigating actions identified in this FMEA will likely improve this phenomenon.

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