


Process improvement using telemedicine consultation to prevent unnecessary interfacility transfers for low-severity blunt head trauma

Gayla Miles ¹, Christopher Shank,² Ann Quinlan,¹ Jennifer Cavender³

To cite: Miles G, Shank C, Quinlan A, *et al.* Process improvement using telemedicine consultation to prevent unnecessary interfacility transfers for low-severity blunt head trauma. *BMJ Open Quality* 2023;12:e002012. doi:10.1136/bmjopen-2022-002012

Received 9 June 2022
Accepted 1 March 2023

ABSTRACT

Objective Mild traumatic brain injuries (MTBI) associated with intracranial haemorrhage are commonly transferred to tertiary care centres. Recent studies have shown that transfers for low-severity traumatic brain injuries may be unnecessary. Trauma systems can be overwhelmed by low acuity patients justifying standardisation of MTBI transfers. We sought to evaluate the impact of telemedicine services on mitigating unnecessary transfers for those presenting with low-severity blunt head trauma after sustaining a ground level fall (GLF).

Method A process improvement plan was developed by a task force of transfer centre (TC) administrators, emergency department physicians (EDP), trauma surgeons and neurosurgeons (NS) to facilitate the requesting EDP and the NS on-call to converse directly to mitigate unnecessary transfers. Consecutive retrospective chart review was performed on neurosurgical transfer requests between 1 January 2021 and 31 January 2022. A comparison of transfers preintervention and postintervention (1 January 2021 to 12 September 2021)/ (13 September 2021 to 31 January 2022) was performed.

Results The TC received 1091 neurological-based transfer requests during the study period (preintervention group: 406 neurosurgical requests; postintervention group: 353 neurosurgical requests). After consultation with the NS on-call, the number of MTBI patients remaining at their respective ED's with no neurological degradation more than doubled from 15 in the preintervention group to 37 in the postintervention group.

Conclusion TC-mediated telemedicine conversations between the NS and the referring EDP can prevent unnecessary transfers for stable MTBI patients sustaining a GLF if needed. Outlying EDPs should be educated on this process to increase efficacy.

INTRODUCTION

Many large healthcare systems consist of a tiered-regional structure. Acutely ill patients from outlying emergency departments are transferred to the top-tiered facility for expert care.¹ As the population ages, the need for transfers will increase.² Currently, transfers account for roughly 20% of ED patient dispositions across the USA.³ Streamlining the patient transfer process is critical to fostering

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The current state of scientific knowledge on the subject of patients sustaining mild traumatic brain injuries is the number is rising as the geriatric population increases. Many of the patients are being transferred to tertiary centers and discharged without receiving procedures or treatment.

WHAT THIS STUDY ADDS

⇒ Using telemedicine, along with direct communication between the requesting emergency department physician and the neurosurgeon, patients can be correctly and immediately identified as sustaining a mild traumatic brain injury and safely managed in their community emergency department or as sustaining a critical injury requiring emergent transfer and care.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The implications from this study support the need for standardization of guidelines for mild traumatic brain injury management by regional trauma systems to decrease unnecessary patient transfers.

patient trust. At times, patients are transferred unnecessarily causing ill effects downstream.⁴

Traumatic brain injuries

Patients sustaining a traumatic brain injury (TBI) are more likely to be relocated to a tertiary centre.⁵ A national standard of care for transferring patients with minor blunt head trauma to regional centres has not been developed.^{6,7} In the USA, in 2017 alone, over 1 million emergency department (ED) visits were TBI related.⁸ Between 2005 and 2014, in the USA, the volume of patients experiencing a TBI increased by 57.7%.⁹ And, TBIs resulting from a ground level fall (GLF) increased 29.5%, especially in the geriatric population.⁹ Rural areas with low-income populations and patients <5 years and >64 years have the highest rate of TBI injury.⁸ Due



© Author(s) (or their employer(s)) 2023. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

¹Trauma, Texas Health Harris Methodist Hospital Fort Worth, Fort Worth, Texas, USA

²Neuro-Trauma, Texas Health Harris Methodist Hospital Fort Worth, Fort Worth, Texas, USA

³Transfer Center, Texas Health Resources, Arlington, Texas, USA

Correspondence to

Gayla Miles;
gayla.miles2013@gmail.com

to the rapid increase in the volume of TBIs, establishing standardised care is requisite.^{9 10}

Mild traumatic brain injuries

Not all TBIs are severe.^{10 11} Many are classified as mild and frequently the patient is seen and discharged from the ED or, at times, transferred to a higher level of care for evaluation and then discharged soon after arrival.^{9–11} In 2018, Medford-Davis *et al* evaluated ED-to ED transfers in six states.¹² As many as 78.9% of patients experiencing a mild TBI (MTBI) were transferred from an outlying ED to a tertiary ED and subsequently discharged after arriving without a procedure being performed.^{4 9 12 13}

Mild blunt head trauma after GLF commonly results in a small positive intracranial radiographical finding.^{14 15} The incidence of delayed worsening of intracranial haemorrhage in MTBI patients has been evaluated showing minimal change.^{14 15} Recent studies evaluating patients with an MTBI injury suggest that worsening of the intracranial haemorrhage is unusual and that the transfers may universally not be necessary.^{11 14 15} In two studies, one from the University of Alabama (UA) and one from the University of South California Davis (USCD), the incidence of delayed worsening of intracranial haemorrhage was low.^{14 15} At USCD, only 1.3% of patients taking the anticoagulant warfarin sodium and only 0.4% of patients not taking anticoagulants had a delayed worsening of their traumatic intracranial haemorrhage.¹⁵ At the UA, 304 admitted patients were evaluated with no neurological worsening during their hospital course, suggesting that patients with isolated MTBI could be safely medically managed at their original facility.¹⁴ In another study, at the University of Pittsburgh, telemedicine consultation was performed by the neurosurgeon (NS) preventing unnecessary transfers of patients with TBI and a GCS of 14–15 without neurological degradation.¹¹ Also, in 2020, Eichburg *et al* evaluated neurosurgery telemedicine cases, and the visits were rated as a success in 99.6% of the cases. The cases labelled as unsuccessful were related to technology failure.¹⁶ With the use of telemedicine, the patient cases were successfully managed. Patients requiring transfer for additional higher level of evaluation and care were accurately identified.¹⁶ The use of telemedicine consultation was recommended to assist with the identification of and prevention of unnecessary transfers.^{11 12 16}

Telemedicine

The COVID-19 pandemic requisites included isolation of one's-self from others and communication without travel.¹⁷ One positive outcome of the pandemic was the incorporation of telemedicine as a communication delivery care method which is described as the practice of medicine using technology to deliver care from a distance.¹⁶

Prior to the pandemic, telemedicine was not heavily used. Governmental barriers such as lack of reimbursement, confidentiality concerns and inadequate technology blocked widespread use.¹⁶ The lack of a physical

exam and the prevention of physician-patient bonding were voiced physician concerns.¹⁶ As the demand for telemedicine grew worldwide due to the pandemic travel restrictions, governmental barriers were relaxed allowing the new medium to burgeon and rapidly expand.^{16 17}

As use steadily spread, physician-based fear decreased and acceptance grew. In 1 week, in the April 2020, telemedicine interactions which included video, audio only, care chat, secure email and telemonitoring increased from 13 000 to 1.7 million visits.¹⁷ And, in 1 year, in the USA, from 2019 to 2020, the use of telemedicine increased by 3000%.¹⁷ Using this medium, time, travel expenses and healthcare system expenditures decreased, and Medicare requirements relaxed to allow expanded reimbursement.^{16–18}

Another pertinent application of telemedicine is the transferability of images when a patient is transported to a new facility. With the introduction of PICTURE Archive Communication System (PACS), images are allowed to be sent/received electronically. With the use of the PACS system, by 2017, duplicate imaging occurring with patient transfers decreasing 50% over a 3-year span.¹⁹

The use of telemedicine will require continued support. Guidelines, legislative policy, privacy protection, infrastructure, along with dissemination of information for use will require further construction and implementation.¹⁷ Over time, the venue will become a valuable worldwide resource especially for rural patients and vulnerable populations.¹⁷

This article describes a collaborative process improvement (PI) project at a large tertiary referral centre to prevent the unnecessary transfer of patients suffering low-severity MTBIs from GLFs using telemedicine neuroconsultation. Currently, our local standard of care is to transfer patients suffering MTBIs to a trauma centre with neurosurgical coverage.

METHOD

Prior standard of care

Prior to implementation of the transfer centre (TC) task force, the requesting facility, initiated transfer requests by contacting the TC. The TC then placed a call to one of the tertiary care centres and connected the requesting emergency department physicians (EDP) to the tertiary centre EDP. A case description was given by the requesting EDP. The tertiary EDP then decided if the transfer was accepted, declined or if further information was needed. For some patients with neurological injuries, the EDP may have elected to include the NS on-call in the transfer discussion and in the decision to accept/decline the transfer. In summary, several phone calls occurred over an extended period of time prior to the patient being accepted or declined for transfer.

In many instances, if transferred, on arrival to the tertiary centre both the patient and the family assume the patient will be admitted and will go straight to an assigned hospital room. After careful review of the patient and

their data by the EDP and the NS on-call, many patients are found to not warrant admission, further testing or procedural intervention. This evaluation results in frustration for the patient and the family. Commonly, the decision to discharge the patient from the tertiary ED is made causing the patient to clamber for a means to get home.

One operational PI opportunity to decrease unnecessary transfers, improve care efficiency and to augment the patient experience was to create a task force between the organisation's TC, the EDPs, the trauma surgeons (TS) and the NS. The task force elected to bypass the receiving EDP and the TS, allowing the outlying EDP to talk directly to the NS on-call for patients meeting specific criteria. The NS would then review the case and advise the outlying EDP on the appropriateness of transfer or observation at the outside facility with subsequent discharge after meeting criteria. This protocol was instituted mid-September (13 September 2021). Disposition outcomes, transfer request volumes, as well as those suffering MTBI related to GLFs, completed transfer volume and neurosurgical intervention rates, were compared both preimplementation (1 January 2021–12 September 2021) and postimplementation (13 September 2021–31 January 2022).

RESULTS

The TC received 1091 neurological-type patient transfer requests from 1 January 2021 to 31 January 2022. The 37-week preimplementation period received 653 neurological-type transfer requests: 406 neurosurgical, 188 neurological and 59 requiring interventional radiological (IR) intervention. Of this group, 456 were accepted for transfer of which 79 were admitted for neurosurgical and neurocritical care management (see [table 1](#)).

The 20-week postimplementation period included 438 neurological-type transfer requests: 353 neurosurgical, 54 neurological and 31 requiring IR intervention. Out of this group, 353 patients were accepted for transfer of which 104 were admitted for neurosurgical and neurocritical care management indicating the transfers were appropriate (see [table 1](#)).

The total number of patients declined (excluding Consults Only) consisted of 53 in the preimplementation group and 50 in the postimplementation group mainly for non-bed-availability. The patients receiving consult only and remaining at their respective EDs consisted of 15 in the preimplementation group of which 9 were neurological consults, 5 neurosurgical consults, 1 IR consult. Of the five neurosurgical consults, two were the result of a GLF resulting in a subdural haematoma (SDH). The patients receiving consult only in the postimplementation group consisted of 37 patients of whom 8 were neurological consults, 23 neurosurgical consults and 6 IR consults. Of the neurosurgical group, six were related to a GLF resulting in an SDH and six had a diagnosis of subarachnoid or intracranial haemorrhage (see [table 1](#)).

The patients transferred and discharged from the tertiary, receiving facility ED consisted of 61 patients in the preintervention group of which 24 had the diagnosis of SDH, 14 subarachnoid haemorrhages (SAH) and 23 had other neurosurgery related injuries. The postimplementation group consisted of 42 patients of whom 13 had an SDH, 6 SAH and 23 patients had other neurosurgical-related type of injuries (see [table 1](#)).

The preimplementation group disposition of the transfer requests consisted of 79 neurosurgical/neurocritical care admissions, 61 discharges from the receiving ED, 1 patient deceased on arrival to the ED and 3 patients leaving the ED against medical advice (AMA). In the postimplementation group, 104 were admitted to the neurosurgical/neurocritical care group, 42 were discharged from the receiving ED, 1 patient deceased in the ED and 3 patients left AMA (see [table 1](#)).

The preimplementation group requiring neurosurgical intervention consisted of 16 patients of whom 15 required surgical intervention within 24 hours. The postimplementation group consisted of 12 patients requiring neurosurgical intervention, of which 11 required surgical intervention within 24 hours. Of the 11 patients, 2 required emergent intervention and were taken directly from the helipad after being cleared for stability by the EDP directly to surgery for immediate neurosurgical intervention (see [table 1](#)).

DISCUSSION

In summary, the described process change to include the on-call NS proximally in the transfer request process was well received by all groups involved. The MTBI patients were safely cared for at their primary facility preventing unnecessary transfers of low-severity patients. The neurosurgical 'consults only' increased 4-fold from 5 to 23 with a 6% overall increase in neurological-type consults in the postintervention period. The patient discharges from the receiving ED decreased from 61 preimplementation to 42 postimplementation allotting bed space for the 25-patient increase in the neurosurgical/neurocritical care admissions deemed necessary transfers by the NS (see [figure 1](#)). By using a neurosurgical telemedicine consult, a win-win situation was created. The communication was effective, organised and available. Physicians and specialists can now work simultaneously extending doctor-to-doctor communication to determine the patient need.

Communication with Outlying physicians

Early lessons learnt included the need for education of the outlying EDP in the process change to promote compliance and to maintain long-term strategic relationships with referring facilities. Even though direct conference between the outlying EDP and the NS included the discussion of safe management of the patient in their primary ED, some of the outlying physicians were not comfortable with the recommendation and transferred their patient to another tertiary facility.

Table 1 Transfer data

Transfer information	Preimplementation (37 weeks)	Postimplementation (20 weeks)
Neurology specialty request		
Neurosurgery	406 (62%)	353 (80%)
Neurology	188 (28%)	54 (12%)
Interventional radiology	59 (9%)	31 (7%)
Total	653	438
Total patients transferred (all specialties)	456	353
Total neurosurgery/neurocritical care transferred	144 (31%)	150 (42%)
Total declined (excludes consult only)	53	50
Consult only (remained at requesting facility)		
Neurology	9	8
Interventional radiology	1	6
Neurosurgery	5	23
Total	15 (4%)	37 (10%)
Consult only intracranial haemorrhage diagnosis		
Diagnosis SDH/ground level fall	2	6
Diagnosis SAH/ICH	0	6
Receiving ED discharge after transfer		
SDH	24	13
SAH	14	6
Other neurosurgery related	23	23
Total	61 (15%)	42 (12%)
Disposition		
Admitted neurosurgery/neurocritical care	79 (19%)	104 (29%)
Discharged	61 (15%)	42 (12%)
Deceased	1	1
Left against medical advice	3	3
Patients requiring neurosurgical intervention		
Neurosurgical intervention within 24 Hours	15	9
Neurosurgical intervention after 24 Hours	1	1
Taken directly from helipad to surgery	0	2
Total	16 (4%)	12 (4%)

ED, emergency department; ICH, intracranial haemorrhage; SAH, subarachnoid haemorrhage; SDH, subdural haematoma.

When transferring a patient becomes a consideration, the inclusion of everyone's thoughts is important allowing the deliberation of benefit versus burden.²⁰ Denying a truly specific need for transfer can be dangerous.²⁰ Even though not always evident in this project, the evolution of telemedicine can allow the involvement of outlying and rural physicians in the decision-making process.²⁰ Telemedicine can be used to differentiate patients with higher priority vs lower priority needs. Being able to accurately decide the difference is a valuable undertaking.²⁰ Increasing trust to overcome lack of knowledge, especially in specialty areas, plays into the effective communication process.²¹ Although, not always occurring in this study, in

a study performed by Emanuelson *et al*, one-third of the patients were not transferred when physicians received reassurance from consulting surgeons.²² Even more importantly, patients were identified who required immediate higher levels of care.¹⁶

For patients requiring emergent intervention, the described process-change facilitated and streamlined definitive treatment for those patients who needed both prompt transfer and emergent neurosurgical intervention, potentially salvaging vital brain tissue and contributing to improved outcomes.⁷ An example is the ability twice during the study period, using direct communication with the NS via telemedicine, the patient was

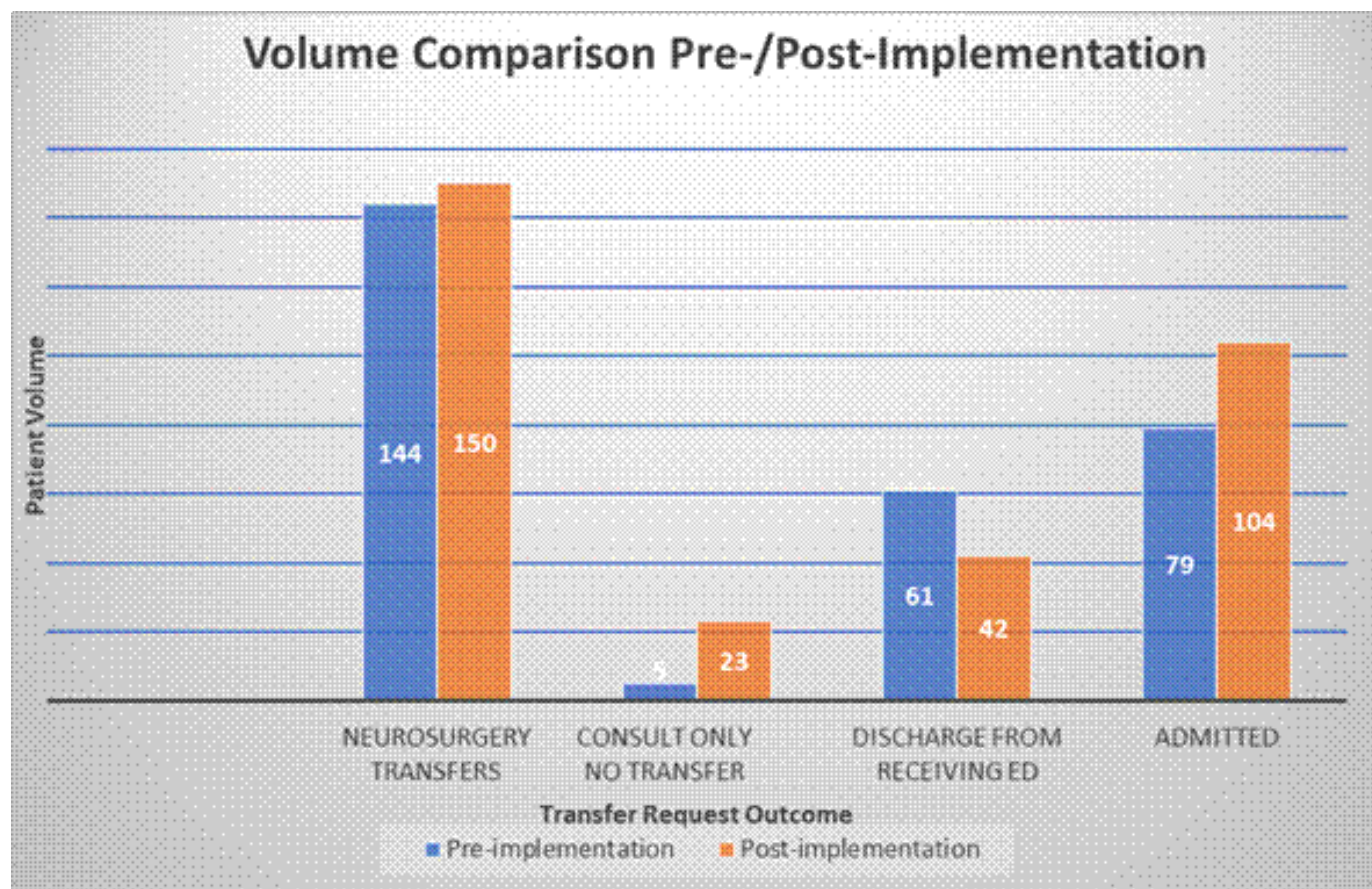


Figure 1 Preimplementation/postimplementation table neurosurgical consult.

identified as an emergent priority and allowed to proceed directly from the transport vehicle to surgery. This process prevented delays in the ED and ensured clinical stability and immediate surgical intervention.

Finally, another neurosurgical dilemma are patients sustaining devastating injuries. The neurosurgical consult process can limit the unnecessary transfer, cost, confusion and false hope for families of patients suffering catastrophic and non-salvageable neurological injuries. Often these patients are transferred with overwhelming, irrecoverable neurological insults and die either during transport or soon after arrival.^{12 13 20} This transfer type occurs more likely on the weekend or off hours and is often less likely to be insured.^{12 13 20} The transfers are decidedly futile with no hope of recovery from the injury associated with an impending death.¹ The consequence of the transfer is misplacement of family out of their community with no support network at a time of grievance. The family faces the extra burden of cost of care in a situation in which the outcome would have been the same if the transfer had not occurred.

ED discharges after transfer

Once the patient arrives and the transfer is completed, the receiving facility and physician bear the burden of the patient evaluation and outcome. A significant portion of patients are discharged from the receiving facility's ED without intervention or admission.^{12 13} If the patient

is subsequently discharged from the receiving ED, the patient is also required to have ready access to go home, magnifying frustration for the patient and caregivers.

At times, transfers are not as urgent as described. Up to one-third (33%) of unnecessary transfers are caused by diagnostic inaccuracy resulting in a change in the diagnosis after arrival.^{4 20} Avoidable transfers not requiring higher level of care range from 20% to 66%.^{20 23} And, as many as 32%–47% of patients transferred to tertiary EDs for traumatic injury and a higher level of care are discharged from the receiving ED without admission, observation or procedures.^{12 13}

Cost/family disruption

Patient transfers are associated with considerable cost.¹² The lowest income population and the geriatric population account for half of the aggregated costs and ED visits in rural areas.⁶ Medical visits in rural areas are considered expensive with an initial ED visit costing approximately US\$1863.^{12 13 18} If transferred, the patient is responsible for both the initial ED visit and the trauma centre charge (minimally US\$6076), which does not include the cost of procedures performed at the facility.^{12 13} The resulting expense is unaffordable for many patients, especially the uninsured and patients from rural, lower-income communities.²³

The cost of ground transportation can range from US\$10 to US\$24.64 per mile averaging US\$400 to US\$6000

per transport.^{20 23} If the patient is critically ill or far away from a tertiary centre, air transport can occur. The cost of air transport ranges from US\$11 000 to US\$30 000.^{23 24} Also, out-of-network costs when air transport occurs can be a surprise to the patient and family.²⁵ Due to the injury, insurance may not be accounted for before-hand, and the patient receives an out-of-network request for payment which may be exceedingly large.²⁴ Even if insured, transport costs may not be covered.²³ Out of 36312 claims reviewed, 775 were out of network and had an average cost of US\$37 747 for an air ambulance transport.^{4 24} The cost of the transfer can be more than their injury management at the facility.^{4 24} Thought must be given for the downstream consequences of the transfer.^{20 23} The total family experience combines the expense of medical care costs, transportation, hotel accommodations, meals and at times childcare.⁹ If able, being treated in their community decreases the burden.⁴

The average distance of transfer in a UA study was 64.5 miles but can be more than 100 miles.^{4 12} Wilson *et al* found that over 60% of the population served lives more than an hour by road to a tertiary care centre and 40% reside more than 4 hours away.^{12 13 21} When the patient is transferred, risk for deterioration is a concern especially during long transports impacted by weather and infrastructure issues.²¹ And, in rural areas, top-tier trauma facilities may serve several states and may be as far as 600 miles away causing a very heavy burden on the patient and family.²⁶

Increasing emergency service demand

Another reality is the fight for real estate and bed accommodations at tertiary centres due to high demand. Emergency department overcrowding has increased over time and dates back to the mid-1980s.²⁷ Over a 3-year period, 75% of hospitals reported increased holding times for admitted patients.²⁷

Along with the rising patient census of complex patients coming to the tertiary centres, is the 'spreading thin' of the surgeon workforce.² Many EDs have difficulty finding full-time on-call coverage for specialists.^{12 13} Up to 74% of EDs have difficulty maintaining on-call coverage with more pronounced difficulties such as neurosurgery or plastic surgeons.^{12 13} Unnecessary transfers can have negative impact on available beds and resources.²² Therefore, making a conscious effort to transport only the patient with definite needs is central to the appropriate allocation of care.^{12 18} Improving processes to allocate resources prudently is imperative. Being resourceful and minimising patient transfers with low-severity injuries, which can be safely managed at their primary EDs with consultation, allows the specialists to allocate better resources to patients with greater needs at the tertiary facility.¹⁸

Concurrently, the demand for emergency medical services (EMS) services has consistently risen over the past 20 years.²⁸ Acuity varies but a large portion of the calls and transports are for low-acuity conditions. The low-acuity patients are often transported to over-crowded

EDs, causing delays in EMS services and a decrease in the quality of care.²⁸ Delayed EMS response negatively affects patient outcomes.²⁹ In rural areas, ambulances have to travel extended distances to care for sparse populations resulting in increased costs and healthcare resource shortages. Disseminating available ambulances to allow for timely responses is an important task to provide appropriate care for patients with higher versus lower needs.²⁹

When being transported, concern for risk of a collision should be considered. In 2010, 6500 EMS collisions were reported with almost half (48%) involving a patient transport.³⁰ The drivers are exposed to a variety of stressors such as inadequate operator training, fatigue, distraction, multitasking, poor knowledge of driving laws and driving at odd hours in unfamiliar territory.^{30 31} Road and flight conditions must also be considered for personnel and patient safety.³⁰

In conclusion, multiple factors carry weight in the decision to transfer a patient. A more coordinated regionalised response would better allocate resources and help manage patients more efficiently closer to home.²² The patient's condition and possible status-change during the transfer, the lack of resources at the requesting site, weather and cost to the patient need to be considered.^{20 22} The decision has downstream effects for the patient, family, healthcare facility and the surgeon.⁴ Collaboration between both the requesting and the receiving physicians and the TC is needed to identify the right patient and right time for a transfer to occur and to foster patient trust in the system.^{4 12 18} Patients who are transported and rapidly discharged without need for admission or specialty intervention, as well as those suffering non-salvageable injuries may benefit the most from avoiding unnecessary transfer.^{14 18} Doing so may improve patient satisfaction and relieve overuse of unnecessary neurological consultation and ED overcrowding.¹⁴ Overall, in this study, the MTBI patients were safely cared for at their primary facility preventing unnecessary transfers of low-severity patients.

LIMITATIONS

The data collection ended prior to obtaining patients during an equal time period for both the preintervention and postintervention groups. Due to seasonal variability in trauma, fluctuations could have affected the non-equivalent periods. There was an increase in the neurosurgical consults postintervention group, but equal comparison was not possible. Lack of support by outlying EDP's also limited the impact of the programme.

CONCLUSION

Hospital organisations should encourage clinical partners to engage in operational-type solutions to streamline care and enhance the patient experience. The changes should include all stakeholders to ensure strategic alignment within the organisation. The use of telemedicine can allow for specialist consultation and prevent unnecessary

MTBI patient transfers, while simultaneously closing the care loop, decreasing cost and increasing patient satisfaction and trust. Increasing communication and sharing of data increases critical physician-to-physician communication to allow standardisation of patient transfer pathways.^{21 22} Development of MTBI guidelines through regional trauma systems would be beneficial.

Acknowledgements The authors have no acknowledgements, received no funding and have no competing interests to report.

Contributors The primary author was GM. CS spear-headed the project and therefore reviewed the article for accurate reporting of the implementation and results. AQ was also involved in the project and reviewed the information for accuracy. JC provided the data and approved the results provided. GM is the author responsible for overall content and guarantor.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

ORCID iD

Gayla Miles <http://orcid.org/0000-0003-2903-6026>

REFERENCES

- 1 Pannu J, Sanghavi D, Sheley T, *et al*. Impact of telemedicine monitoring of community ICUs on interhospital transfers. *Crit Care Med* 2017;45:1344–51.
- 2 Philip JL, Yang D-Y, Wang X, *et al*. Effect of transfer status on outcomes of emergency general surgery patients. *Surgery* 2020;168:280–6.
- 3 Augustine J. Latest data reveal the ED's role as hospital admission gatekeeper. In: *ACEP Now: The Official voice of Emergency Medicine*. 2019. Available: <https://www.acepnow.com/article/latest-data-reveal-the-eds-role-as-hospital-admission-gatekeeper>
- 4 Putnam J, Pedreira R, Fox P. Hand surgery transfers to level 1 center: variables affecting transfer method and diagnostic accuracy. *Plast Reconstr Surg Glob Open* 2020;8:e3279.
- 5 Usher MG, Fanning C, Fang VW, *et al*. Insurance coverage predicts mortality in patients transferred between hospitals: a cross-sectional study. *J Gen Intern Med* 2018;33:2078–84.
- 6 Moore B, Liang L. Costs of emergency department visits in the United States, 2017. In: *Healthcare Cost and Utilization Project: Statistical Brief # 268 in Agency for Healthcare Research and Quality. December 2020*. 2020: 1–13.
- 7 Kindermann D, Mutter R, Pines J. Emergency department transfers to acute care facilities, 2009. In: *Healthcare Cost and Utilization Project: Statistical Brief #155 in Agency for Healthcare Research and Quality*. 2013: 1–12.
- 8 Reid L, Fingar K. Inpatient stays and emergency department visits involving traumatic brain injury, 2017. In: *Healthcare Cost and Utilization Project: Statistical Brief #255 in Agency for Healthcare Research and Quality*. 2020: 1–12.
- 9 Hsia RY, Markowitz AJ, Lin F, *et al*. Ten-Year trends in traumatic brain injury: a retrospective cohort study of California emergency department and hospital revisits and readmissions. *BMJ Open* 2018;8:e022297.
- 10 Gaw CE, Zonfrillo MR. Emergency department visits for head trauma in the United States. *BMC Emerg Med* 2016;16:5.
- 11 Alan N, Kim S, Agarwal N, *et al*. Inter-facility transfer of patients with traumatic intracranial hemorrhage and GCS 14–15: the pilot study of a screening protocol by neurosurgeon to avoid unnecessary transfers. *J Clin Neurosci* 2020;81:246–51.
- 12 Medford-Davis LN, Holena DN, Karp D, *et al*. Which transfers can we avoid: multi-state analysis of factors associated with discharge home without procedure after ED to ED transfer for traumatic injury. *Am J Emerg Med* 2018;36:797–803. 10.1016/j.ajem.2017.10.024 Available: <https://doi.org/10.1016/j.ajem.2017.10.024>
- 13 Holena DN, Kaufman EJ, Hatchimonji J, *et al*. The impact of interhospital transfer on mortality benchmarking at level III and IV trauma centers: a step toward shared mortality Attribution in a statewide system. *J Trauma Acute Care Surg* 2020;88:42–50.
- 14 Ditty BJ, Omar NB, Foreman PM, *et al*. The nonsurgical nature of patients with subarachnoid or intraparenchymal hemorrhage associated with mild traumatic brain injury. *J Neurosurg* 2015;123:649–53.
- 15 Chenoweth JA, Gaona SD, Faul M, *et al*. Incidence of delayed intracranial hemorrhage in older patients after blunt head trauma. *JAMA Surg* 2018;153:570–5.
- 16 Eichberg DG, Basil GW, Di L, *et al*. Telemedicine in neurosurgery: lessons learned from a systematic review of the literature for the COVID-19 era and beyond. *Neurosurgery* 2020;88:E1–12.
- 17 Omboni S, Padwal RS, Alessa T, *et al*. The worldwide impact of telemedicine during COVID-19: current evidence and recommendations for the future. *Connect Health* 2022;1:7–35.
- 18 Haleem A, Javaid M, Singh RP, *et al*. Telemedicine for healthcare: capabilities, features, barriers, and applications. *Sens Int* 2021;2:100117.
- 19 Sheppard CW, Groll AL, Austin CL, *et al*. Impact of duplicate CT scan rate after implementation of transfer image Repository system at a level 1 trauma center. *Emerg Radiol* 2018;25:275–80.
- 20 Kuhn EN, Warmus BA, Davis MC, *et al*. Identification and cost of potentially avoidable transfers to a tertiary care neurosurgery service: a pilot study. *Neurosurgery* 2016;79:541–8.
- 21 Wilson MM, Devasahayam AJ, Pollock NJ, *et al*. Rural family physician perspectives on communication with urban specialists: a qualitative study. *BMJ Open* 2021;11:e043470.
- 22 Emanuelson RD, Brown SJ, Termuhlen PM. Interhospital transfer (IHT) in emergency general surgery patients (EGS): a scoping review. *Surg Open Sci* 2022;9:69–79.
- 23 Friebe I, Isaacs J, Mallu S, *et al*. Evaluation of appropriateness of patient transfers for hand and microsurgery to a level I trauma center. *Hand (N Y)* 2013;8:417–21.
- 24 Fuse Brown EC, Trish E, Ly B, *et al*. Out-of-network air ambulance bills: prevalence, magnitude, and policy solutions. *Milbank Q* 2020;98:747–74.
- 25 The Top Six Examples of Quality Improvement in Healthcare. Health catalyst editors. 2019. Available: www.healthcatalyst.com/authors/health-catalyst-editors/
- 26 American Trauma Society. Find your local trauma center. Available: www.amtrauma.org/page/FindTraumaCenter [Accessed 1 Sep 2022].
- 27 Savioli G, Ceresa IF, Gri N, *et al*. Emergency department overcrowding: understanding the factors to find corresponding solutions. *J Pers Med* 2022;12:279.
- 28 Pinet-Peralta LM, Glos LJ, Sanna E, *et al*. Ems utilization predictors in a mobile integrated health (miH) program. *BMC Med Inform Decis Mak* 2021;21:40.
- 29 Lee E, McDonald M, O'Neill E, *et al*. Statewide ambulance coverage of a mixed region of urban, rural and frontier under travel time catchment areas. *Int J Environ Res Public Health* 2021;18:2638.
- 30 Sanddal TL, Sanddal ND, Ward N, *et al*. Ambulance crash characteristics in the US defined by the popular press: a retrospective analysis. *Emerg Med Int* 2010;2010:525979.
- 31 Hsiao H, Chang J, Simeonov P. Preventing emergency vehicle crashes: status and challenges of human factors issues. *Hum Factors* 2018;60:1048–72.