THEORETICAL AND ACTUALIZED TRAUMA CARE IN A LEVEL 3 TRAUMA CENTER

by

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Abstract

The concept of trauma systems is a generally agreed upon principle in the world of trauma, where patients access appropriate care for their injuries in an appropriate time frame, resulting in rehabilitation and reintegration into society. The literature favours care of the severely injured at tertiary centers, thus a system is formed to pull the patient to the ideal center of care. Though theoretical frameworks exist, how the system is actualized remains ambiguous, variable, and difficult to capture. Current system measurements perhaps are not reflecting system actualization, especially for non-tertiary centers with no staff assigned to surveillance of the injured patient through the system. After a scoping review of the literature, it was found that secondary triage and subsequent under-triage could be a significant indicator of system function and actualization. Thus, a retrospective chart review was done at a non-tertiary center to assess system function through secondary triage to tertiary care. All injured patients transferred to a tertiary center from a level 3 trauma center between January 1, 2017-December 31, 2017 were reviewed. Inpatient transfers were used to reflect under triage. It was found that patients had a 50% likelihood of being appropriately triaged when they met the major trauma patient criteria of the health authority. Call times to the patient transfer network were poorly documented and showed significant delay of access to care. As well, results showed a significant underuse of general surgery consultation with only 5 of the 27 patients being seen by the service, 4 of them were then transferred from the emergency department. Though this site has theoretical system planning, support tools, and algorithms—actualization was variable and showed an underappreciation for the injuries and their sequelae. Exploring tools to decentralize surveillance and influence include a using a simple Cribari Matrix to calculate an under-triage rate, applying a Learning Health Systems cycle, and drawing on High Reliability Organization principles to optimize care. Ultimately, culture will drive practice, therefore it is imperative that we drive culture with relentless intention to best influence the care of the injured.

Lay Summary

Severely injured patients require specialized care at specialized hospitals. Though access to these hospitals is a part of all health authorities planning, it is not always realized in the manner it was intended. Smaller, less specialized hospitals are often responsible to recognize severe injury and activate the system to ensure their access to specialized care. This body of work endeavours to describe the uptake of these intentions and observe whether patients are accessing specialized care for injury from non-specialist hospitals.

Preface

The concept for this paper is an original idea of the author, though refined and influenced over time by both Dr. Hameed and Dr. Wilson. Dr. Hameed directed me towards high reliability organizations and learning health systems for the final chapter and was involved in the outline development. Dr. Hameed also assisted with editing the manuscript for grammar, thought flow, and development. Dr. Wilson assisted with data access and collection once ethics was complete.

Also obtained was a Harmonized Ethics Review approval from UBC Clinical Research Ethics Board via the UBC RISE Certificate H18-01792 for the retrospective chart review in Chapter 2. As well Operational Approval 2018-19-056-H was granted December 3, 2018.

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Dr. Wilson has given me her honest, earnest, and compassionate support at every turn and I am forever indebted to her. She has opened doors and has been my perpetual champion, always generous, and ever kind.

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Thank you, Dr. Campbell for your friendship and support as an advisor and Dr. Khazei for your positivity and thoughtfulness always.

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My family and friends-thank you for your love and sacrifice for my benefit.

For my children. That they might know their passion and live it out daily.

1.Introduction

Injury is a significant public health issue and in the province of British Columbia (BC) it is reported that approximately 700,000 injuries occur yearly with a cost of nearly 3 billion dollars (1). Not only is this a significant amount of injury, the financial burden continues when 9,000 patients are permanently disabled (1). It is agreed upon in the world of trauma, that severely injured patients should be cared for within inclusive systems of trauma care and that there is a significant increase in morbidity and mortality when these systems are not well integrated (2-23).

1.1 The Ideal

A trauma system is a specifically differentiated group of prehospital, hospital, and rehabilitative services, within predetermined boundaries of function and capacity, that is equipped to meet well defined and specific goals in the care of the injured (2,3,12–21,4,22–24,5–11) . From the initial injury to the reintegration into work and society, a trauma system functions within geographical boundaries and specific capacities at all service levels in varying regions with diverse resources, to maximize positive outcomes for the injured. Ultimately, the trauma system is in place to ensure the injured patient is able to access appropriate resources in a safe, direct, and timely manner (2-35).

Though the trauma system concept is well defined, well studied, and ubiquitously accepted, there remains a disconnect between the intellect of the issue and the action in response to the issue. There are many principles that the trauma community agrees on, however, the details of minute to minute care of a trauma patient, especially at non-tertiary centers, remain variable and unpredictable (5,8,19,25).

Not only is the implementation of the system inconsistent, performance measurement remains ambiguous, lack of structure and consensus leaves data lying unmined and unreported to frontline staff (3,12,14,17,19,24–33). Further exploration is needed to expose why current outcome measurement does not reflect system actualization, and deeper still why actualization varies so greatly from the theory.

Trauma systems in Canada have been traditionally defined by the Trauma Association of Canada (TAC) which established an accreditation process for centers across Canada (36). In British Columbia (BC), Trauma Services of British Columbia (TSBC) defines levels of service for trauma centers across the provincial inclusive system (37). TSBC provides definitions of the levels of care as shown in Table 1 (36,37) and though this is helpful, the definitions are not explicit and do not outline appropriate care boundaries, especially at the non-tertiary centers.

Table 1. Trauma Center Designations by Trauma Association of Canada 2011 (36,37)

LEVEL	DESCRIPTION
Level I	These trauma centres play a leadership role in a provincial trauma system and are central in a regional trauma system. They provide Tertiary and major trauma care, including complex and unique (quaternary) trauma systems for the province. They also represent academic leadership, including trauma training and research programs usually located in large metropolitan areas.
Level II	These trauma centres are required in areas without Level I trauma centres or where trauma caseload is high. They are large community based medical centres that may or may not be university affiliated.
Level III	These trauma centres are required in areas without access to Level I or II trauma centres. They are typically in small urban or rural communities and are not usually university affiliated.

Level IV	These trauma centres divert major trauma to Level I or II trauma centres and provide care for secondary trauma cases. They are typically located in urban centres with nearby major trauma centres. They are large community based or university affiliated medical centres.
Level V	These trauma centres receive pediatric or adult cases within their catchment area if airway management is required. Otherwise they divert trauma patients to the nearest appropriate trauma centre. They are usually located in rural, small community hospitals or treatment centres.
Level Pediatric-I (P-I)	These trauma centres play a central roles in provincial and regionals pediatric trauma systems. They maintain academic leadership in research and training and may serve as lead in jurisdictions of more than one Level I or II adult trauma centre. They also play an outreach role in education, advise, consultation, triage and clinical care. They are university affiliated pediatric trauma centres with full array of medical subspecialties and advanced technology and may be recognized as a "children's hospital".
Level Pediatric-II (P-II)	These trauma centres typically exist as a separate administrative entity within a larger Level I or II trauma centre. They cover a comprehensive array of medical sub-specialities and services dedicated to children and may or may not be university affiliated.

The levels of service only state the minimum services that need to be ***available***, not at what ***capacity*** they should be working within.

Our lack of understanding of the extent of trauma system actualization in BC is reflected in even the most basic data. The 2015 TSBC injury report (Figure 1, 37) shows the distribution of the injured by hospital and region. The graph shows that only certain sites, 10 of 75, saw severely injured patients. Intuitively, this cannot be accurate as severe injuries happen everywhere in the province. Notably, a Level 3 hospital within the Interior Health Authority is listed as seeing no severely injured patients, while 2 other level 3 centers in BC that see the same volume of injuries report at least 200 severely injured patients in 2015. These cases are reflected in provincial trauma statistics because these sites staff a trauma care coordinator who captures data and

enters it to into the provincial registry. This creates a significant misconception of events if one was just to look for the most severely injured patients from these graphs and determine they only occur at the represented centers. In reality, there are severely injured patient events that are not captured or reflected anywhere in the system and that creates error and skewing of the data.

Figure 1. TSBC Distribution of Injury by Region 2015 (37) These figures pulled from the provincial report on injury, reflect the absence of capture of the severely injured at non-tertiary centers in the province.

Figure1.1 Interior Health

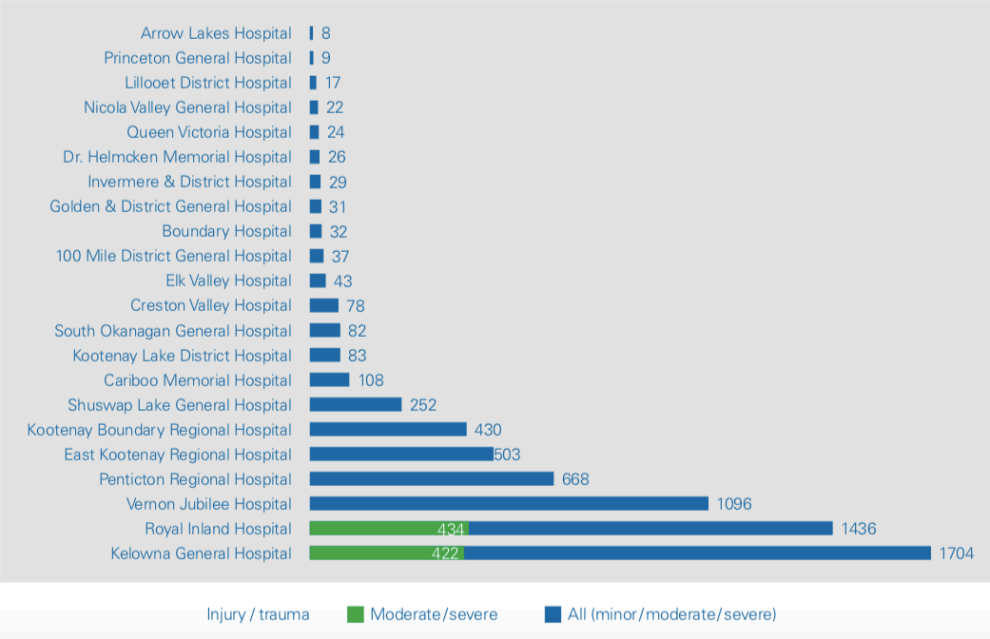


Figure 1.2 Island Health

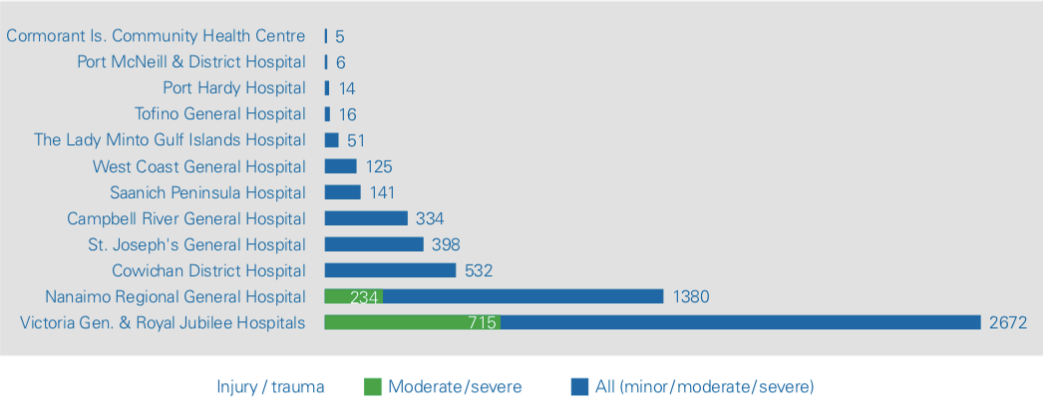


Figure 1.3 Northern Health

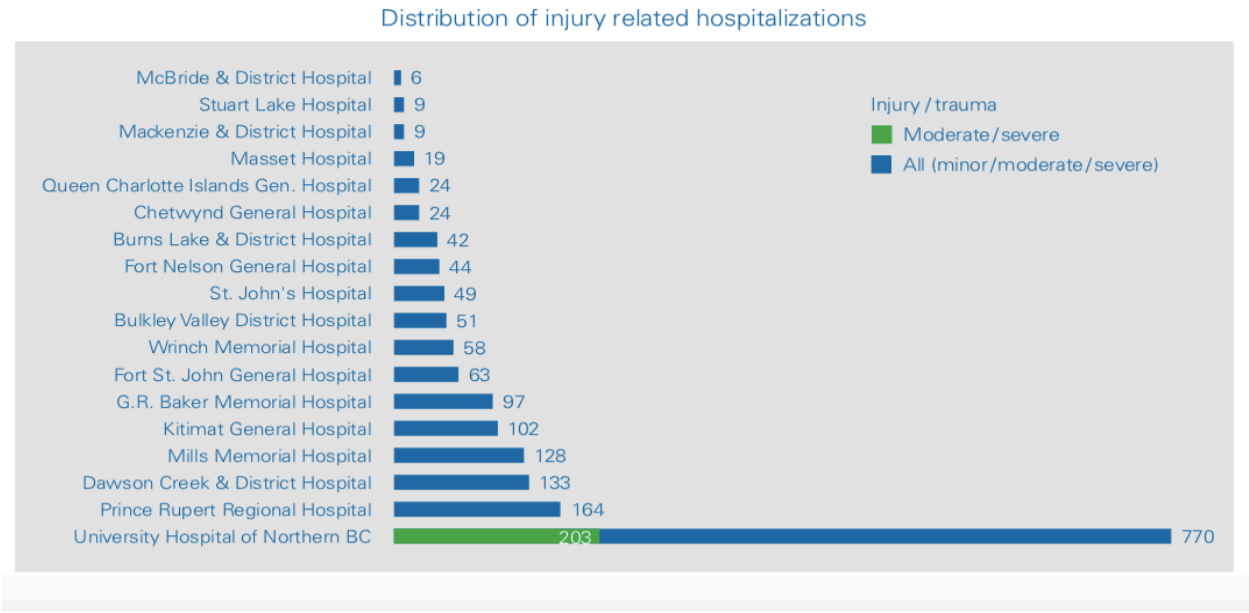


Figure 1.4 Coastal Health

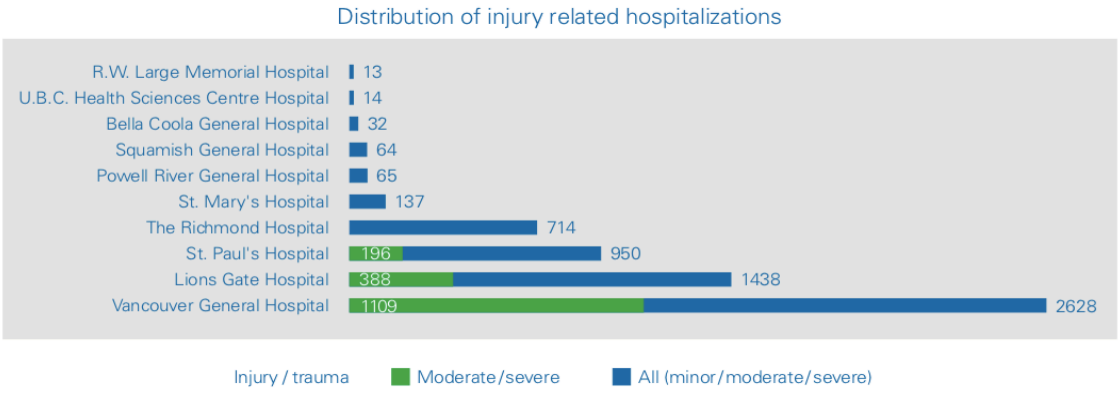
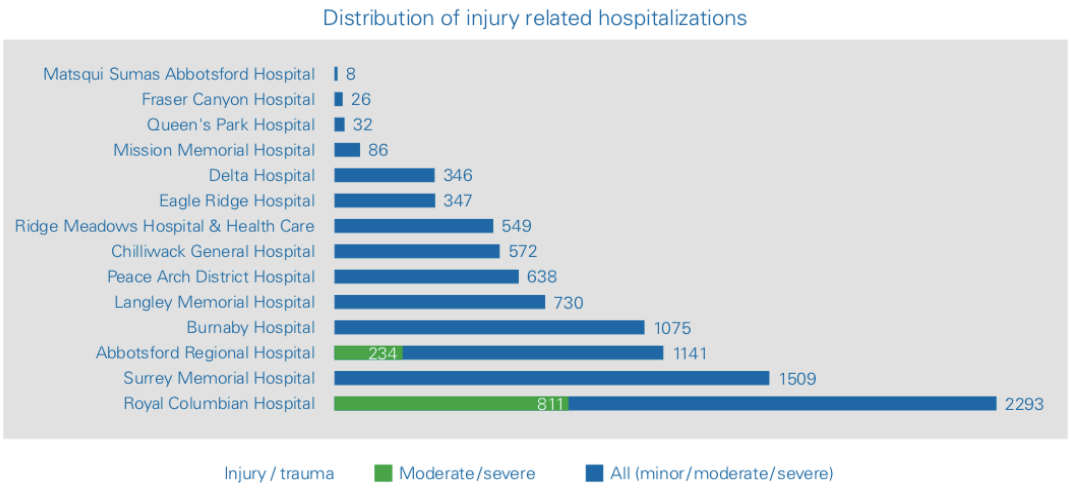


Figure 1.5 Fraser Health



1.2 Theoretical versus actualized systems of care for the injured: A scoping review of the literature

The purpose of this review is to explore and understand current performance measurement in trauma system function, points of influence, and opportunities to recalibrate system measurement. This will enable a more accurate and consistent picture of actualized care to engage the greatest leverage in improving patient care and outcomes. The thesis will subsequently focus on a Level 3 trauma center, its access to

transfer data, performance in appropriate use of transfer guidelines, and secondary triage of the injured to tertiary care. We hypothesize that the current regional and provincial trauma systems have gaps in its measurement of the burden of trauma and that there is no capture of decision making around the care and triage of severely injured patients.

Actualization can be defined as "[making] something that could possibly happen or be achieved really happen or be achieved"(38). This is a helpful expression of purpose and efforts made within a system. In trauma, we see this in two areas. Firstly, actualizing (making real) a theoretical system. Secondarily, the ability of the system to reflect effectively what is actually happening within the system to know what has actualized—what has become real, and whether the system is activated to its intention and potential. We would like to reflect the extent that current performance measurement can capture system function and actualization, and whether that data reflects what has become real at the bedside.

1.2.1 Methods

With the help of an Interior Health Librarian, Michelle Main, a comprehensive search of the literature was conducted via Medline January 26, 2018 to identify current published performance measures that reflect trauma system integration, function, and standardization using MESH criteria gleaned key publications from trauma system experts. (Appendix A). A significant number of studies in this area have been done in association by Nathens and colleagues (4,20,25,30). This body of work was used as a foundation for this thesis and, in particular, as a starting point for this literature review.

The following search terms were used: **multiple trauma, time to treatment, patient selection, regional health planning, regional medical programs, quality improvement, health services accessibility, health care quality/access/and evaluation, quality indicators and health care, quality of health care, outcome and process assessment, guideline adherence, traumatology, triage, patient transfer, trauma centers.**

1.2.2 Results

There were 26 exact matches and 51 articles described as close matches (Appendix A). The articles were screened for relevance to performance measures of system integration, their references explored, and overall 47 articles were deemed relevant to review. The literature was reviewed again in the fall of 2018 to capture any further relevant publications. Upon exploration of the selected articles, 8 themes surfaced in relation to trauma system performance, integration, and performance measurement (Figure 2). Listed here in descending order of frequency:

1) ***Triage to tertiary care or secondary triage*** (4,5,15–20,22–25,6,29,33,34,39–44,7–10,12–14)
2) ***Lack of consensus/standardization and ambiguity in performance measures and expectations of care*** (2,4,22,23,26–28,30–33,35,5,40,45,46,7,12–16,20)
3) ***Transfer guidelines (presence or lack of)*** (2,4,17–19,22,23,29,34,39,40,42,6,43,47,7,9,10,12–15)
4) ***Transfer problematic and complex*** (5,7,22,23,26,29,32,39–41,43,48,10,12,14,16–20)

5) Human factors

a. *Compliance* (5,6,30,32,39,41,44,46,7,10,12,16,20,22,23,25)

b. *Communication* (6,7,41,43,44,46,49,9,12,14,19,25,27,30,32)

c. *Education* (6,7,46,12,16,25,30,34,41,43,44)

6) ***Emergency department length of stay (EDLOS)***

(4,7,40,47,50,10,12,13,15,17,18,34,39)

7) Mortality as main outcome measure associated with:

a. *regionalization* [(8,9,42,46,50,11,12,14,15,24,27,30,35)

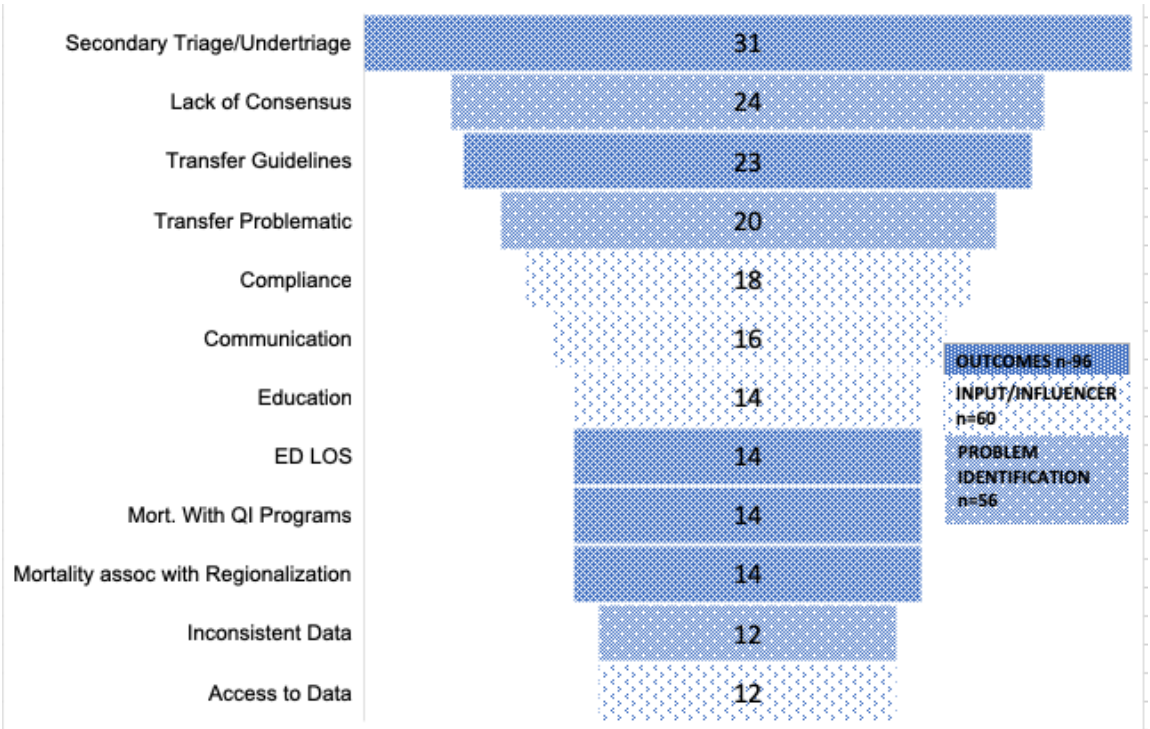
b. *quality improvement programs* (2,3,48–52,15,25,26,28,31,35,44,46)

8) Data

a. *Inconsistency in data* (12,21,33,34,22,26–32)

b. *Access to data* (12,21,48,50–52,22,27–33)

Figure 2. Literature review result

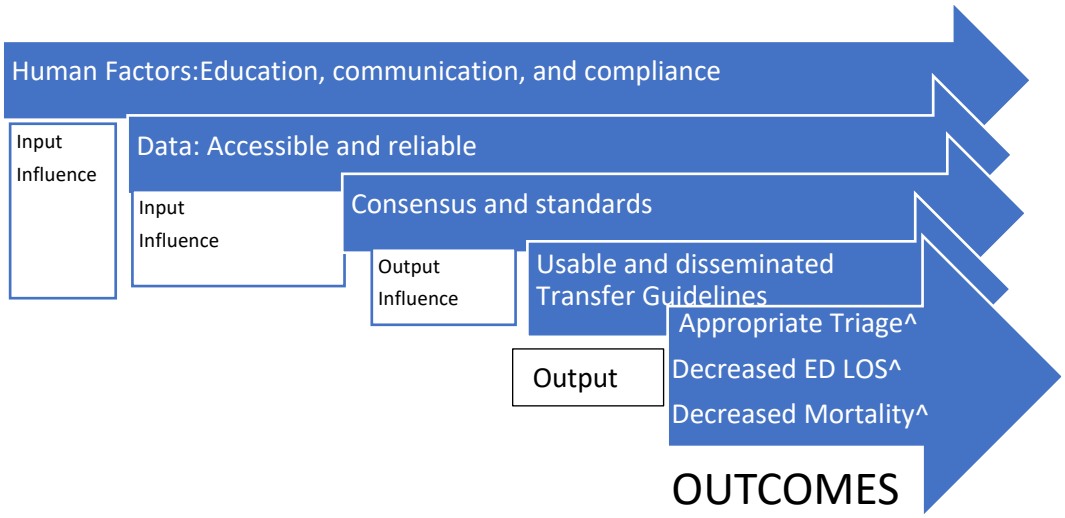


What is so very interesting about these results is that the majority of the literature focuses on outcomes (n=96), whereas inputs or influences (n=60) and problem identification (n=56) are less commonly mentioned. This unveils a possible oversight in mainstream performance measurement. With focus on outcomes and little attention paid to the influencing factors, inputs, and problems, one cannot influence them if there is little understanding of what actually affects them, outcomes being only to tip of the iceberg. The outcomes themselves are completely useful and reflect part of the story, however, they tell us minimally of the complex processes that lead to the end results. Riley et al. astutely summarize this in their statement 'all patient care is the result of a process, defined as a series of steps to produce an outcome' (p.558, (53). What we see here is that the literature has concentrated on outcomes, leaving the factors that might be leveraged to influence them under reported and understudied.

Seen below, is a schematic showing the main themes of this review set on a continuum (Figure 3), which captures the far reach of foundational influencers on outcomes, secondary triage being the most frequently mentioned. Thus, if the literature focuses and reports on outcome and impact without appreciation, investigation, and validation of the vast and complex contributing factors and how to shape them, there might be a redundancy (strong word) in reporting them at all. It is not an either-or scenario, it's a 'this and therefore' phenomenon. Though the influencing factors are described in some articles extremely well, the outcomes as a whole were not paired with influencing factors explicitly. Seen clearly is the overarching nature of human factors influence in every phase of system function. However, the curiosity is that the

bulk of the literature focuses on the output or outcome not the influence upon that outcome.

Figure 3. Themes in the literature related to process and practice



^ Notes outcomes as most frequently studied theme, as opposed to inputs and influencing factors

Consequently, analysis of the literature will focus on the central theme of secondary triage to tertiary care and the phenomenon of under-triage as a case study of assessing actualization of a regional trauma system. Attention will be paid to attributing factors, determinants, and themes of influence upon triage decision making.

Human Factors: Education, communication and compliance

Various human factors are a consistent foundational contributor to the patient outcomes found in this review (Figure 2,3). They are a significant theme, as with other inputs, though there is little direct instruction upon how to leverage them to influence outcomes. As Secondary triage, and subsequent under-triage, was the most common theme overarching the reviewed literature, the discussion of human factors will be

related to that decision point. In a grounded theory study of 27 emergency staff in Ontario, from varying levels of care, it was found that the majority of staff felt that physician practice patterns were un-reliant on training and experience but rather rested on 'innate' clinical gestalt and capacity to discern a patient's needs (12). Physicians were found to admit a sense of insecurity when calling higher levels of care and would delay or defer doing so in an effort to deflect professional discomfort (4). This is honest and distressing. Therefore, even if they had a referring center to discuss the patient trajectory with, they are reluctant to. So, there is a discrepancy in what should happen and what actually happens due to variability in physician compliance, and that uncertainty outweighs the physician's commitment to the policy or practice guideline. Also discovered in these interviews, there was a trend for nurses later in their career to have lower engagement with continuing education, and that those sites with nurses and physicians with greater than 10 years' experience had longer ED LOS.

Shafi et al. describe significant non-compliance at trauma centers with recommended clinical interventions (23) . They found that implementing optimal care would significantly reduce mortality, which seems obvious, but their point is that despite knowing all these things, care providers remain non-compliant at the cost of life (16). Exploring what compels professionals to compliance in trauma leads us to the mystery of professional culture and personal belief systems. If practitioners continue to be non-compliant with current practice guidelines given all the evidence as described above where severely injured patients are treated at tertiary centers, what factors have to be in place to produce compliance in the future? Faezel et al. argue that decision rules help compliance, such as those for stroke or myocardial infarction, however, Shafi et al.

assert that even if decision rules are produced with good evidence, they will remain unimplemented (4,23). This is again, unacceptable when it is human life and well-being at stake.

Data: Accessibility, reliability, and relevance

In a recent comprehensive review of the literature surrounding quality and reliability of trauma registry data, O' Reilly et al. found that 'the definition and classification of trauma registry data quality is ambiguous' (p.565, 32). Only four of the sixty-nine articles reviewed discussed quality of data and how to classify it (32). Again, in a survey of sixty-five trauma registry custodians, results were found to vary greatly with transfer from another hospital and admission being the only two themes noted to span every registry (27). Gagliardi et al. describe specifics of high performing hospitals in relation to EDLOS, and found that those with lower EDLOS had regular rounds, with access to performance data and feedback and active quality improvement (12).

Bradley et al. examined transferred patients and assessed completion of documentation of care (32). They report that prehospital documentation of severely injured transfer patients and data capture is poor in the province of BC which subsequently complicates care and continuity (26). What reality do we know other than the one we either observe or believe to be true based on what we are told. If the data collected is sparse, incomplete, and perhaps defines a reality that is missing large amounts of patient populations, one will not have an informed enough framework to determine, system wide, what is needed. Similarly, the Level 3 issue described above, where no severely injured patients are being captured at a provincial services level at many level 3 sites complicates the issue of measuring what care is being delivered and

knowing what to do about it in the future. If one bases policy, funding, and data collection practices upon this belief, severely injured patients will go unaccounted for and unmonitored in the system. Thus, reliable and accessible data can drive informed decision making and help with consensus across a system, and reliable data comes from compliant, informed, documentation and practice, which relies on care givers education and understanding of the care they are giving, as well as site policy and procedure.

Lack of consensus and standardization of performance measures and expectations of practice and care lead to problematic system function

The second most common theme in the reviewed papers was the need to define expectations of practice and have consensus across system stakeholders. Many papers reported 'lack of consensus' in everything from fundamental performance measures at minimum to interventions at the maximum, and do not go on to offer absolute recommendations.

A tertiary trauma center is not only a site with multiple specialties, it is a specialty center (8). Davenport et al. demonstrated that siloed specialties will not perform at the same capacity as designated trauma centers, and that without a specialized trauma service, casting an overarching vision of culture, with specific performance improvement mandates, they remain merely 'hospitals with specialties' and not trauma specialist hospitals (8). Trauma programs, theoretically, give the system an agreed upon foundation of practice, however, if the literature proves there is significant lack of consensus in everything from practice to performance measurement, even at tertiary centers, what then are the non-tertiary centers to do? For example, Haas et al.

conclude their paper with ‘Strategies to reduce under-triage need to be implemented and evaluated’ (p.1515, 9). This is not instructive, but merely states the obvious. Again, in O’Reilly et al. ‘the usefulness of trauma registries, the metrics and reporting of data quality need to be standardised.’ (p.559, 32) with no offer of what the standard is presently or should be in the future. Moore et al. report that there is little to no information or evidence to substantiate content and construct validity of process performance indicators (PPI) typically extracted from registry data bases (31). Their study innovatively goes on to suggest common PPI that can be pulled from data already in most registries and were common across multiple sites in the region of study (35).

Gomez et al. (14) attribute poor triage practices to the lack of consensus and standardized transfer agreements within the region of their study. Yet it is also argued that though standards exist within American College of Surgeons along with Advanced Trauma Life Support etc., these recommendations continue to fail to be implemented (14,16).

Clearly one can see that a lack of consensus in the literature, leads to a lack of consensus in practice and implementation. This complicates formation of agreements between facilities and further action on those agreements.

Triage: Reflecting system actualization

Upon review of the exact and close matches, as well as references from search results, 31 articles were found to list triage of the injured to definitive care, or secondary triage to tertiary care of the injured as an indicator of trauma system performance (4,5,15–19,22–25,29,6,32–34,39,42–45,54,7–10,12–14). The process of discerning a

patient's needs and care requirements is called triage (5,41,43). Triage of the injured patient is a dynamic ongoing process to discern appropriate interventions, what definitive care is and where it should take place (5,12,22,25,41,43). Under-triage is a term used to describe the event when a patient's disposition is deemed appropriate for the site when in fact, the needs of the patient exceed the sites resources (5,22,41).

Determining whether a sites resources are adequate for the patients' immediate needs seems straight forward, however, what the right care is and where it should take place remains subjective in nature even when there are established transfer guidelines (12,16,41,43). Not only are the immediate needs of the patient assessed, it is paramount that the patient be in an appropriate center that can definitively treat evolving injuries and their sequalae (16,23,41,43). Under-triage, or underestimation of injury severity and sequelae, occurs at any place along the patient timeline and can be related to not only clinical, but many non-clinical factors. Under-triage is also associated with increased morbidity and mortality (3,5,6,8,25) Triage begins in the field with an initial scene assessment of mechanism, extraction, and obvious injuries noted by the ambulance service. The patient can be triaged by the receiving hospital prior to arrival via notification from the ambulance service which helps with the decision to activate the trauma team and prepare. Once the patient has arrived at an acute care facility, again the patient is assessed in the ED where resources are allocated appropriately.

Appropriate triage is an outcome as described above, however, it is complex and multi-faceted and relies upon individuals in various environments to come to the same conclusions consistently regarding patient disposition. Decision making in trauma has been explored in the literature and the complexity of triage decisions discussed, though

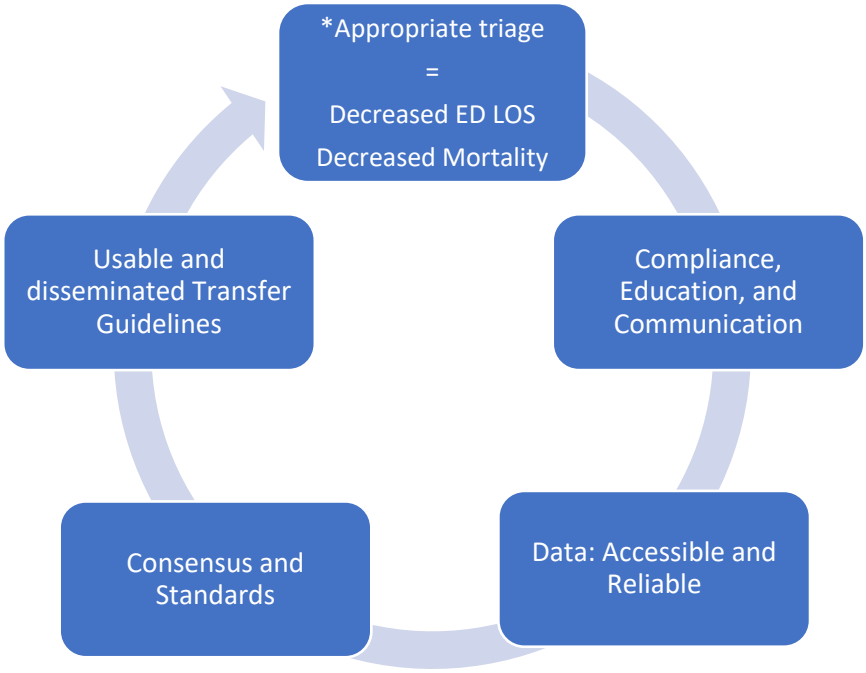
authors stress that this area still remains understudied, ambiguous, and difficult to influence (2,4-8,12,14-16,18,20,23,26,27,29-35,39-43,47,48). Understanding the extent of this issue is imperative if any process improvements are to be made at a system or personal level. Lossius et al. state that the absolute foundation of the trauma system is the transfer between facilities, ergo why have a system at all if there is no need to rely on services outside one's own facility (15). In the same way, as there is a general agreement in the literature and trauma community that severely injured patients benefit from treatment at a trauma center, all energy, effort, and focus must be on getting that patient to the appropriate resources for an optimal outcome. Consequently, not only the 'outcome' of under-triage needs consideration, but all the inputs and influencers upon that process as well. Triage to definitive care is truly an expression or culmination of all the other themes in this review, thus is able to reflect system actualization and function (Figure 4). Therefore, if a severely injured patient is appropriately triaged, one would expect a decrease in EDLOS and mortality as described in the literature, when treated in an inclusive system and at a tertiary center.

1.3 Discussion

The literature clearly demonstrates that though physicians and systems are theoretically equipped, with expectations defined, the actualization of that system remains variable, ambiguous, and difficult to measure (7,8,21,39,41). Gomez et al. describe this as 'the availability of trauma services does not ensure their utilization' (p.163, 8), in that though 60% of Ontarians had access to tertiary trauma care, only 38% of the most critically ill trauma patients actualized it (16). They attribute this to simply 'suboptimal triage practices in the setting of appropriate resources' (p.160, 8) though

they are unable to illuminate influencing factors. This is unacceptable and points to extreme gaps in system utilization and function.

Figure 4. Continuum of Performance Measure Outcomes



Severely injured patients were shown to have a significantly less chance of being transferred to tertiary care if they were taken to a Level 3 hospital as opposed to a Level 4/5 (14). The authors describe a resource rich phenomenon that occurs in Level 3 hospitals, that have many resources but are not trauma centers, and patients are either transferred late or not at all (13). This coupled with a study which showed patients treated definitively at Level 3 sites had a higher likelihood of death, should be a catalyst for formal system audit and review to assess levels of discrepancy in theoretical and actualized care (19). Haas et al. describe a significant increase in mortality of 30% when patients are initially treated at Level 3 centers, and we know from Gomez et al. that only

38% of injured patients are seen at tertiary centers, accordingly there is a significantly underserved population at risk to adverse outcomes (8,9). Ciesla et al. similarly report that though 98% of their study cohort had theoretical access, defined as being within the geographical boundary of the trauma center, only 52% of the severely injured actualized it (9). Deconstructing the discrepancies in theoretical resources while also capturing system actualization is imperative to understanding how the system is actually being utilized to enable one to intervene accordingly. This can be done practically by excavating the current barriers to appropriate system actualization at a site, identifying key cultural contributors to inappropriate secondary triage, and then formulating a strategic plan to influence them.

Within this review, a few studies were exceptional at exploring human factors in an effort to reflect actualized care and bedside decision making. Gagliardi et al. endeavored to better understand secondary triage decision making and by using grounded theory were able to identify key provider, facility, and system factors that led to a decreased length of stay for the transfer patient (12) They found that no other study had addressed specifically the many competing factors and barriers around triage and transfer of the injured patient (12). As seen in Table 2, there are key themes that high performing hospitals with shorter length of stay demonstrated in their culture. These are hinge points upon which one can effectively influence actualized care and not simply regurgitate a theory. These are the paradoxically simple yet complex cultural factors that impact care in profound ways. These findings are particularly applicable to non-tertiary sites and affirm the schematic in Figure 3. Simple adjustment of influencing factors shape system function and actualization as seen by decreased EDLOS.

Table 2. Summary of beneficial and limiting factors influencing transfer (12,55)

Institutional	• Limited CT access • *Pairing of new and experienced staff* • *Minimum work hours for EP staff* • *Rounds and access to performance data* • *Active quality improvement projects* • Limited staffing, especially on nights • No monitoring of physician trauma education
System	• *Pre-hospital expertise and ability to transport patients safely* • Organizing safe transport in a timely manner • Difficult communication practices with receiving centers • Unknown expectations by both sending and receiving centers • Provincial call center problematic causing physician distraction from patient care • Specialty refusal of transfer i.e.) Neurosurgery
Provider	• *Training, experience, ability of nurses to advocate for transfer* • Physician reluctance to call specialties attributed to avoiding being perceived as unsure • Limited nurse participation in ongoing education in the more experienced nurses • Fear of judgment, limited reporting of incidents

^ Italics indicates association with shorter ED length of stay hospitals, plain text associated with longer ED length of stay hospitals

Similarly, Mohan et al. undertook a vignette-based study to reflect triage decision making in the severely injured, which they describe as ambiguous and uninfluenced by performance improvement efforts (41). They discovered that emergency physicians significantly under-triaged patients at more than 5 times the frequency than surgeons (41). Surprisingly their two-phase analysis of both vignette and clinical performance revealed a propensity to risk the false negative of under-triage, though vignette

performance did not eventually actualize in practice, and only declined showing much higher under-triage rates in reality (41). This is both alarming and extremely interesting. They describe their study as small and limited, however, the results ignite curiosity about who the best person is to make that triage decision, how they are trained, and how we influence them.

In other studies by Mohan et al., they describe decision threshold as the degree to withstand error—either false positive/negative, and perceptual sensitivity as the ability to discern between different patients and their needs (12,43). They identified that to influence triage decision making, decisional thresholds and perceptual sensitivity must be altered and influenced (43). They did not, however, offer any outline of what those interventions might entail.

1.2.4 A simple equation to reflect system function

Under-triage is the most commonly mentioned performance measure in this literature review, however, many studies treat it as a secondary theme to mortality and other morbidity outcomes. Remarkably, even though novel insights are identified, there are very few system solutions or direct recommendations offered to improve under-triage and its capture. As a performance measure, under-triage is capable of reflecting actualized care if considered in a holistic manner. If one appreciates the contributing factors to the outcome, then the outcome will appropriately reflect system actualization. Peng et al. report that often under-triage is miscalculated using the Cribrari matrix (Table 3. 33). They propose that under-triage is under reported in that most analysts include minor trauma in the denominator, making the rate calculated usually quite low (Table 3. 33). Using their version of the calculation, one could state the under-triage rate

of the severely injured patient quite simply. Using this data, and with a holistic perspective and focused chart review, it is possible to reflect factors of influence on the outcome.

Table 3. Cribari Matrix (33)

	Minor[1]	**Major[2]**	**Total**
Emergency Transfer	a	b	a+b
Inpatient Transfer	c	d	c+d
Total	a+c	b+d	n

1)Minor: does not meet major trauma patient criteria per protocol 2) Major: Patient meets major trauma patient criteria per protocol

The incredible thing about this simple equation is that any staff can do this calculation once the definitions of minor/major trauma are identified. No need for registry data, more money, programs, or statistics training. This is a simple, applicable, accessible metric to help define system function.

1.4 Conclusion

This review demonstrates that secondary triage is the axis upon which patients access and receive the care they require, and that this process remains ambiguous despite the literature, common knowledge, and established transfer guidelines (3-8,11,24,40). Under-triage remains an underutilized tool to reflect system function. However, this performance measure is limited in that though it produces quantitative outcomes; and though it is more holistic metric than mortality, it does not express the process of how and why under-triage occurs and needs to be considered along with other influencing factors.

By taking the observed themes in the literature, one can construct an algorithmic flow expressing the problem: Variable education minimums, communication practices, and lack of policy compliance leads to a lack of reliable data that is accessible to front line staff. This leads to inconsistent perceptions of realities, which then leads to ambiguity, therefore either lack of transfer guidelines or lack of consensus on transfer guidelines which then muddies accurate triage. All this finally culminates in under-triage, which produces the 2 dominant outcomes of increased mortality/morbidity and lengthened ED LOS.

However, using those same themes one can also craft a possible solution:

If one (region/person/province/hospital) endeavours to standardize education minimums, altering the acceptable degree of error culturally, and ensure appropriate communication this will lead to reliable data capture. Ensuring this reliable data is made accessible to front line staff, practitioners could then come to an informed consensus/standard of expectations to limit areas of ambiguity/degrees of error thus clarifying the complex transfer process. This ultimately leads to appropriate triage, and finally the desired outcomes of decreased mortality and decreased ED LOS—profoundly the metrics are not needed initially to inform the process but are used as a final expression of system function.

2. Under-triage rate at a Non-Tertiary Center: A Retrospective Chart Review

2.1 Retrospective Chart Review

This study examines the extent to which principles of integrated trauma care are actualized in a regional trauma system. This will be done primarily through a detailed analysis of triage practices for patients with complex, life threatening injuries, who present initially to a busy non-tertiary center.

2.1.1 Research Hypothesis and Objectives

Severely injured patients meeting the Management of Major Trauma Criteria (Appendix B) are under-triaged at a non-tertiary center in Interior Health (IHA) and current performance measures are not capturing them.

Objectives:

1) To explore processes of care for all patients requiring transfer from a local hospital to a regional trauma center for the definitive management of complex injuries.
2) To identify barriers, if any, to appropriate initial triage to tertiary care from ED
3) To identify discrepancies, if any, in data capture of the severely injured patient at the local and regional level

2.1.2 Methods

Study Design

This study is a retrospective chart review examining processes of care for patients undergoing immediate versus delayed transfer from a local level 3 hospital to a regional

or provincial trauma center for definitive care. An environmental scan was done as well to better understand this site's pre-existing resources, policies, and standard of work.

Study Population

Transferred injured patients of all ages from Vernon Jubilee Hospital within Interior Health Authority, to a tertiary center for definitive care between January 1, 2017 and December 31, 2017. Patients discharged home or non-injured patients were excluded regardless of transfer status or injury occurrence. Transferred patients were stratified into 2 groups: those transferred from the ED (early transfers) and those transferred as inpatients (delayed transfers).

Outcomes/Endpoint

Primary:

- Number of severely injured Inpatient transfers

Secondary:

- Number of severely injured transfer patients that met the Major Trauma Patient criteria
- Number of inpatient transfers that were initially refused by a subspecialty
- Compliance with regional Pre-Printed Order set
- Time to call Patient Transfer Network (PTN)
- Data reliability and consistency

Study Procedures

Upon REB and Operational approval an exhaustive exploration of aggregate administrative data already collected and aggregated by analysts in Interior Health and Trauma Services of British Columbia was conducted via email enquiry for the injured patients outlined above between January 1, 2017 and December 31, 2017. Data sets were explored to understand if a chart review is indicated. The data available from analysts was limited to volume of injured transfer patients from the emergency department and as inpatients. Thus, a data search chart review was conducted as described below.

a) Total number of injured patients
b) Total number of injured patients admitted to Vernon Jubilee Hospital (VJH)
c) Total number of injured patients that were admitted to Intensive Care (ICU)
d) Total number of injured patients that were admitted to the Operating Room(OR)
e) Total number of injured that were transferred from the Emergency Dept.(ED)
f) Total number of injured that were transferred from an Inpatient bed
g) Time of Patient Transfer Network (PTN) call
h) Service Referred to
i) Transferred Yes/No
j) Site of receiving center (ie. Vancouver General or Kelowna General)
k) Massive hemorrhage protocol (MHP) initiated
l) Length of stay in ED
m) Pre-Printed Oder set used
n) Physician orders written
o) Sending physician dictation Y/N
p) Did the patient meet ‘Major Trauma’ Criteria as outlined in Appendix B
q) Area of injury or polytrauma
r) General Surgical Consult Y/N

Data Collection/Management

Once the medical record numbers were obtained through IHA analysts, Health Records was contacted to request the cohort of charts. The charts were anonymized by removing the site letters from the ID number and a study number assigned. Furthermore, no identifying information was collected such as specifics of injury, date of injury or exact age. Injury site was collected on area of injury for example head injury, thoracic injury, abdominal trauma, orthopedic, or polytrauma meaning more than one system. Only the information listed in the attached tool was collected.

Statistics and Data Analysis

Data was analyzed in Excel and GraphPad Prism version 8.0.1 for Windows, GraphPad Software, San Diego, California USA. Prism was used to run the Mann Whitney U to compare ED and Inpatient transfer groups, as well as descriptive statistics. As discussed in Chapter 1, the Cribari matrix was used to calculate under-triage rate by dividing (d) by the total number of major trauma patients both with ED and Inpatient transfer (b+d) (33). Definition of major trauma patient using criteria as described in Appendix B was used to differentiate the variables within the Cribari Matrix (Table 3. 33).

Table 3. Cribari Matrix (33)

	Minor[1]	Major[2]	Total
Emergency Transfer	a	b	a+b
Inpatient Transfer	c	d	c+d
Total	a+c	b+d	n

1)Minor: does not meet major trauma patient criteria per protocol 2) Major: Patient meets major trauma patient criteria per protocol

2.1.3 Results

The above data points (a-r) were collected as described in the methods section above. After an initial environmental scan, it was found that the sites regional policy for care of the major trauma patient at a non-tertiary center for Interior Health (Appendix B), is included in the orientation of nursing staff to trauma nurse leader (TNL) but is not included in orientation of new physicians. There is no site or regional trauma orientation for physicians, and there is no standard pattern of disseminating existing expectations of care of the significantly injured patient to emergency physicians at this site. There is a pre-printed order (PPO) set in regard to care of the injured at a non-tertiary center including prompts such as to call patient transfer network early and administer tranexamic acid in the event of hemorrhage. Furthermore, there is no one assigned at the site or within the region specifically responsible to audit and report performance in the care of the injured. There is no trauma care coordinator and no medical liaison with authority to hold the site accountable for injured patients and their care other than regional oversight.

Data was sourced from two different avenues. Firstly, an Interior Health analyst was contacted to obtain items a-f. As well, for aggregate data, the Injuries presenting to Interior Health Emergency Departments (IPIHED) report was obtained from the regional trauma program. This report, however, is not disseminated regularly or readily available to VJH ED site leadership. The IPIHED is also not reviewed with intention by any leadership/education portfolio at VJH. Data analysts report this level 3 site saw 11,425 injury related visits within January 1, 2017 and December 31, 2017, whereas in the IPIHED for 2017 11,421 injury related visits were reported (Figure 5). Of these visits, 822 were admitted and of those, 37 were admitted to the Intensive Care Unit, and 407 directly to the operating room (OR) (Figure 6). The analyst report, based on discharge code criteria, shows 39 injured transfer patients, whereas IPIHED identify only 25 injured transfer patients.

Using the analyst data, the 39 transferred patients were further separated into either ED transfers or inpatient transfers and their medical records number obtained. It was found that 15 patients were transferred directly from the ED and 24 were transferred from inpatient beds (INPT) (Figure 6). These 39 charts were reviewed to capture the remaining data set (Figure 7). After exploring these charts, 2 had expired and their charts were not available for review and a further 10 patients were excluded for the following reasons: single digit amputations/laceration (n=3), repatriation (n=4), and eventual medical related transfers (n=3). Of the remaining 27 patients, 22 met the major trauma criteria (81.48%) as outlined in Appendix B, and only 5 did not (Figure 9). Of the 5 patients that did not meet criteria for major trauma, 3 were inpatient transfers and 2 were ED transfers (Figure 7). One included patient did expire, at the tertiary center after

transfer and their chart was available for review (Figure 7). Notably not one IHA pre-printed order set was found in a patient chart (Figure 8).

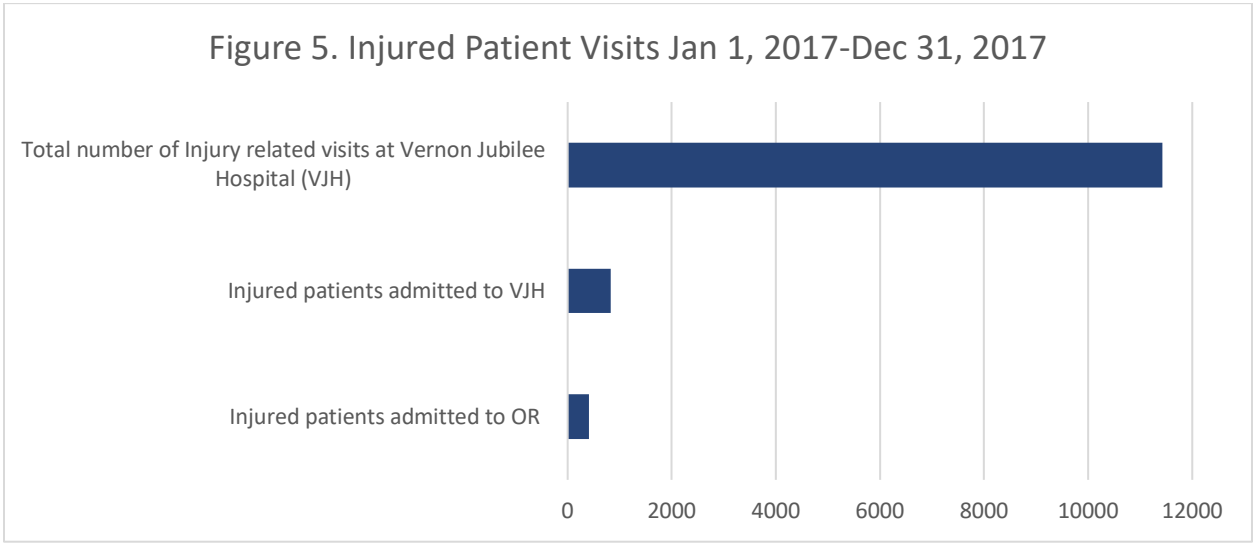
A significant finding is the frequency of general surgical consultation in the injured patient. Only 5 of the 27 patients received general surgical consultation as shown in Figure 8, and of those only one was an inpatient that occurred on day 5 of their hospitalization. There is, however, no site policy requiring surgical consultation on the injured admitted to ICU or the ward.

Injury distribution was wide, though head/spinal injuries (n=9) and polytrauma (n=9) were the most common areas of injury as shown in Figure 10. The majority of polytrauma patients (n=6) went from the ED, while the majority of neurosurgery/spine (neuro/spine) patients (n=6) went from inpatient beds. Of those six neuro/spine patients, two had documented calls in the ED to neuro/spine at a tertiary center via the patient transfer network and were declined at the time of consult. As well one polytrauma patient had a Neurosurgical consult from the ED and was declined at that time, trauma team leader was not called, and the patient went on to be transferred to a tertiary center ICU 8.5 hours later. All other inpatient transfers had no documented consults outside of the facility until the time of transport. There was some overlap of services, as ICU would accept a nephrology patient, or a neurosurgery patient etc., however, the primary accepting service was chosen and reflected in the data.

Patients were most commonly transferred to Kelowna General Hospital (KGH) n=22, secondarily to Vancouver General Hospital (VGH) n=4, and lastly to Royal Inland

Hospital (RIH) n=1 (Figure 11). Receiving services varied, though Neurosurgical/Spine and Intensive care had the highest frequency (Figure 12).

Call times to the Patient Transfer Network (PTN) were documented only 48% of the time (n=13) and varied greatly (Table 4, 5, Figure 8,13,14). Emergency Department PTN calls had a minimum time of 80 minutes, which is 5 times the recommended, and a mean of 187.9 minutes (Table 5, Figure 14).



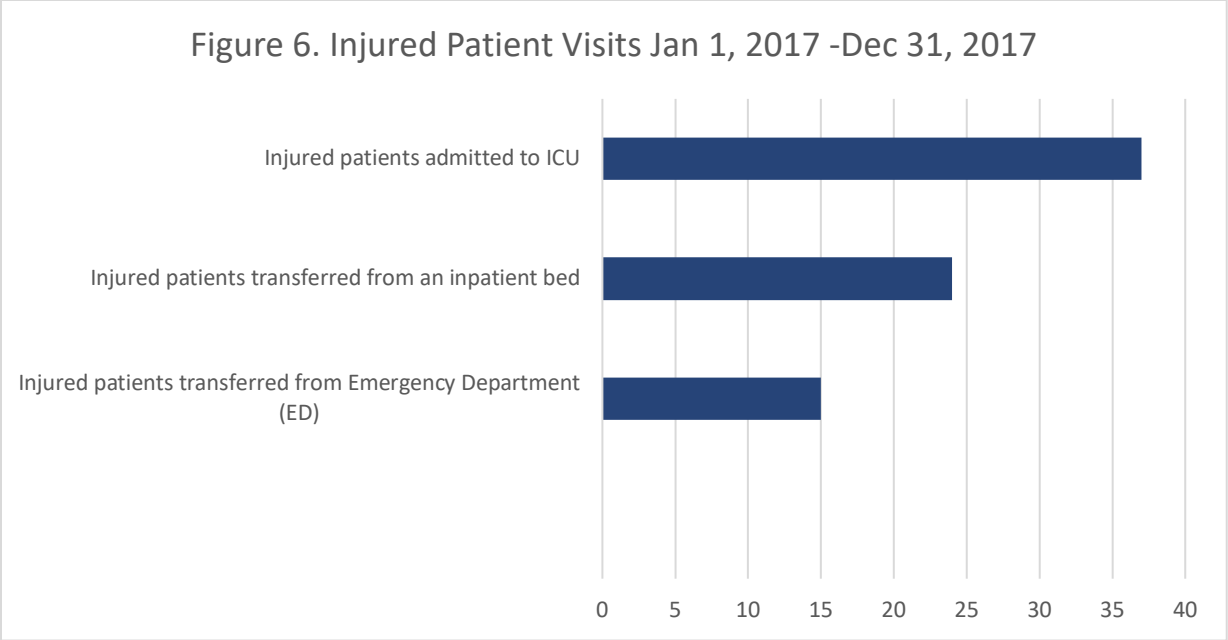


Figure 7. Patient Inclusion/Exclusion pathway

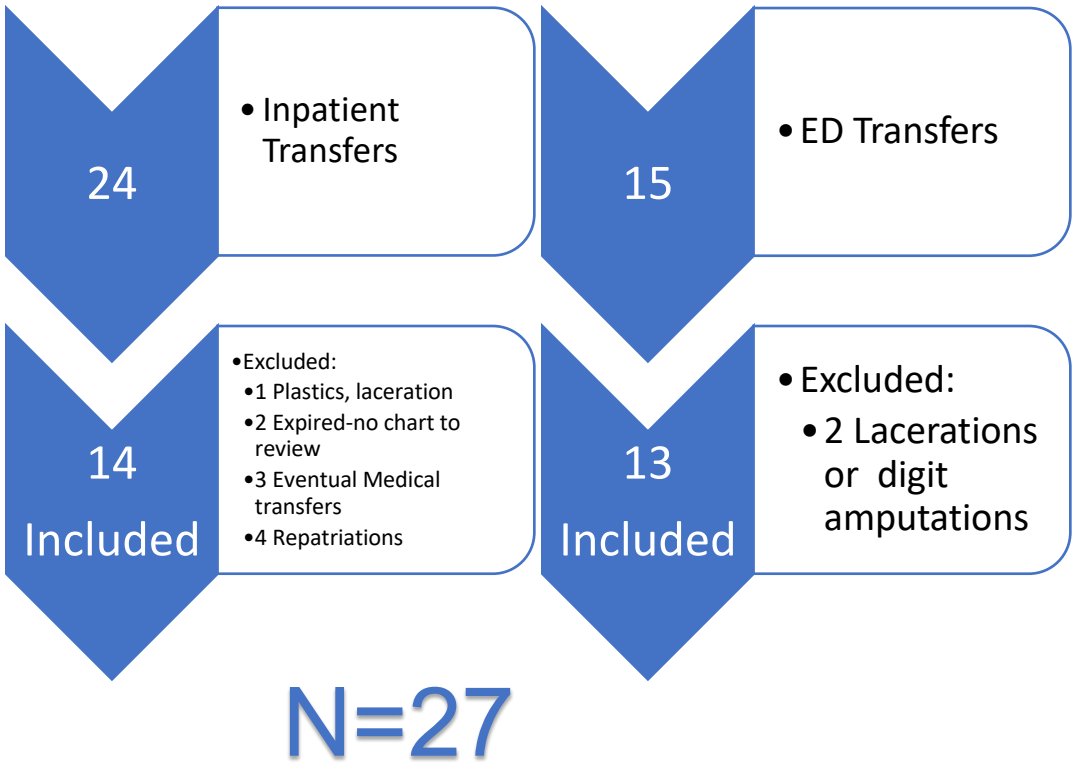
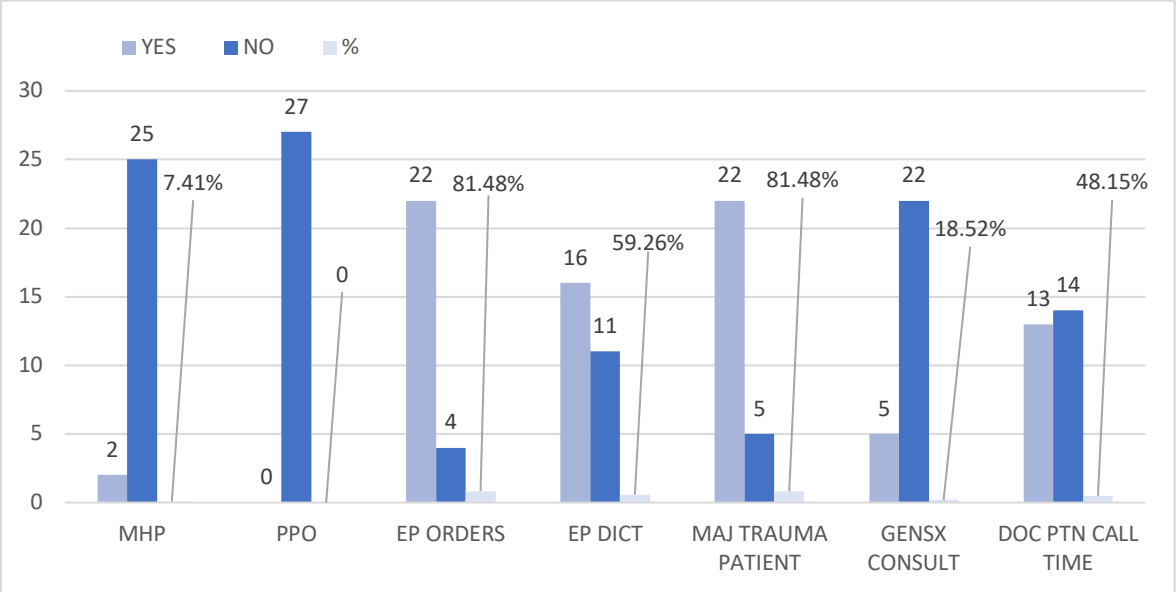


Figure 8. Tasks completed for the injured patient (n=27)



Key: MHP: Massive Hemorrhage Protocol, PPO: Pre-printed orders, EP Orders: Emergency physician orders completed, EP DICT: Emergency physician dictation completed, MAJ Trauma Patient: Major trauma patient criteria met, GENSX CONSULT: General surgery consult; DOC PTN CALL TIME: Documented Patient Transfer Network call time in chart

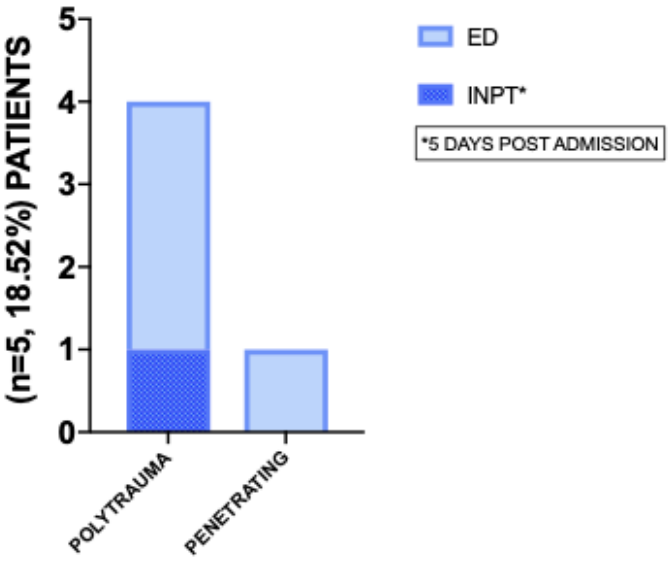


Figure 9. General surgical consultation outlines the use of the service for transferred patients differentiated between ED and INPT transfers and polytrauma and penetrating injuries.

Figure. 10 Distribution of injury and department of transfer

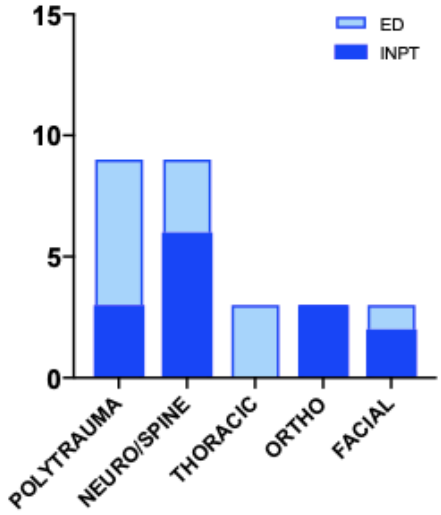


Figure 11. Receiving center

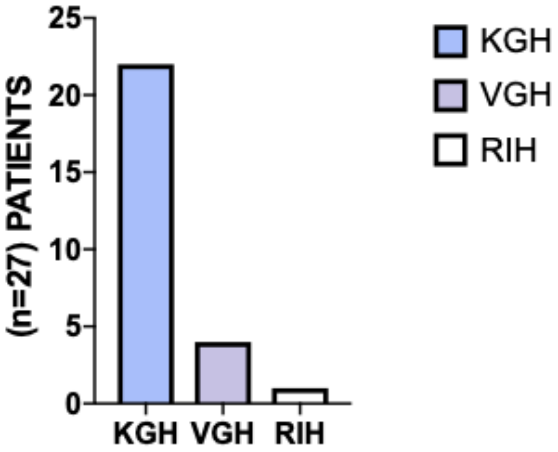


Figure 12. Receiving Services

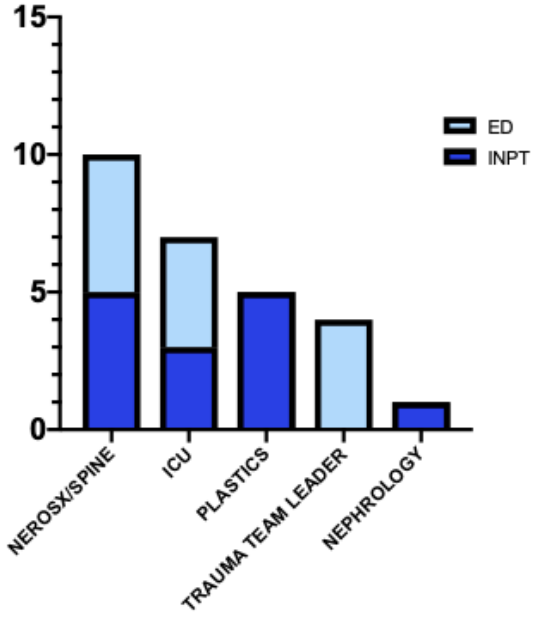


Table 4. Call times in minutes to Patient Transfer Network	13
Minimum	80.00
25% Percentile	137.5
Median	180.0
75% Percentile	390.0
Maximum	1140
Range	1060
95% CI of median	
Actual confidence level	97.75%
Lower confidence limit	125.0
Upper confidence limit	420.0
Mean	300.8
Std. Deviation	287.0
Std. Error of Mean	79.59
Lower 95% CI of mean	127.4
Upper 95% CI of mean	474.2

Figure 13. Call times in minutes to PTN

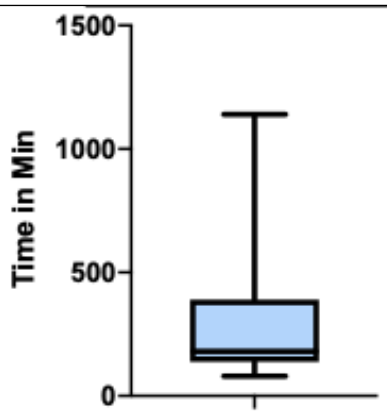


Figure 13. Call times in minutes to PTN -Call times to PTN varied greatly as reported in Table 4 with a range of 1060 minutes. The range, however, is expected as inpatient transfers will obviously have longer times to initiate transfer. Notably there were many missing call times thus this remains an incomplete picture.

Table 5. Call times in minutes to PTN ED transfers

Number of values	**7**
Minimum	80.00
25% Percentile	125.0
Median	180.0
75% Percentile	180.0
Maximum	420.0
Range	340.0
Mean	187.9
Std. Deviation	108.9
Std. Error of Mean	41.14
Lower 95% CI of mean	87.19
Upper 95% CI of mean	288.5

Figure 14. Call times in minutes to PTN ED transfers

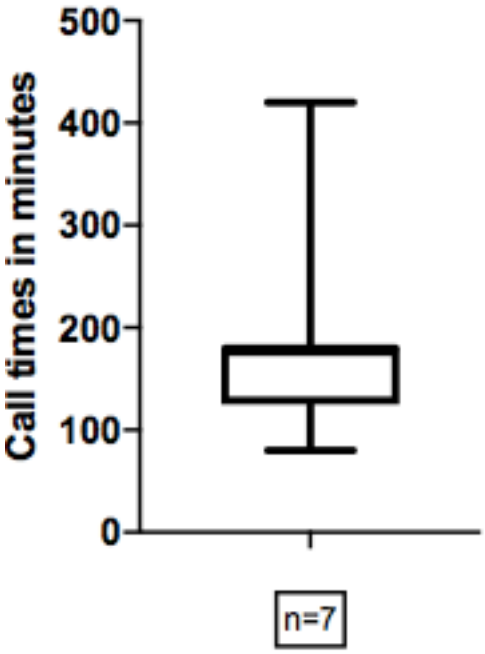


Figure 14. Call times in the ED had a median of 180 minutes, varying greatly from the suggested contact time by the Management of Major Trauma algorithm of 15 minutes (Appendix B). The outlier at 420 minutes with a 320-minute range in values. However, looking at only the values within the 25th and 75th percentiles, the values range from 125-180 minutes, with a minimum of 80 minutes.

3. Discussion

Severely injured patients at this level 3 site had a 50% chance of being appropriately triaged to tertiary care and a 50% chance of having a delay in access to tertiary care (Table 6). As mentioned above, this review captures discrepancies in system actualization on both the non-tertiary and tertiary sides of triage. We see sub specialty refusal upon initial triage from the ED and we see no tertiary or general surgical referral on polytrauma ICU patients. This reflects well the variable decision making at both the tertiary and non-tertiary sites, as well as the absence of system actualization for the benefit of the patient. This is possibly due to subjectively interpreted transfer agreements. There is a key box in the Management of a Major Trauma Patient (Appendix B) where things are unclear, as it reads 'do the patient's needs exceed the resources at your facility?'. That could be answered many different ways depending on the perception of the practitioner as to this site's capabilities, their situational awareness of available OR and critical care services, as well as belief in specialty competency such as orthopedic surgeons and ICU staff. Not only that but also a contributing factor is the tertiary site's perception of their responsibility to the patient. Looking at the groups in comparison (Table 7,8), it was found that the time to transfer for the inpatients were significantly longer than those transferred from the ED (Mann-Whitney U, $p<.0001$), and even some overlap occurred in the extreme outliers (Table 7,8, Figure 15). As gleaned from the literature review, there is an inferred mortality and morbidity cost with delay to definitive care as well as care given outside a tertiary trauma center (2-23).

Table 6. Cribari Matrix Applied at a Level 3 site

	Minor[1]	Major[2]	Total
Emergency Transfer	2	11	13
Inpatient Transfer	3	11	14
Total	5	22	27
Under Triage rate	d/b+d	11/22=50% rate of under triage	

1)Minor: does not meet major trauma patient criteria per protocol 2) Major: Patient meets major trauma patient criteria per protocol

Table 7. Descriptive statistics ED and Inpatient transfers in hours (Figure 14)

	ED	Inpatient
Number of values	13	14
Minimum	1.880	6.750
25% Percentile	2.635	14.42
Median	3.500	25.75
75% Percentile	5.695	228.0
Maximum	12.00	456.0
Range	10.12	449.3
95% CI of median		
Actual confidence level	97.75%	98.71%
Lower confidence limit	2.600	12.67
Upper confidence limit	5.830	264.0
Mean	4.645	116.1
Std. Deviation	2.823	142.5
Std. Error of Mean	0.7831	38.07
Lower 95% CI of mean	2.939	33.81
Upper 95% CI of mean	6.351	198.3

Figure 15. Comparison of transfer times in hours log10

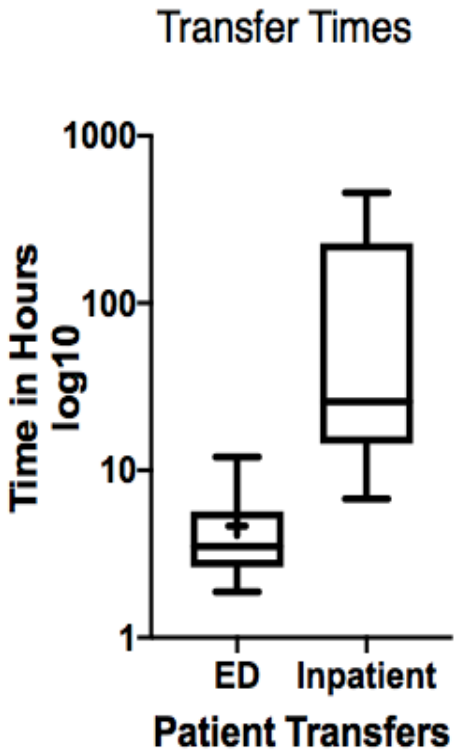


Table 8. Mann Whitney U

P value	<0.0001
Exact or approximate P value?	Exact
P value summary	****
Significantly different (P < 0.05)?	Yes
One- or two-tailed P value?	Two-tailed
Sum of ranks in column A,B	94 , 284
Mann-Whitney U	3
Difference between medians	
Median of column A (ED)	3.500, n=13
Median of column B (INPT)	25.75, n=14
Difference: Actual	22.25
Difference: Hodges-Lehmann	21.54
95.18% CI of difference	11.50 to 207.8
Exact or approximate CI?	Exact

This clinician led chart review completed its primary objective to assess triage to tertiary care by reviewing injured transfer patients both from the ED and inpatient beds. It was found that the under-triage rate is 50% with drastically variable transfer times (Table 7). Overall patients had surprisingly limited access to general surgical consultation. Inpatients waited 25 times longer than ED transfer patients to access tertiary care, and again ED patients waited 5 times longer than the recommended referral time to the PTN, at a minimum (Table 5, Figure 14). Despite the presence of algorithmic regional policy, patients meeting the major trauma criteria, were not identified for transfer, and a further 3 were subsequently under-triaged by the tertiary center. A contributing factor is a weak link in the phrasing at the decision point to call for outside assistance. The question 'does this patient's needs exceed your resources' is ambiguous and can be up for interpretation. Perhaps a clarifying concrete binary question would aid in decreasing the subjective interpretation of the level 3's resources, as well as concrete acceptance agreements solidified with the tertiary center would ensure the pull patients consistently from the ED.

Another contributing factor to the system actualization discrepancy could be the diversity of physician's interpretation of severity of injury and subsequent treatment priorities. In a creative study looking at physician consistency in comprising care priority lists, Krauss et al. describe significant variance in physicians' mental models when approaching a problem list (56). They found that when given identical cases, physicians prioritized acuity of pressing issues in significantly varying ways (56). This is interesting and should be a consideration when making policy or algorithms, to ensure through

orientation, culture, and communication, that there is a shared and consensual mental model when approaching the treatment and transfer of severely injured patients.

A strength of this study is that as it was done by a front-line staff, and a concrete plan to communicate these findings to the physician and nursing group, as well to regional and local executives. This will optimize and leverage findings towards appropriate triage and perhaps influence culture to see a greater uptake of system actualization as intended by the theory.

Limitations

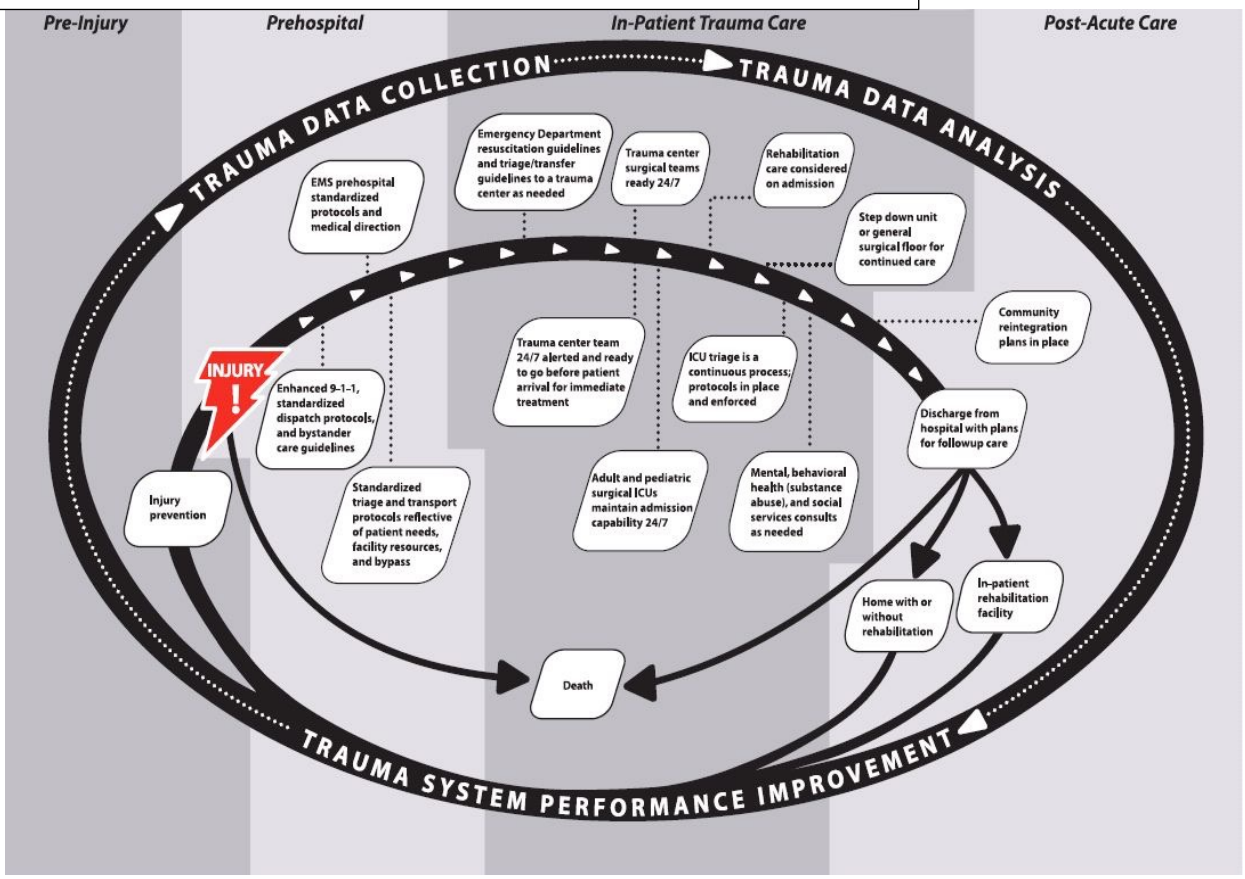
Though this chart review identified the frequency of transfers from the ED and inpatient beds, it may not be able to identify cause for variation in care and outcome. As different numbers were obtained for ED visits, injured transfers, and admission depending on the source, discharge codes may be inaccurate and the lists incomplete. As well, no panel has reviewed each case and determined whether it was clinically indicated to keep the patient at the sending site, though that the patient was eventually transferred strongly suggests their need for higher care upon initial arrival. Missing data includes time of PTN call (n=14).

4. Concluding Thoughts

4.1 Current state of affairs for trauma system performance surveillance improvement

Quality improvement and performance surveillance in the realm of trauma is an essential piece to any accredited trauma program (57). The American College of Surgeons utilize a continuum of care published in their manual 'Resources for the optimal care of the injured patient' originally designed by the US Department of Health (57). This image captures the many complex layers of care, the locations that care takes place in, and outlines the performance improvement continuum to ensure assessment of system function and practice change (Figure 16, 58).

Figure 16. Trauma System Performance Continuum (58)



This manual assists in the development of trauma centers and is an incredible resource to aid in the development and maintenance of trauma programs. Not only is it part of accreditation, it is big business. Massive organizations run registry training and programs for yearly fees such as Trauma Quality Improvement Program that is subscribed to by many trauma centers across North America. Their sales pitch reads 'joining TQIP is an investment, not just an expense.' (59). The program offers quarterly reports with national comparison across level 1-3 trauma centers and endeavours to help sites see areas of variance from average performance. Programs such as these are very centralized and leave the influence and onus far from the patient's bedside. This program can be effective at capturing specific data sets and reflecting adverse events; however, it does not offer an assessment of system function and relies upon intensely trained data stewards to execute the gathering, entering, and interpreting the data points in the registry system. Though registry data is used for tertiary site performance improvement, it is not typically used to assess non-tertiary site and system function. Not only have registry programs been limited to tertiary centers, they are also notoriously inconsistent and incomplete (9,26,31,35).

As seen in the literature review, common registry metrics and performance measures do not capture and reflect accurately system function in entirety. However, using themes gleaned from the literature and applying them to a non-tertiary center, one can get a quick glance at system function by calculating a simple under-triage rate. This is only one tool in an armamentarium of quality improvement strategies. An advantage to this is a site does not need anything exceptionally sophisticated to quickly see if patients are getting the care that is indicated. One must only need the standard of triage

in the facility, region, or province, the number of patients meeting that criteria, and the ones who meet the criteria but did not receive the care their injuries indicated. This is not a gold standard by any means, however, this process can empower sites without registry stewards or trauma coordinators to assess system access and function.

4.2 System function as an expression of system culture

System function can be thought of an expression or direct result of system culture, which is ultimately tolerated and accepted norms. The difficulty of this is that culture, as reflected in the literature and the chart review, is complex and ambiguous. Much has been said about culture and change theory in hospital administration and management in the past 10 years. Programs to map and stream line processes as well as increasing communication with lower level management are common place. Effort has been made to identify and influence the safety and efficiency of care (53,60,61). Nevertheless, more can still be done to leverage and influence contributing factors to the outcomes we study so much. Outcome data, historically, has driven budgets, change, and is the foundation of the scientific process. However, outcomes data has not thus far, captured and reflected system actualization as it does not allow for stories. Weick and Sutcliffe affirm this as those who have expertise, are the ones who are the storytellers, capturing events and outlining opportunity to respond, as well as accounting for potential trajectories of care (62). As healthcare professionals, we are deeply driven to effectively care for the needs of our patients, and it is often a specific patient or patient population that prompts study and curiosity. A person—that drives curiosity, passion, and problem solving. If we can't see and tell the stories, outcome reporting and data alone will remain ineffective at driving optimal care as it cannot draw on conviction that

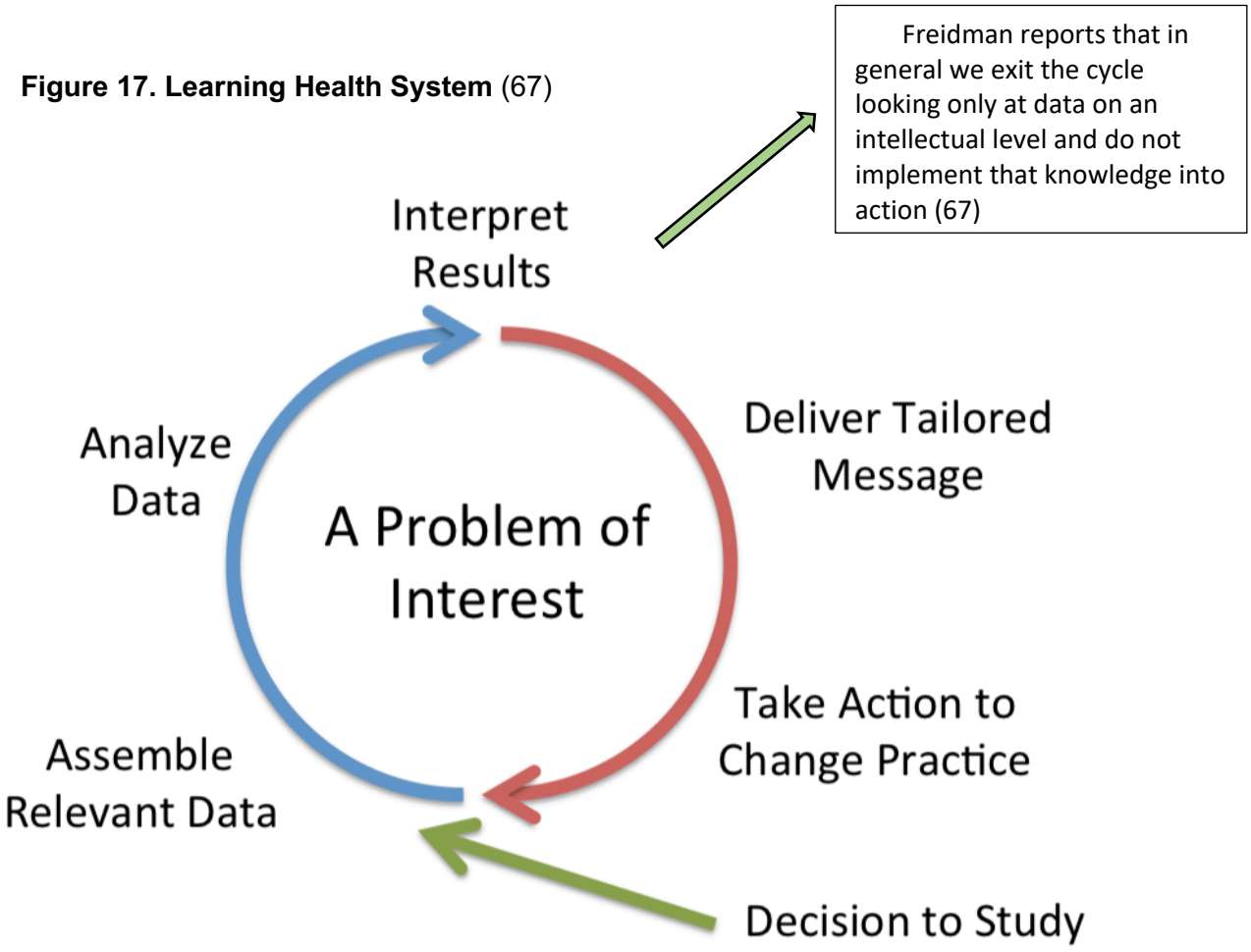
may not exist in the current culture. Perhaps culture can be used as a tool to actualize potential of trauma systems.

One possible intervention that can be helpful in addressing this phenomenon is to frame the current culture of the care of the injured through the lens of a Learning Healthy System (LHS) and the principles of high reliability organizations (HRO).

4.3 Learning health systems: A cultural approach for system actualization

The Learning Healthcare Project has aptly identified the issue of latency in the uptake of current research into practice and has offered a systematic response (63–65). They describe creating a healthcare system that learns as it goes, fluid to the needs of the moment, and systematically completing learning cycles culminating in altered behaviour or decision making. The cycle begins with a prompt to study or examine an issue and culminates in implementation of learned principles. They argue that often in medicine, the culture to take up an area of interest is strong, however, the actualization of the initial action, resulting in changed practice or behavior, remains suboptimal (61-63). They outline barriers to change as motivation, opportunity, and capability (66). Specifically, their example that if the effort level needed to successfully adhere to a straightforward change in process is one, then proposing that a health professional alter their own behaviour is greater than a hundred at the minimum (67). Thus, even though one might intellectually ingest the data, logic, and rationale—if there is a fundamental change required, the level of effort may be too onerous for that change to manifest. Freidman et al. capture this well in their description of these principles as a Learning Health System (LHS) and further in their image of a complete Learning Health Systems Cycle (Figure 17. 68)

Figure 17. Learning Health System (67)



Friedman et al. describe the cycle breaking consistently before gained knowledge can be implemented (68). This is fascinating but not shocking. Often organizational culture can be described as 'ready' for change; however, this minimizes one's moral and ethical commitment to the care of the patient in front of them. Leaning on this concept deflects responsibility to the system and the executive from the bedside practitioner. This is dismissive of the obligation of the individual practitioner to optimize and leverage their system for the benefit of that patient, regardless of the change climate/likelihood of change within in a system. Well known author, Malcom Gladwell speaks harshly of this tension when discussing concussions and brain injury associated with football in his podcast series 'Revisionist History'(69).

He says ***"Sometimes proof is just another word for letting people suffer"***(67). He is referring to a culture that refuses to acknowledge, let alone implement, a safety culture around known research for the well-being of their players. How much more responsible, are we then in medicine, to practice a culture of safety actuating knowledge moment to moment for the ultimate good of the patient in front of us. Dependency on the caveat that there is still more information needed does nothing for the patient in front of you. Deciding to utilize what is already known, taking into account that there is always more to know, is how practically one can become a catalyst for clinical uptake of current knowledge in spite of the many obstructing issues for system level change. For as we know, a trauma system is just numerous sequential processes and actions actuated by *people* who are compelled, hopefully, by their knowledge and commitment to their patient to leverage their resources for optimal outcomes. This provided they know what optimal outcomes are and agree upon how to obtain them. At what point does the culture shift from perpetually studying outcomes and begin to influence the things that are known to improve them? It's a revolving door, that if you don't walk through to the other side, you effect no change and continue to discuss what might be on the other side of the door hours or years from now. One must utilize what one already knows, otherwise it is unlikely one will act on any knowledge gained in the future.

LHS assert that there is need for both internal knowledge, from local data and observations and external knowledge, found in journals, texts, and education (65). Rubin et al. argue that though external information is needed, if the system reflected the internal data in as close to real time as possible, this would facilitate the uptake of current knowledge for the patient in the present (65).

To apply a Learning Health Cycle to the above study in Chapter 2, we see that though there is ample external evidence to support transfer to tertiary care, we see adequate internal transfer guidelines and assessment tools, directing severely injured patients towards tertiary care, and we see that though the theoretical system exists, it becomes actualized in a very different reality than expected. However, there is currently no access to the internal data for this site other than this study, and perhaps implementing regular complete information cycles will facilitate a bedside response. A trauma care coordinator at the site might help monitor and reflect system actualization (internal), where as a distant registry with no completed feedback loop to the site is not influential (external). As described by Mohan et al., it is also observed is the culture of this site to err on the false negative, to deny system actualization to the injured (20). To confirm that is to err on the side that risks the most for the patient. Following the example in Figure 16, one would exit the LHS cycle here content with knowing more and satisfied that something of interest was found in the research. However, this is precisely where the opportunity lies—the potential to take this awareness, disseminate it, and not only advocate for adherence to known practice guidelines and policy, but also act on this new internal knowledge with conviction in one's own practice. Thus, for one person, integrating both external and internal knowledge the cycle completes, and perhaps lays a foundation upon which others might begin and complete a cycle of their own interest and conviction. Mohan et al. describe physician decision making as an expression of either their ability to tolerate error (decisional threshold) or their ability to discern sick and not sick patients (perceptual sensitivity) (12,41,43). They found that physicians rely heavily on their error tolerance as a threshold for decision making,

instead of perceptual sensitivity (41,43). Thus, they suggest aiming efforts at lowering decisional thresholds for error instead of, as most performance improvement programs do, focusing on perceptual sensitivity (41,43). Gagliardi et al. report that though one might know who to call, they will be inhibited by cultural norms and personal insecurity (12). Profoundly, Friedman et al., studied physicians' confidence in diagnosis and decision making and found that practitioners cannot be solely relied upon to know when they are in need of the support tools in place to prevent error or harm (70). The difficulty here with secondary triage, is that without a tight, rhythmic culture of shared decision making, physician autonomy will outweigh any protocol or policy (71).

Thus, in the case of secondary triage, influencing the threshold of error might be a consistent culture shift towards services limiting their acceptance of severely injured patients such as in using the need for ICU as a trigger to contact a tertiary center, or perhaps advocating that admitting services calling the tertiary centers themselves if the emergency physician does not think it warranted. Once all the stakeholders come together, both tertiary and non-tertiary, to review the current capture of system function, a decision can be made about how best to actualize and leverage current resources in place. Thus, clarifying the ambiguity found in the current algorithm and decreasing the margin for subjective interpretation. Eventually, with consistent application of appropriate care, within agreed upon boundaries, the culture can be facilitated to shift towards transfer of these patients instead of keeping them.

4.4 High Reliability Organizational Principles: Tools for culture shift

Another highly influential concept in reconciling the theoretical and the actual is the High Reliability movement. High reliability organization (HRO) is a term used to capture the culture of an organization or system that has a high burden of risk or hazard within complex systems that is adaptive to threats of dysfunction and responsive to anticipated failure (53,60,62,72). High reliability organizations; such as aviation, and nuclear power, fixate on 5 key principles: preoccupation with failure, reluctance to simplify, sensitivity to operations, commitment to resilience, and deference to expertise (53,60,62,72)(Table 9). HRO principles help culture decentralize ownership of data/influence, becoming a responsive culture to issues in the moment, instead of over-reliance or co-dependence on bureaucracy. Becoming incessantly watchful and relentless in the deconstruction of weak signals of failure or error, while refusing to dismiss trends, accepting interruptions as opportunities to redefine and reframe issues, and migrating to those who are able to tell the whole story—develops a system or organizations ability to 'stretch without breaking' (p.98, 62).

Perhaps utilizing the LHS cycle as a platform, HRO principles might be a way in which to sustainably pull lessons learned into culture (Figure 18). When we apply these concepts to secondary triage of the injured patient, we see direct points of influence (Table 9, 53,59,71) . HRO principles described by Weick and Sutcliffe, help reframe potential risk and actual hazards, by broadening the focus from 'decisions' to 'does this make sense' (62). They argue that decisions become battles of the ego and are

Table 9. Application of HRO Principles to Secondary Triage

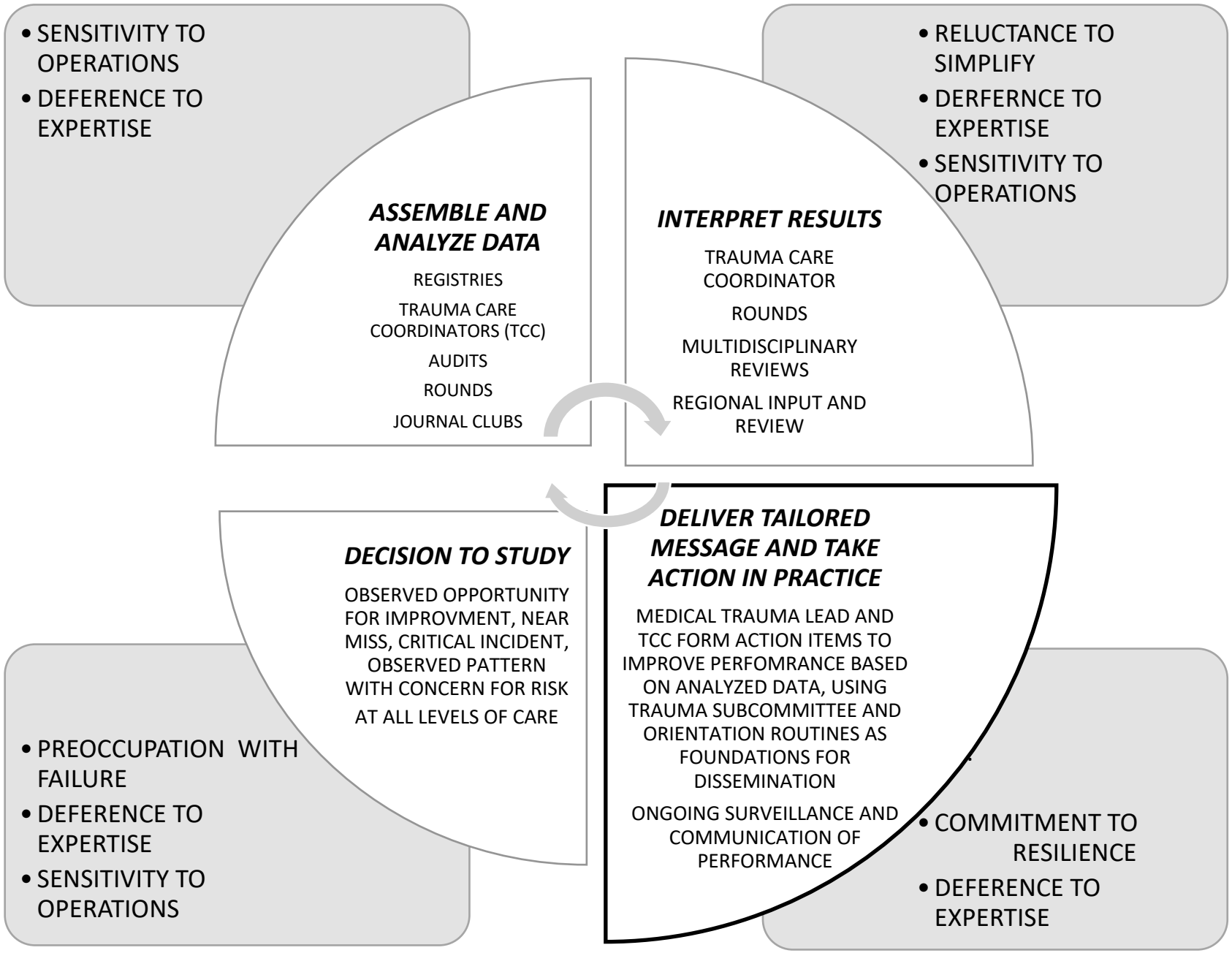
Concept	Preoccupation with Failure	Reluctance to Simplify	Sensitivity to Operations	Commitment to Resilience	Deference to Expertise
Key Ideas **(p. 139, 60**)	*'Chronic wariness'* **'***Proactive, pre-emptive, and after action' to prevent harm and understand failures* **'**Detect small, emerging failures' (62)	*'Questioning assumptions'* *'Create a more complete and nuanced picture of current situation'* *"Differentiation of categories' (62)*	*'Interaction and information sharing…create integrated and big picture'* *'Seeing what we are actually doing' (p.79, 62)*	*'Developing capabilities' to maintain responsive safe care amidst threats and failures'* *'Locating pathways to recovery'* (p. 150, 62)	**'***Migrate to the person with the most expertise with the problem at hand regardless of authority'*
Application (53,60,62,73)	Reflect severely injured patients to bedside practitioners, observe trends, report under-triage rates Belief that late transfers are near misses and expose legitimate risk to the patient and not a success of avoidance of harm in the end Failure is not a reflection of competence but illuminates an opportunity to improve and rectify either personal or systemic factors that put patients at risk Failure as a catalyst for change, not an end point, injury case reports of recent patients reviewed by multiple disciplines	Capture every patient as a learning opportunity for team and system function Single decision by physician is not seen as only issue but seen as complex result of many technical and non-technical contributors Nothing is taken for granted, every opportunity for improvement is explored from protocol to timing of interventions, all contributing to appreciation of injury and appropriate assignment of resources Relentless deconstruction	Situational awareness of resources on site and off, of healthcare providers capacity, imminent OR accessibility, blood bank notification, order entry completion, patient status etc. Maintain a summary culture that accounts for all the details, whilst simultaneously reflecting the big picture to ensure ***shared mental model*** i.e. 'the patient needs to be in CT in 5 minutes' 'Start the blood, PTN is on the phone, let's start thinking about packaging this patient if the condition remains unchanged after the blood'	Training, utilizing known education proven to facilitate appropriate trauma care Commitment of nursing staff to continue education even if not subsidised by management Relentless adaptability for the patients benefit, advocating for appropriate system activation regardless of opposition Ensuring team members capable of facilitative skills such as closed loop communication, situational awareness	Consensus on who is to make the triage decision, flexible depending on patient needs Reliance on regional supports for shared decision making as opposed to autonomous decisions made in isolation Team Leader 'heedful' of team members comfort and concerns with patient status and trajectory, and responsive to same, hears the 'story' Enable and empower frontline staff to either be the expert or able to rapidly identify the expert

inflexible, where as if one ‘makes sense’ then that is a more fluid posture that can evolve over time in response to recognized contributing factors (72). Entrenching these concepts into orientation, bedside language and shared mental model construction, will help drive culture towards consistency and safety.

4.5 Conclusion

These principles discussed are only effective if they are acted upon. Therein, again, lies the rub. Decentralizing responsibility of culture from the corporate to the personal is the first step. Disseminating findings and informing the current incomplete reality around secondary triage and under triage at this level 3 site is imperative to influence any uptake of this knowledge and to complete a learning cycle. Knowing though, is only half of the issue. Being encouraged and empowered to build resiliency and capacity simply within the safety culture of this department will hopefully enable caregivers to become owners of their work in a new and inspiring way. When what is already known is not implemented consistently, and we are more enamoured with the mystery of what we don’t know or may know in the future, we betray the patient and our responsibility to them. However, to compel people to change, to resilience, to expertise, it must be done side by side, with investment personally to speak over people what they could do, who they could become and not only by reprimand and repeatedly communicating what they are not. Ultimately, care of the injured is reliant on multiple professionals making theoretical systems real, which is again dependant on many unpredictable variables. Thus, it is of the utmost importance to dig down into the passion, intelligence, expertise, and diligence that is already present, yet to be uncovered, and continue to build its capacity for safe and appropriate care based in evidence and best practice.

Figure 18. Combining LHS with HRO principles: If one only looked at the LHS cycle, one can see that without the last quadrant of delivering tailored message, the other three quadrants are without direct impact on patient care, they are theoretical. However, HRO principles when applied offer action at every quadrant as described in Table 9.



Integrating these principles into orientation, conversation, chart reviews, staff meetings, patient handover summaries, and debriefings, will each in turn contribute to complete the broken LHS cycle that is currently the culture at this site, decreasing the acceptable threshold of error and degree of variable care. All this to actualize the system optimally for the most important patient—the one in front of us.

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Appendix A: Literature Search History

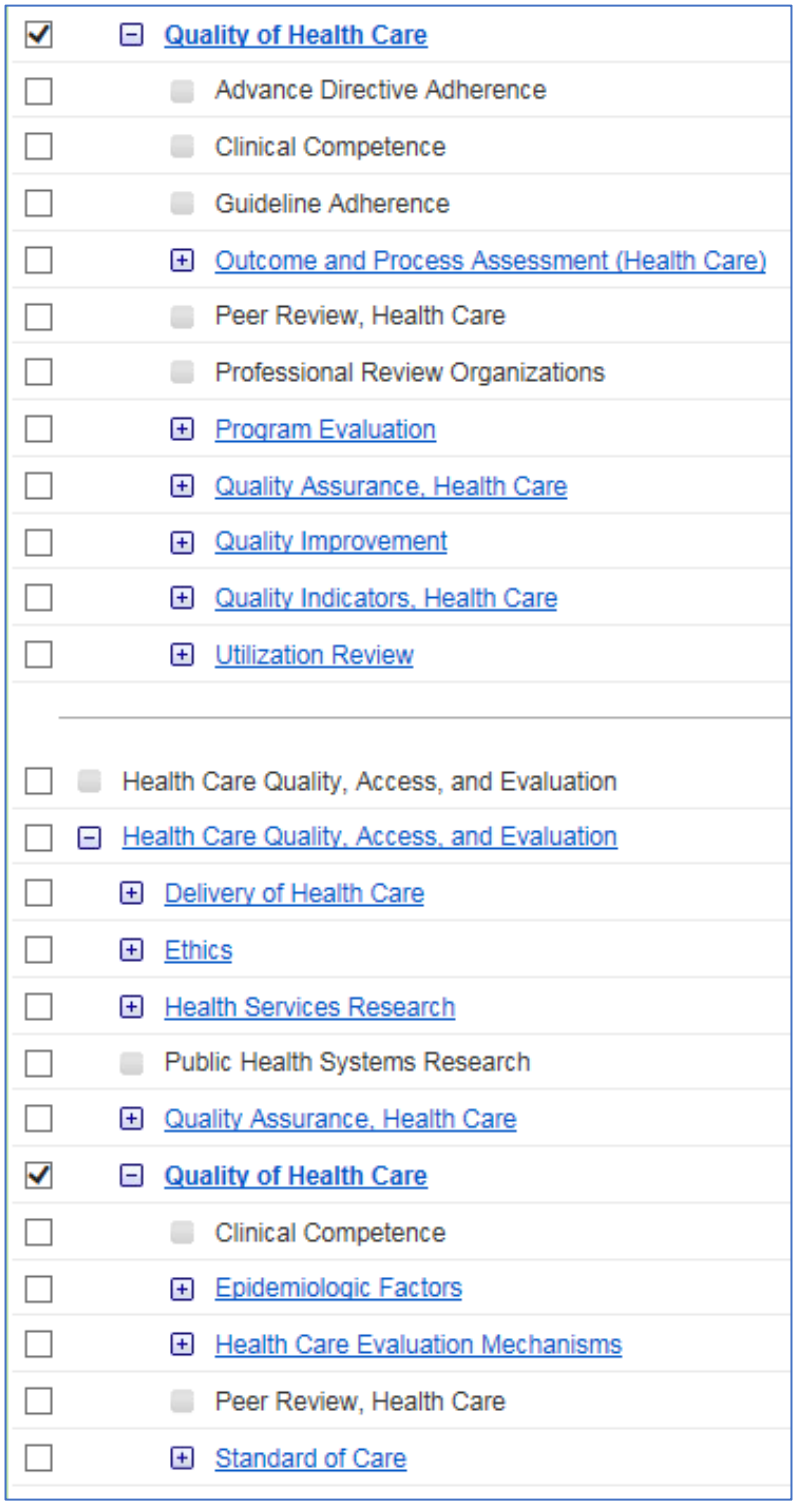
Topic: Trauma
Librarian: Michelle Main
Date: January 26, 2018

1. Looked through articles I (Michelle) pulled by Nathens, AB (on topic ones of first 100 of 350 in Medline = 12) – collected MeSH. Also collected MeSH from your two articles (Gomez) and a few others. I've scanned my notes to you.

2. Did MeSH searches in Medline as below. Come see me if you'd like me to show you how to do this. I've attached a class handout with instructions to my email.

S16	(MM "Multiple Trauma+")
S15	(MM "Time-to-Treatment")
S14	(MM "Patient Selection")
S13	(MM "Regional Health Planning+")
S12	(MM "Regional Medical Programs")
S11	(MM "Quality Improvement+")
S10	(MM "Health Services Accessibility+")
S9	(MM "Health Care Quality, Access, and Evaluation+")
S8	(MM "Quality Indicators, Health Care+")
S7	(MM "Quality of Health Care+")
S6	(MM "Outcome and Process Assessment (Health Care)+")
S5	(MM "Guideline Adherence")
S4	(MM "Traumatology")
S3	(MM "Triage")
S2	(MM "Patient Transfer")
S1	(MM "Trauma Centers")

MM means Major Concept, + means the MeSH has been exploded.


Quality of Health Care
Advance Directive Adherence
Clinical Competence
Guideline Adherence
Outcome and Process Assessment (Health Care)
Peer Review, Health Care
Professional Review Organizations
Program Evaluation
Quality Assurance, Health Care
Quality Improvement
Quality Indicators, Health Care
Utilization Review
Health Care Quality, Access, and Evaluation
Health Care Quality, Access, and Evaluation
Delivery of Health Care
Ethics
Health Services Research
Public Health Systems Research
Quality Assurance, Health Care
Quality of Health Care
Clinical Competence
Epidemiologic Factors
Health Care Evaluation Mechanisms
Peer Review, Health Care
Standard of Care

S26	S1 AND S9	s (1,376)
S25	S3 AND S17 AND S24	s (118)
S24	(MM "Decision Making+")	s (80,749)
S23	S17 AND S19	s (214)
S22	S2 AND S17 AND S20	s (5) V
S21	S2 AND S17 AND S18	s (75)
S20	S14 OR S15	s (16,774)
S19	S12 OR S13	s (20,337)
S18	S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11	s (1,301,798)
S17	S1 OR S3 OR S16	s (17,141)
S16	(MM "Multiple Trauma+")	s (8,233)
S15	(MM "Time-to-Treatment")	s (1,425)
S14	(MM "Patient Selection")	s (15,354)
S13	(MM "Regional Health Planning+")	s (20,337)
S12	(MM "Regional Medical Programs")	s (2,006)
S11	(MM "Quality Improvement+")	s (8,864)
S10	(MM "Health Services Accessibility+")	s (51,964)
S9	(MM "Health Care Quality, Access, and Evaluation+")	s (1,292,721)
S8	(MM "Quality Indicators, Health Care+")	s (9,327)
S7	(MM "Quality of Health Care+")	s (762,637)
S6	(MM "Outcome and Process Assessment (Health Care)+")	s (47,351)
S5	(MM "Guideline Adherence")	s (12,917)
S4	(MM "Traumatology")	s (2,633)
S3	(MM "Triage")	s (5,228)
S2	(MM "Patient Transfer")	s (4,346)
S1	(MM "Trauma Centers")	s (4,187)

Appendix B

Interior Health
Interior Health Regional Trauma System

Management of Major Trauma

Criteria for Identification of a Major Trauma Patient

Assess for Trauma Criteria

Physiologic Signs

Glasgow Coma Scale (GCS)	- 13 or less
Systolic Blood Pressure (SBP)	- less than 90 mmHg
Respiratory Rate	- less than 10 or greater than 29 breaths per minute (or less than 20 breaths per minute for less than one year of age)

YES → Patient Meets Major Trauma Criteria – Requires Trauma Team Activation

NO

Anatomical Signs

- Chest wall instability or deformity (eg. flail chest)
- Penetrating injuries to head, neck, chest and abdomen, groin and extremities proximal to elbow or knee
- Pelvic fractures
- Paralysis
- Open or depressed skull fracture
- Crushed, degloved, mangled or pulseless extremity
- 2 or more proximal long bone fractures
- Amputation proximal to wrist or ankle

YES → Patient Meets Major Trauma Criteria – Requires Trauma Team Activation

NO

Mechanism of Injury (MOI)

Fall
- **Adult** - greater than 20ft (6m)
- **Child** - greater than 10ft (3m) (or 2-3 times height of child)

High Risk Motor Vehicle Crash
- Intrusion (incl. roof)
  - greater than 30 cm - occupant site
  - greater than 45 cm - any site
- Ejection from vehicle (partial or complete)
- Death in same passenger compartment

Pedestrian / Cyclist Struck
- With significant impact greater than 30 Kph
- Thrown
- Run over

Motorcyclist
- Crash greater than 30 Kph

Evidence of High Energy Impact Mechanisms

YES → Patient Meets Major Trauma Criteria – Requires Trauma Team Activation

NO

Special Considerations

- **Older Adults**
  - Greater than or equal to 55 years of age
  - SBP less than 110 mmHg – greater than 65 years of age
  - Low impact mechanisms (i.e. ground level falls) – greater than or equal to 55 years of age
- **Children**
  - Less than 15 years of age
  - Trauma team activations should be considered based on mechanism of injury alone
- **Anticoagulation and bleeding disorders**
  - Patients with a head injury are at risk for rapid deterioration
- **Burns**
- **Pregnant greater than 20 weeks**

YES → Patient Meets Major Trauma Criteria – Requires Trauma Team Activation

NO → Continue Current Management Plan Consider Admission

Major Trauma Patient Criteria – FINAL Nov 6, 2013
Based on: CDC&P Guidelines for Field Triage of Injured Patients (2011)

Stabilize and Prepare Patient for Transport

Do the patient's needs exceed resources at your facility?

YES → Stabilize and Prepare Patient for Transport

NO → Continue Current Management Plan Consider Admission

ON-GOING REASSESSMENT:

Does Patient Show Signs Of:
- Any **prolonged** respiratory distress or shortness of breath?
- **Sustained** tachycardia despite fluid resuscitation and analgesia?
- SBP less than 100mmHg despite fluid resuscitation?
- Required blood transfusion(s) during resuscitation?
- **Persistent** abdominal tenderness on serial abdominal exams?
- Trauma related abnormalities on chest X-ray and/or positive seat belt sign?
- Sustained abnormal or declining GCS?
- Suspected fracture of the humerus, femur, pelvis, vertebral body, knee or hip?
- Rib fracture grade of 7 or higher?
- Requires a higher level of care?

YES → Stabilize and Prepare Patient for Transport

Management of Major Trauma (non-tertiary) –FINAL- November 12, 2013

Trauma Transfer Algorithm

Major Trauma Identified

- Call Patient Transfer Network (PTN) *(formerly bcbedline)* within 15 minutes and initiate LLTO Protocol 1-866-233-2337

Referral Guidelines for Sending Physician

When requesting transfer:
1. Provide description of patient clinical status including:
   - Mechanism of Injury
   - Assessment – include vital signs and weight
   - Treatment/Interventions
2. Identify receiving centre required
3. Specify priority for transport and clinical care requirements (medications, equipment, monitor)
4. Request to speak to **receiving facility Emergency Physician** or **Emergency Physician On-Line (EPOS)** if clinical decision support is required to determine the appropriate clinical transfer resource (ie. Air, Ground, HART) and/or receiving clinical specialty

*** If significant transfer delays are experienced, initiate site Support Action Plan*

Clinical Treatment Guidelines Prior to Transfer

1. Airway / Breathing
- Airway compromise and/or declining GCS affecting patient's ability to maintain and/or protect airway (as appropriate – consider airway management for prolonged transport)
  - Consider advanced airway management (ie. Intubation)
  - Maintain c-spine immobilization
- Breathing – Clinical Assessment
  - Insert chest tube if indicated (do not delay transfer for chest x-ray if not immediately available)
- *Patients with major Mechanism of Injury* (MOI) *should remain in C-spine immobilization until final destination*

2. Circulation
- Intravenous access (2 large bore) or intraosseous access
- Control obvious bleeding (ie. staples for scalp lacerations)
- Consider tranexamic acid administration for massive hemorrhage

3. As Indicated
- Pelvis X-ray – stabilize with sheet or approved pelvic binder
- Urinary catheter (unless obvious pelvic fracture or genital injury)
- Oral gastric tube (if intubated)
- Antibiotics for open fracture
- Splinting of long bone fractures
- Tetanus prophylaxis

4. Prepare Patient for Transfer
- Complete Trauma Transfer Record
- *Do not delay transport if documentation is incomplete, if necessary, documentation can be faxed to receiving facility*

Based on: Trauma 97 Protocol Resources for Optimal Care of the Injured Patient 2006
Trauma Transport Algorithm – FINAL Revision – November 8, 2013

*** Do Not Delay Transport For Imaging**