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The Effects of COVID-19 Pandemic on Trauma Registry and Performance Improvement Operations and Workforce Nationwide: A Survey of Trauma Center Association of America Members



Adel Elkbuli, MD, MPH,^{a,*} Mason Sutherland, B.S,^a Haley Ehrlich, B.S,^a Luis Santiesteban, B.S,^a Huazhi Liu, MS,^b Darwin Ang, MD, PhD, MPH,^{b,c} and Mark McKenney, MD, MBA, FACS^{a,d}

^a Department of Surgery, Division of Trauma and Surgical Critical Care, Kendall Regional Medical Center, Miami, Florida

^b Department of Surgery, Division of Trauma and Surgical Critical Care, Ocala Regional Medical Center, Ocala, Florida

^c Department of Surgery, University of Central Florida, Ocala, Florida

^d Department of Surgery, University of South Florida, Tampa, Florida

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ABSTRACT

Background: Trauma Centers integrate Trauma Registrars and Performance Improvement Nurses to drive quality care. Delays in their duties could have negative impacts on outcomes and performance. We aim to investigate the impact of COVID-19 pandemic on Trauma Center operations by assessing performance of trauma registry and performance improvement processes across the United States.

Methods: A cross-sectional study was performed utilizing data from two anonymous questionnaires distributed to Trauma Center Association of America members. Descriptive statistics, Fisher's Exact Test, and multivariable logistic regression were performed with statistical significance defined as $P < 0.05$.

Results: Of 90.2% (83) of Trauma Registrars and 85.9% (67) of Performance Improvement personnel reported that their Trauma Centers have treated COVID-19 patients. Among trauma registrars, respondents did not significantly differ in the current status of completing registry cases ($P > 0.05$), during COVID-19 compared to prior ($P > 0.05$), or adjusted odds of COVID-19 delaying completion of entries ($P > 0.05$). Having >2 Performance Improvement Nurses was significantly associated with improved performance during the COVID-19 pandemic ($P = 0.03$) whereas working at a Trauma Center which treats adults-only or mixed patient population (adult and pediatric) was associated with being 1-3 months behind in closing of performance improvement cases ($P = 0.02$).

* Corresponding author: Department of Surgery, Kendall Regional Medical Center, 11750 Bird Road. Miami, FL 33175. Tel: + 786 637 5287; fax: + 305 480 6625.

E-mail address: Adel.Elkbulli@HCAHealthcare.com (A. Elkbulli).

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Conclusions: The negative impact of COVID-19 on Trauma Registrars and Performance Improvement Nurses has been minimal. Adequate staffing/experience seem to mitigate delays and decreased performance. Implementation of expanded staffing, improved training, and evidenced-based revision of Trauma Center logistics may help mitigate future disruptions relating to COVID-19 and allow Trauma Centers to recover and improve their operations.

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Background

Maintaining access to quality trauma services during the COVID-19 pandemic remains quintessential as trauma is the leading cause of death in the United States (US) for ages 1-44.¹⁻³ Trauma Centers undergo verification (Levels 1-4) based on resources, volume, specialists, and other factors.⁴ Accurate registry data is an invaluable tool for achieving a higher-level verification, improving outcomes, establishment of new standards-of-care and research.⁵⁻⁸

Trauma Centers incorporate Trauma Registrars (TRs) and Performance Improvement Nurses (PINs) into the multidisciplinary teams needed to optimize performance improvement and patient safety (PIPS). The main function of a TR is to collect and enter data pertaining to the initial injury, prehospital information, diagnosis, care, outcomes, patient demographics, and costs associated with treatment of injured patients, whereas a PIN monitors systematic issues related to the quality of care provided, develops audits and case reviews, and help identify trends in performance with frequent participation in committee case reviews.⁸⁻⁹

The American College of Surgeons Committee on Trauma (ACS-COT) emphasizes the importance of continuous PIPS.⁸ Previous studies have addressed certain effects of COVID-19 on Trauma Center operations such as decreased traumatic injury admissions, differing mechanism and types of injuries treated, efficiency of being able to receive surgical treatment, and studies which speculate on a possible negative effect on PIPS processes.¹⁰⁻¹⁴ However, there is currently a deficit of literature evaluating the effects of COVID-19 on the essential trauma registry and PIPS processes. We aim to investigate the impact of the COVID-19 pandemic on Trauma Center operations by assessing the characteristics and performance of TRs and PINs across the US through two primary research questions: (1) Has COVID-19 had an impact on trauma registry and performance improvement operations? (2) What are the factors, which may be associated with experiencing (or not experiencing) delays or decreases in trauma registry and performance improvement operations/productivity during the COVID-19 pandemic?

Methods

Survey design and study population

A cross-sectional study was performed through two distinct anonymous questionnaires distributed to Trauma Cen-

ter members of the Trauma Center Association of America. The Trauma Center Association of America was chosen for survey distribution as it is one of the only major trauma organizations whose members are comprised of trauma registrars, performance improvement nurses, trauma program managers and/or directors, trauma medical directors, trauma surgeons, researchers, and others.¹⁵ Therefore survey distribution through this organization was ideal to reach our study target population. The 31-question PIPS survey was composed of primary multiple-choice and free response questions querying PINs, TRs, trauma program managers, and trauma medical directors. Major issues addressed include the qualifications and staffing of PINs and their responsibilities, PIPS, information regarding the Trauma Quality Improvement Program, morbidity & mortality conferences, multidisciplinary trauma case reviews, and multidisciplinary team composition (**Appendix 1**). The PIPS survey also inquired as to duration needed by PINs to complete peer review of cases, PIPS efficiency, and if COVID-19 affected the performance of PINs. The 20-question TR survey consisted of primary multiple-choice and free response questions querying TRs, trauma program managers and trauma medical directors addressing data collection elements as it pertains to a trauma patients' admissions, TRs qualifications and staffing issues, trauma registry completion and update status, and if COVID-19 affected the performance of TRs (**Appendix 1**). Additionally, both surveys evaluated performance by Trauma Center verification and/or designation level, volume of trauma admissions, TRs/PINs' years of experience, training and state mandated qualifications, number of Full Time Equivalent (FTEs) positions, and if the COVID-19 pandemic affected the volume of trauma cases.

Survey validation

A pilot survey was distributed internally to trauma registrars and performance improvement nurses of our institution for content validation and to increase the clarity, accuracy, and relevancy of the questions asked. Additionally, the two surveys were also externally validated by the Trauma Centers Association of America Education and Projects Committee in order to improve the clarity and accuracy of questions & answer choices. Both TR and PI surveys were approved for electronic distribution by the Education and Projects Committee of the Trauma Center Association of America from July to August 2020. Personal identifiable information such as name, institutional address or IP address were not collected. Cronbach's alpha values were calculated to estimate internal consistency and reliability. For the survey responses of 78 PI nurses and 92 Trauma registrars, the Cronbach's alpha for the overall survey for the Performance Improvement nurses was 0.81, which indicates a very good degree of internal consistency and reli-

Table 1 – Effect of COVID-19 on trauma registrars: stratified by number of FTE TRs.

Number of FTE TRs	0~1 (N = 18) [†]	1.1~2 (N = 19)	2.1~3 (N = 22)	3.1~4 (N = 12)	>=5 (N = 21)	P-values
COVID-19 delayed completion of trauma registry entries						
N (%)						
Unadjusted Odds Ratio (95% CI)						
* Adjusted Odds Ratio (95% CI)						
Yes	5 (29.4%)	6 (31.6%) 1.11 (0.27,4.60)	5 (23.8%) 0.75 (0.18,3.19)	5 (41.7%) 1.72 (0.36,8.09)	5 (23.8%) 0.75 (0.18,3.19)	0.82
No	12 (70.6%)	13 (68.4%) 5.05 (0.50,51.14)*	16 (76.2%) 7.72 (0.34,176.9)*	7 (58.3%) 8.77 (0.32,237.6)*	16 (76.2%) 5.25 (0.12,222.6)*	0.82
COVID-19 Affected TR Performance						
Same	12 (66.7%)	16 (84.2%)	18 (81.8%)	11 (91.7%)	18 (85.7%)	0.52
Worse	2 (11.1%)	2 (10.5%)	2 (9.1%)	1 (8.3%)	0 (0%)	0.60
Improved	1 (5.6%)	0 (0%)	1 (4.6%)	0 (0%)	3 (14.3%)	0.37
Unknown	3 (16.7%)	1 (5.3%)	1 (4.6%)	0 (0%)	0 (0%)	0.23
Current status						
Current	9 (50%)	6 (31.6%)	8 (36.4%)	5 (41.7%)	8 (38.1%)	0.84
<1 mo behind	3 (16.7%)	7 (36.8%)	5 (22.7%)	2 (16.7%)	6 (28.6%)	0.64
1-3 mo behind	6 (33.3%)	5 (26.3%)	7 (31.8%)	4 (33.3%)	6 (28.6%)	0.98
>3 mo behind	0 (0%)	1 (5.3%)	2 (9.1%)	1 (8.3%)	1 (4.8%)	0.84

* Adjusted by the presence of state mandated trauma registry qualification standards (binary outcome [yes/no]), annual patient volume (categorical), number of registry data collection elements (categorical), trauma center patient population (adults only, pediatrics only, adult and pediatric populations) (categorical), trauma center level (I-IV), COVID-19 burden (binary outcome [yes or no] if trauma center treated COVID-19 infected patients).

[†] Variable/cohort utilized as the reference group for regression analysis; odds ratios interpretation should be relative to this reference group. Abbreviations: FTE = Full Time Equivalent, TR = Trauma Registrars, CI = Confidence Interval.

Table 2 – Effect of COVID-19 on trauma registrars: stratified by presence of state mandated TR qualification standards.

State mandated TR qualification standards	Yes (N = 42) [†]	No (N = 43)	Unknown (N = 7)	P-values
COVID-19 delayed completion of trauma registry entries				
N (%)				
Unadjusted Odds Ratio (95% CI)				
* Adjusted Odds Ratio (95% CI)				
Yes	13 (31%)	10 (23.8%) 0.70 (0.27,1.83)	3 (50%) 2.23 (0.40,12.56)	0.41
No	29 (69%)	32 (76.2%) 0.51 (0.14,1.81)*	3 (50%) 9.01 (0.71,114.5)*	0.41
COVID-19 affected TR performance				
Same	33 (78.6%)	38 (88.4%)	4 (57.1%)	0.11
Worse	3 (7.1%)	3 (7%)	1 (14.3%)	0.68
Improved	3 (7.1%)	2 (4.7%)	0 (0%)	0.78
Unknown	3 (7.1%)	0 (0%)	2 (28.6%)	0.01
Current status				
Current	15 (35.7%)	19 (44.2%)	2 (28.6%)	0.68
<1 mo behind	9 (21.4%)	12 (27.9%)	2 (28.6%)	0.71
1-3 mo behind	16 (38.1%)	9 (20.9%)	3 (42.9%)	0.14
>3 mo behind	2 (4.8%)	3 (7%)	0 (0%)	0.99

* Adjusted by the number of FTE TRs in the trauma department (categorical), annual patient volume (categorical), number of registry data collection elements (categorical), trauma center patient population (adults only, pediatrics only, adult and pediatric populations) (categorical), trauma center level (I-IV), COVID-19 burden (binary outcome [yes or no] if trauma center treated COVID-19 infected patients).

[†] Variable/cohort utilized as the reference group for regression analysis; odds ratios interpretation should be relative to this reference group. Abbreviations: FTE = Full Time Equivalent, TR = Trauma Registrars.

Table 3 – Effect of COVID-19 on trauma registrars: stratified by TR years of experience.

Years of Experience of TR	<1 y (N = 3) [†]	1-2 y (N = 5)	2-3 y (N = 10)	3-4 y (N = 9)	4-5 y (N = 8)	>5 y (N = 55)	N/A (N = 2)	P-values
COVID-19 delayed completion of trauma registry entries								
N (%)								
Unadjusted Odds Ratio (95% CI)								
* Adjusted Odds Ratio (95% CI)								
Yes	1 (33.3%)	0 (0%)	5 (50%)	4 (44.4%)	2 (25%)	14 (25.9%)	0 (0%)	0.41
		<0.001	2.00	1.60	0.67	0.70	<0.001	
		(<0.001,>999)	(0.13,29.81)	(0.10,24.70)	(0.04,11.94)	(0.06,8.33)	(<0.001,>999)	
		<0.001	10.66	16.01	5.32	3.84	<0.001	
		(<0.001,>999)	(0.14,790.0)*	(0.20,>999)*	(0.08,336.3)*	(0.06,241.4)*	(<0.001,>999)*	
No	3 (66.7%)	5 (100%)	5 (50%)	5 (55.6%)	6 (75%)	40 (74.1%)	1 (100%)	0.41
COVID-19 Affected TR Performance								
Same	2 (66.7%)	5 (100%)	8 (80%)	7 (77.8%)	7 (87.5%)	46 (83.6%)	0 (0%)	0.15
Worse	1 (33.3%)	0 (0%)	1 (10%)	0 (0%)	0 (0%)	5 (9.1%)	0 (0%)	0.57
Improved	0 (0%)	0 (0%)	0 (0%)	2 (22.2%)	1 (12.5%)	2 (3.6%)	0 (0%)	0.26
Unknown	0 (0%)	0 (0%)	1 (10%)	0 (0%)	0 (0%)	2 (3.6%)	2 (100%)	0.02
Current status								
Current	1 (33.3%)	4 (80%)	1 (10%)	3 (33.3%)	5 (62.5%)	21 (38.2%)	1 (50%)	0.12
<1 mo behind	0 (0%)	1 (20%)	3 (30%)	2 (22.2%)	1 (12.5%)	16 (29.1%)	0 (0%)	0.95
1-3 mo behind	2 (66.7%)	0 (0%)	4 (40%)	4 (44.4%)	2 (25%)	15 (27.3%)	1 (50%)	0.37
>3 mo behind	0 (0%)	0 (0%)	2 (20%)	0 (0%)	0 (0%)	3 (5.5%)	0 (0%)	0.55

Abbreviations: FTE = Full Time Equivalent, TR = Trauma Registrars. N/A = Not Available.

* Adjusted by the presence of state mandated trauma registry qualification standards (binary outcome [yes/no]), the number of FTE TRs in the trauma department (categorical), annual patient volume (categorical), number of registry data collection elements (categorical), trauma center patient population (adults only, pediatrics only, adult and pediatric populations) (categorical), trauma center level (I-IV), COVID-19 burden (binary outcome [yes or no] if trauma center treated COVID-19 infected patients).

[†] Variable/cohort utilized as the reference group for regression analysis; odds ratios interpretation should be relative to this reference group.

ability.¹⁶⁻¹⁸ The Cronbach's alpha for the overall survey for the Trauma Registrars was 0.61, which indicates an acceptable internal consistency and reliability for an exploratory investigation.¹⁶⁻¹⁸

Statistical analysis

Descriptive statistics, Fisher's Exact Test, and unadjusted and adjusted multivariable logistic regression analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC) with significance defined as $P < 0.05$. Variables used in the regression models were included to account for confounders which could have an independent effect on the exposure group or outcome. These variables were presence of state mandated trauma registry qualification standards, the number of FTE TRs in the trauma department, annual patient volume, number of registry data collection elements, Trauma Center patient population (adults only, pediatrics only, adult and pediatric populations), Trauma Center level (I-IV), COVID-19 burden (binary outcome [yes or no] if Trauma Center treated COVID-19 infected patients). This study was conducted in compliance with ethical standards, was reviewed by our institutional review board and was deemed exempt.

Results

The PINs and TR surveys were distributed to a total of 383 hospital staff members across the US. A total of 170 responses composed of 78 PI personnel and 92 TR personnel were received, representing an overall response rate of 44.4%. Of 67 (85.9%) PINs and 83 (90.2%) TR personnel reported that their Trauma Centers have treated COVID-19 patients (eTables 1-2).

Trauma registry survey

When stratified by the number of FTE TRs in their department, 23.8%-41.7% of respondents reported that COVID-19 delayed completion of registry entries, however no significant associations between COVID-19 and current status of registry cases, performance of TRs, or odds of delaying completion of entries were found ($P > 0.05$) (Table 1).

When stratified by their Trauma Center patient population (adult versus pediatric versus both), 22.2%-30.8% of respondents reported COVID-19 delaying completion of registry entries, however no significant associations between COVID-19 and current status of registry cases, performance of TRs, or odds of delaying completion of entries were found ($P > 0.05$).

Table 4 – Effect of COVID-19 on performance improvement: stratified by number of FTE PINs.

Number of FTE PINs	0 (N = 23) [†]	0.1~1 (N = 32)	1.1~2 (N = 16)	>2 (N = 7)	P-values
COVID-19 delayed closure of PI cases					
N (%)					
Unadjusted Odds Ratio (95% CI)					
* Adjusted Odds Ratio (95% CI)					
Yes	13 (59.1%)	14 (45.2%) 0.57 (0.19,1.72) 4.27 (0.30,60.15)*	8 (50%) 0.69 (0.19,2.53) 6.05 (0.27,134.4)*	6 (85.7%) 4.15 (0.42,40.63) 80.36 (1.51,>999)*	0.26
No	9 (40.9%)	17 (54.8%)	8 (50%)	1 (14.3%)	0.26
COVID-19 affected PIN performance					
Same	15 (65.2%)	24 (75%)	14 (87.5%)	4 (57.1%)	0.32
Worse	3 (13%)	5 (15.6%)	2 (12.5%)	1 (14.3%)	0.99
Improved	0 (0%)	1 (3.1%)	0 (0%)	2 (28.6%)	0.03
Unknown	5 (21.7%)	2 (6.3%)	0 (0%)	0 (0%)	0.09
Current status					
Current	7 (30.4%)	5 (16.1%)	1 (6.3%)	1 (14.3%)	0.26
<1 mo behind	4 (17.4%)	6 (19.4%)	8 (50%)	1 (14.3%)	0.08
1-3 mo behind	11 (47.8%)	18 (58.1%)	5 (31.3%)	3 (42.9%)	0.43
>3 mo behind	1 (4.4%)	2 (6.5%)	2 (12.5%)	2 (28.6%)	0.19

* Adjusted by the presence of state mandated performance improvement qualification standards (binary outcome [yes/no]), annual patient volume (categorical), trauma center patient population (adults only, pediatrics only, adult and pediatric populations) (categorical), trauma center level (I-IV), COVID-19 burden (binary outcome [yes or no] if trauma center treated COVID-19 infected patients).

[†] Variable/cohort utilized as the reference group for regression analysis; odds ratios interpretation should be relative to this reference group. Abbreviations: FTE = Full Time Equivalent, PI = Performance Improvement, PIN = Performance Improvement Nurse.

When stratified by their Trauma Center annual patient volume, 23.8%-44.4% of respondents reported COVID-19 delaying completion of registry entries, however no significant associations between COVID-19 and current status of registry cases, performance of TRs, or odds of delaying completion of entries were found ($P > 0.05$).

When stratified by the presence of state mandated TR qualification standards, 23.8%-50% of respondents reported COVID-19 delaying completion of registry entries, however no significant associations between COVID-19 and current status of registry cases, performance of TRs, or odds of delaying completion of entries were found ($P > 0.05$) (Table 2).

When stratified by the lead registrar years of experience, 0%-50% of respondents reported COVID-19 delaying completion of registry entries, however no significant associations between COVID-19 and current status of registry cases, performance of TRs, or odds of delaying completion of entries were found ($P > 0.05$) (Table 3).

Performance improvement survey

When stratified by the number of FTE PINs in their department, 45.2%-85.7% of respondents reported COVID-19 delaying completion of PI cases. Statistical analysis revealed having >2 FTE PINs was associated with significantly improved PIN performance during the COVID-19 pandemic ($P = 0.03$) (Table 4).

When stratified by their Trauma Center patient population (adult versus pediatric versus both), 20%-60.4% of respondents reported COVID-19 delaying completion of PI cases. Statistical

analysis revealed 57.1% of those treating adults-only, 40.9% of those treating adults and pediatrics, and 0% of those treating pediatrics-only reported a 1-3-mo delay in closing PI cases ($P = 0.02$).

When stratified by their Trauma Center annual patient volume, 31.3%-68.8% of respondents reported COVID-19 delaying completion of PI cases, however no significant associations between COVID-19 and current status of registry cases, performance of TRs, or odds of delaying completion of entries were found ($P > 0.05$).

When stratified by the presence of state mandated PIN qualification standards, 40%-60.9% of respondents reported COVID-19 delaying completion of PI cases, however no significant associations between COVID-19 and current status of registry cases, performance of TRs, or odds of delaying completion of entries were found ($P > 0.05$) (Table 5).

When stratified by the lead PIN years of experience, 48.3%-63.2% of respondents reported COVID-19 delaying completion of PI cases however no significant associations between COVID-19 and current status of registry cases, performance of TRs, or odds of delaying completion of entries were found ($P > 0.05$).

Discussion

PIPS operations are integral components in optimizing patient care, generating research, and shaping the future of trauma care.^{5,8,19-20} This study found that although not reaching statistical significance, TR respondents varied widely in reporting

Table 5 – Effect of COVID-19 on performance improvement: stratified by presence of state mandated PI qualification standards.

State mandated PI qualification standards	Yes (N = 5) [†]	No (N = 49)	Unknown (N = 24)	P-values
<i>COVID-19 delayed closure of PI cases</i>				
N (%)				
Unadjusted Odds Ratio (95% CI)				
* Adjusted Odds Ratio (95% CI)				
Yes	2 (40%)	25 (52.1%) 1.63 (0.25,10.65) 4.32 (0.28,67.15)*	14 (60.9%) 2.33 (0.32,16.82) 32.22 (0.76,>999)*	0.65
No	3 (60%)	23 (47.9%)	9 (39.1%)	0.65
<i>COVID-19 affected PIN performance</i>				
Same	5 (100%)	36 (73.5%)	16 (66.7%)	0.41
Worse	0 (0%)	8 (16.3%)	3 (12.5%)	0.99
Improved	0 (0%)	3 (6.1%)	0 (0%)	0.63
Unknown	0 (0%)	2 (4.1%)	5 (20.8%)	0.05
<i>Current status</i>				
Current	1 (20%)	7 (14.6%)	6 (25%)	0.43
<1 mo behind	3 (60%)	13 (27.1%)	3 (12.5%)	0.07
1-3 mo behind	1 (20%)	22 (45.8%)	14 (58.3%)	0.26
>3 mo behind	0 (0%)	6 (12.5%)	1 (4.2%)	0.64

* Adjusted by the number of FTE PI nurses in the department (categorical), annual patient volume (categorical), trauma center patient population (adults only, pediatrics only, adult and pediatric populations) (categorical), trauma center level (I-IV), COVID-19 burden (binary outcome [yes or no] if trauma center treated COVID-19 infected patients).

[†] Variable/cohort utilized as the reference group for regression analysis; odds ratios interpretation should be relative to this reference group. Abbreviations: FTE = Full Time Equivalent, PI = Performance Improvement, PIN = Performance Improvement Nurse.

whether COVID-19 delayed registry entries when stratified by the number of FTE TRs in their Trauma Center, presence of TR qualification standards, years of experience of lead registrar, annual patient volume, and patient population treated. Among PIN respondents, having >2 FTE PINs was significantly associated with improved PIN performance during the COVID-19 pandemic. Additionally, serving the adult trauma patient population was significantly associated with reporting 1-3-mo delays in closing PI cases. Among both TR and PIN respondents, respondents serving a larger patient volume generally reported higher rates of delays in the TR and PIN processes.

Retaining an accurate and updated registry and timely PIPS process is integral in maintaining standards of care, with delays possibly leading to negative impacts on patient outcomes if preventable technological or clinical errors are not recognized and resolved. It was found that when stratified by patient population treated (adult versus pediatric versus mixed), 13%-16.7% of respondents report that their PIN performance has worsened due to COVID-19, with respondents from adult-only and mixed Trauma Centers being significantly associated with reporting being 1-3-mo behind in completing PI cases. This delay during the COVID-19 pandemic may be due to a combination of staff reallocation to critical care settings in order to care for infected adult patients and compensate vacancies in PIN positions, as well as the possibility of a reduced volume of pediatric patients admitted during the pandemic.^{10-11,14,21}

Although statistically insignificant, respondents from Trauma Centers which experience a high annual patient volume generally reported greater delays in closure of PI cases and entry of registry data as a result of COVID-19. Recent literature has indicated that 12% of patients who could benefit from urgent or emergency care have avoided seeking care due to concerns regarding COVID-19.²² Additionally, it has been shown as high as a 32.5% reduction in trauma patient volumes during the COVID-19 pandemic occurred with significant reductions in motor vehicle collisions and other injury patterns with the implementation of federal stay-at-home orders.²³⁻²⁴ Considering that the number of PINs employed is generally adequate to manage the trauma patient volume received, our findings that higher patient volumes are associated with higher delays may be attributable to the temporary conversion of PIN responsibilities to patient care, overwhelming of hospital capacity, and conversion of acute care facilities into overflow COVID-19 units to handle surges of infected patients.²⁵⁻²⁷ Furthermore, it is worth noting that high-capacity Trauma Centers are generally located in highly populated areas where COVID-19 has had the highest burden on hospitals and further supports our findings of high-volume centers experiencing greater delays in Trauma Center operations.²⁸ However, our findings indicate that trauma registry activities and performance & quality improvement operations were not significantly impacted during the COVID-19 pandemic compared to prepandemic years.

Table 6 – Recommendations for PIPS and trauma registry processes.

Recommendations for performance improvement and trauma registry processes		
Staffing	Increase trauma registrar and performance improvement nurse staffing in the event of decreased performance or prolonged delay in case closure.	Frequent needs-based evaluation and distribution of staff to departments in need during high non-trauma patient burden.
Education	Strengthen trauma registrar and performance improvement nurse training through increased knowledge of how COVID-19 patients are managed.	Safeguard multidisciplinary case review meetings to prevent delays.
Logistics	Revision of mass disaster protocols and cooperation with local/state/national entities to prevent patient overflow.	Utilize COVID-19 data to update triage protocols for possible resurgences and management of variants.

Table 7 – Potential solutions to mitigating negative impact of COVID-19 on trauma registry.

Trauma registries: identifying potential disruptors during COVID-19	
Potential difficulties	Inadequate personnel training/qualifications.
	Decreased workforce and/or personnel support.
	Decentralized data gathering/reporting.
	Lack of funding and/or resources to sustain patient overflow.
	Inadequate data entry/extraction software.
Possible interventions	Lack of protocol(s) for the use of Trauma Center resources and personnel in non-trauma emergency circumstances.
	Require training beyond standard trauma registry competency to ensure readiness in emergency settings (pandemics, natural disasters, resource shortages, etc). This will entail local/regional/national modification of trauma registrar training curriculums.
	Ensure adequate staffing and establish peer backup rosters to properly respond to unexpected personnel shortage.
	Establish centralized data gathering/reporting system(s) capable of interfacing with local/regional/state/national data registries. Moreover, ensure data can be accessed by authorized entities under emergency circumstances.
	Build partnerships with local/regional/state authorities to create emergency funds to supplement trauma centers during supply shortages.
	Design nationally compatible trauma registry software packages that can be used in states of emergency which will allow registrars to input/output pertinent trauma-related reports to readily predict and communicate health trends.
	Establish local/regional/state/national protocols for repurposing of trauma centers for use in non-trauma related states of emergency.

A reduced or insufficient workforce can diminish the institutions ability to appropriately respond to impending trauma cases, increase medical errors, reduce administrative efficiency, cripple improvement operations, and overwhelm personnel.⁸ Our findings of respondents who reported higher number of TRs and PI personnel also reported being more current in completing registry entry/cases supports previous literature which details improved institutional performance and patient outcomes for Trauma Centers with more adequate staffing.²⁹⁻³⁵ This notion is further supported when considering that having >2 FTE PINs was significantly associated with improved performance during the COVID 19 pandemic. As understaffing of PIN and TR positions has the capability to overload and fatigue practicing PINs/TRs and predispose to worse performance, our findings have the implication that that proper and adequate staffing of TR and PI personnel has the potential to mitigate negative effects of COVID-19 on PIPS moving forward.³⁶ Therefore, interventions which can serve to maintain adequate staffing and case-load distribution, such as the utilization of more numerous trauma registrars and PINs,

may have the capability to mitigate negative effects of COVID-19 on PIPS.³⁶⁻³⁷

It was found that among both TR and PI respondents, working at a Trauma Center with state mandated qualification standards for TRs and PINs was not significantly associated with differences in performance or COVID-19 producing delays in entering registry data and/or closing PI cases. Although literature regarding this topic is scarce, our findings indicate that those with state mandated TR/PI standards were able to perform and respond to COVID-19 similarly compared to those without state mandated standards. While likely multifactorial and warranting further investigation, these findings may indicate that state mandated qualification standards do not confer a significant improvement in trauma registrar and PIN performance. An alternative explanation may be that state mandated qualification standards are not a significant factor affecting performance of registrars and PINs in a pandemic scenario specifically. These findings likely serve as a nidus for future investigations in order to determine if refinement of state mandated qualification standards is in need of revision in or-

der to improve TR and PIN performance after the COVID-19 pandemic.

Common to both the PIPS and registry processes are the implications that delays and worse performance has on ACS-COT verification. As part of the ACS-COT verification process, centers must be re-evaluated on a 1- or 3-y basis to ensure high quality performance.⁸ As maintaining ACS-COT verification requires the closure of 80% of trauma registry and PIPS cases within 60 d of patient discharge, delays have the potential to contribute to medical errors in the acute setting and can threaten ACS-COT verification.⁸ As our study highlighted a proportion of respondents who reported their delays in trauma registry entry and closing of PI cases extending past three months as a result of COVID-19, this finding highlights the importance of thoroughly evaluating the impact of the current pandemic on trauma registry and performance improvement operations and introduces a potentially long-term consequence of COVID-19 that compounds the acute challenges on Trauma Centers. Additionally, our findings suggest that PINs serving adult patient populations may be at greatest risk of experiencing delays in closing cases past 60 d and have the potential to benefit from interventions.

There are limitations to our study. First, our investigation is subject to limitations inherent to cross-sectional survey studies including the possibility of non-response bias and recall bias. Relatedly, recall bias may play a role in producing differing Cronbach alpha values between trauma registrars and PINs as the latter generally has multiple encounters with patient profiles and therefore a decreased chance of recall bias. In addition, the true burden of COVID-19 on the TR & PI processes may be underestimated due to varying institutional policies and resources available for COVID-19 screening and work environment across trauma centers nationwide.

We offer several recommendations moving forward to minimize the effects of COVID-19 on PIPS and trauma registry processes which we have stratified by interventions for staffing, education, and logistics (Table 6).^{2,35,38-41} Additionally, given their instrumental role in the management, advancement, and long-term improved outcomes of trauma patients, we highlight how to address potential difficulties experienced by trauma registrars in Table 7.^{2,35,38-41} The direct assessment of COVID-19 pandemic effects on clinical outcomes as a result of disruption or delays in the trauma registry operations and PIPS processes may be best accomplished using clinical datasets at the institutional, regional and national level. As effective trauma systems are dependent on registry and PIPS processes, the correlation of trauma systems operations, trauma registry metrics, and PIPS processes and patient clinical outcomes across Trauma Centers who have treated COVID-19 patients should be further investigated on a larger scale in order to fully understand the potential linkage and full effects of the COVID-19 pandemic on both trauma system operations and clinical outcomes. Comparison of COVID-19 pandemic effects on trauma registry and performance/quality improvement operations between Trauma Centers that treated COVID-19 patients versus those that did not could provide additional details on the extent of the COVID-19 pandemic impact on trauma systems' operations, and whether Trauma Centers which did not treat COVID-19 patients were similarly impacted or not during the COVID-19 pandemic. In addi-

tion, although our study has identified several factors which contribute to delays in registry entries and closure of performance improvement cases, future studies should further elucidate factors for delays in registry/PIPS processes not investigated in this analysis such as the impact that working remotely and hospital-specific lockdown procedures have had on trauma center operations. Greater investigation of current TR and PIN qualification standards in relation to performance is needed to help identify criteria/policies, which can maximize trauma registry and performance improvement operations moving forward.

Conclusion

Overall, trauma registry function and performance improvement processes have been minimally impacted at the national scale due to the ongoing effects of the COVID-19 pandemic. Adequate staffing was found to be associated with experiencing improved overall PIPS performance during the COVID-19 pandemic. Respondents from adult and mixed patient population Trauma Centers experienced significant 1-3-mo delays in closing performance improvement cases whereas the presence state mandated qualification standards, annual patient volume, and years of experience of lead registrars/performance improvement nurses were not significant factors in whether trauma registry and performance improvement operations were affected during COVID-19. Implementation of more Trauma Registry and Performance Improvement Nurse staffing may serve as a method to mitigate negative effects of COVID-19 on Trauma Center operations moving forward. Additionally, utilization of evidenced-based interventions described herein has the potential to bolster Trauma Registry and Performance Improvement Nurse staffing, education, and Trauma Center logistics to help meet the needs of the national trauma system and maintain Trauma Center verification during and after COVID-19. Our investigation serves as a nidus for additional studies to investigate the impact of COVID-19 on trauma registry and performance improvement processes in greater detail.

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Disclosure

Authors disclose no competing interests.

Supplementary Materials

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