Factors associated with organ donation by trauma patients in Nova Scotia

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BACKGROUND: Trauma patients represent a significant pool of potential organ donors (PODs), and previous research suggests that this population is underutilized for organ donation (OD). Our objective was to assess factors associated with OD in the trauma population.

METHODS: We retrospectively analyzed OD in Nova Scotia over a 7-year period (2009–2016) using data from the Nova Scotia Trauma Registry and Nova Scotia Legacy of Life Donor Registry. All trauma patients who died in the hospital were included. Multiple logistic regression was used to assess factors associated with donation. We also evaluated characteristics, donation types, and reasons for nondonation among trauma PODs.

RESULTS: There were 689 trauma-related deaths in all hospitals in NS during the study period, of which 39.8% (274 of 689) met the Nova Scotia Trauma Registry definition of a POD. Data on OD were available for 108 of these patients who were referred to the Legacy of Life Program. The conversion rate was 84%. Compared with nondonors, organ donors were significantly younger, had a higher Abbreviated Injury Scale head score and a lower scene Glasgow Coma Scale score, were more likely to suffer ischemia from drowning or asphyxia and to require air transport, and were less likely to have comorbidities. Regression analysis showed that donation was associated with younger age (odds ratio [OR], 0.97; 95% confidence interval [CI], 0.95–0.99) and lower Glasgow Coma Scale score at the scene (OR, 0.76; 95% CI, 0.66–0.88). Odds of donation were increased with air transport compared with land ambulance (OR, 8.27; 95% CI, 2.07–33.08) and injury within Halifax Regional Municipality compared with injury outside Halifax Regional Municipality (OR, 4.64; 95% CI, 1.42–15.10). Among the 60 referred PODs who did not donate, family refusal of consent was the most common reason (28 [46.7%] of 60).

CONCLUSION: Younger age, greater severity of injury, and shorter time to tertiary care were associated with OD in trauma patients. (*J Trauma Acute Care Surg.* 2020;88: 128–133.

LEVEL OF EVIDENCE: Prognostic and Epidemiological, Level III.

KEY WORDS: Organ; donation; predictors; trauma.

Organ transplantation is the only therapeutic option for patients with end-stage organ failure. Unfortunately, the demand for solid organs continues to far outweigh the available supply. According to Canadian Blood Services and the Canadian Institute for Health Information, the organ donation (OD) and transplantation system in Canada is underperforming.[1] Even though OD increased by 29% in Canada between 2006 and 2015, these rates are still well below leading countries, such as Spain, Croatia, and the United States.[2] There are opportunities to improve donation rates from the trauma population as these patients represent a significant pool of potential organ donors (PODs).[3,4] Our group performed a meta-analysis of OD in trauma victims and estimated a pooled donor conversion rate of 48.1% in these patients.[5]

Organ donation is dependent on a multitude of factors. Patient-level factors include age and medical suitability.[1] Obtaining consent from the patient's family is associated with their culture and ethnicity, the amount of time between brain death and approaching the family for consent, having a trained person approach the family, and the amount of time the coordinator spends with the family.[6] Other factors are related to the institution (e.g., attitudes of health care professionals toward OD, trauma center designation, presence of an in-house OD coordinator, and availability of resources for organ procurement and transplantation).[7] Furthermore, there is variation in the clinical and legal definitions of brain death,[8] and in the policies regarding the donation process and obtaining consent.[9] Few studies have investigated factors associated with OD in Canada[1,10]; none of these studies were focused on the trauma population.

Similar to other provinces, there remains a deficit in organs available for transplantation in Nova Scotia, and strategies to improve OD practices in trauma patients are required. Previous work from our group has described the epidemiology of OD in Nova Scotia.[11] The objective of the present study was to assess factors associated with OD among trauma patients who died in a Nova Scotia hospital.

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METHODS

Study Design and Data Sources

We conducted a retrospective cohort study at the Queen Elizabeth II Health Sciences Centre (QEII HSC), an academic tertiary care center in Halifax, Nova Scotia. This Level I trauma center is the primary referral hospital for the province of Nova Scotia (population, 942,926). This study was performed in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for reporting observational studies.[12] Ethics approval for this study was obtained from the Nova Scotia Health Authority Research Ethics Board in Halifax, Nova Scotia, Canada.

Data for this study were accessed from the Nova Scotia Trauma Registry (NSTR) and linked with data from the Nova Scotia Legacy of Life Donor Registry (LLDR). The NSTR is a population-based registry under the Nova Scotia Department of Health & Wellness that collects detailed information on all major traumas in Nova Scotia, as well as some traumas from other Maritime provinces (Newfoundland, New Brunswick, Prince Edward Island). Criteria for inclusion in the NSTR are any traumas with an Injury Severity Score (ISS) greater than 12 and an appropriate International Classification of Disease External Cause of Injury Code (ICD-10-CA). Penetrating injury cases with an ISS of 9 or greater are also included in the NSTR, as well as any trauma team activation (TTA) regardless of ISS, and any injuries resulting in death at the scene or in the emergency department (ED). The LLDR contains information on PODs from across the province who were transferred to the QEII HSC, as well as information on PODs who were not referred to the Legacy of Life Program.

Eligibility Criteria and Data Collection

We included all trauma patients in the NSTR who died in-hospital, as well as all PODs in the LLDR who were trauma patients. The study period was April 1, 2009, to March 31, 2016. From the NSTR, we collected injury date, patient age, sex, postal code, injury type (blunt, penetrating, burn, drowning/asphyxia), injury location (within the Halifax Regional Municipality [HRM], outside HRM), ISS, Abbreviated Injury Scale (AIS) head score, Glasgow Coma Scale (GCS) score at the scene, number of intermediate facilities, transport mode to final institution (land, air [helicopter, fixed-wing aircraft], combination of land and air, private vehicle, walk-in), time to final institution (time from injury to arrival at final institution, including time spent at any intermediate facilities), TTA, and any patient comorbidities. With respect to data on injury severity, the NSTR used both AIS'90 coding (April 1, 2009 to March 31, 2015) and AIS'05 coding (April 1, 2011 to March 31, 2016) during the study period; thus, it was not possible to collect ISS and AIS head scores between 2009 and 2016 using solely AIS'90 or AIS'05. For the purpose of this study, we collected ISS and AIS Head scores based on AIS'90 coding since it was available for a greater number of patients during the study period (85.5% vs. 73.6%). Data collected from the LLDR included diagnosis, whether the patient had indicated their intent to become an organ donor by signing their Medical Services Insurance (MSI) health card, eligibility for OD (either for donation after neurological death [NDD] or donation after cardiac death [DCD]), number of actual donors (NDD, DCD), types of organs procured, and reasons for nondonation. Any patients with missing variables were reported in the results.

Study Definitions

For patients in the NSTR, we based our definition of a POD on the recommendations of the Deceased Donor Data Working Group.[13] A POD was defined as a trauma patient who received mechanical ventilation, died in hospital, and had an appropriate ICD-10-CA injury code (Supplemental Digital Content, Document, http://links.lww.com/TA/B478). A potential donor in the LLDR was defined as a patient with the following: (1) grave prognosis of GCS ≤ 5 T, (2) injured brain or nonrecoverable injury or illness, (3) intubated and mechanical ventilated, and (4) end-of-life discussion held with family and decision made to withdraw life sustaining therapy.[14] A missed referral was a potential donor who met all four criteria but who was not referred to the Legacy of Life Program. An eligible donor was a POD referred to the Legacy of Life Program from anywhere in Nova Scotia who was deemed medically suitable and whose family was willing to proceed with donation.

A patient was declared NDD if they suffered brain death, with two physicians making the determination of brain death based on a standardized list of neurological criteria and testing. A patient was eligible for DCD if they suffered a fatal injury or illness but did not meet formal brain death criteria; for these patients, cardiorespiratory support was withdrawn and a declaration of death occurred when circulation ceased. The eligibility criteria for DCD are much more restrictive than NDD (e.g., lower age threshold, death must occur at the QEII HSC). An actual donor was a deceased donor who donated at least one solid organ for the purpose of transplantation. The conversion rate was defined as the percentage of eligible donors who became actual donors (based on eligible donors in the LLDR), and the consent rate was the number of PODs with family consent obtained divided by PODs approached for consent.

Data Analysis

To characterize the study population, we used descriptive statistics including means, standard deviations, and proportions. In keeping with the privacy policy of the Nova Scotia Department of Health and Wellness, any counts less than 5 are suppressed and reported as "n < 5". We grouped trauma patients as "donors" and "nondonors," and we compared characteristics between these groups using Student's t test and χ^2 analysis as appropriate. A multiple logistic regression model was created to assess for factors associated with OD. The following independent variables were included in the model: age (continuous), sex (male, female), residence (urban, rural), injury type (blunt, drowning/asphyxia), injury location (within HRM, outside HRM), GCS at the scene (continuous), transport mode (land, air, land/air), number of intermediate facilities (0, 1, ≥2), TTA (yes, no), presence of any comorbidities (yes, no), day of the week (weekday, weekend), and season of the year (fall, winter, spring, summer). All analyses were performed using IBM SPSS Statistics Version 24 (Armonk, NY: IBM Corp).[15] Crude (i.e., unadjusted) and adjusted odds ratios (ORs) with 95% confidence intervals (CIs) are reported for the measurement of effect

size. The Hosmer-Lemeshow goodness-of-fit test was used to evaluate the appropriateness of the regression model.

RESULTS

Overall, there were 6,781 patients with major traumatic injuries during the study period. Of these, 689 died in hospital and were included in the analysis. Figure 1 shows the number of potential, eligible, and actual donors in the study cohort, including reasons for nondonation. There were 274 patients who met the NSTR criteria for a POD, of whom 78.1% (214 of 274) died at the QEII HSC and 39.4% (108 of 274) were referred to the Legacy of Life Program. The remaining 166 PODs were not referred for OD; 53% (88/166) of these patients died in the ED at the QEII HSC.

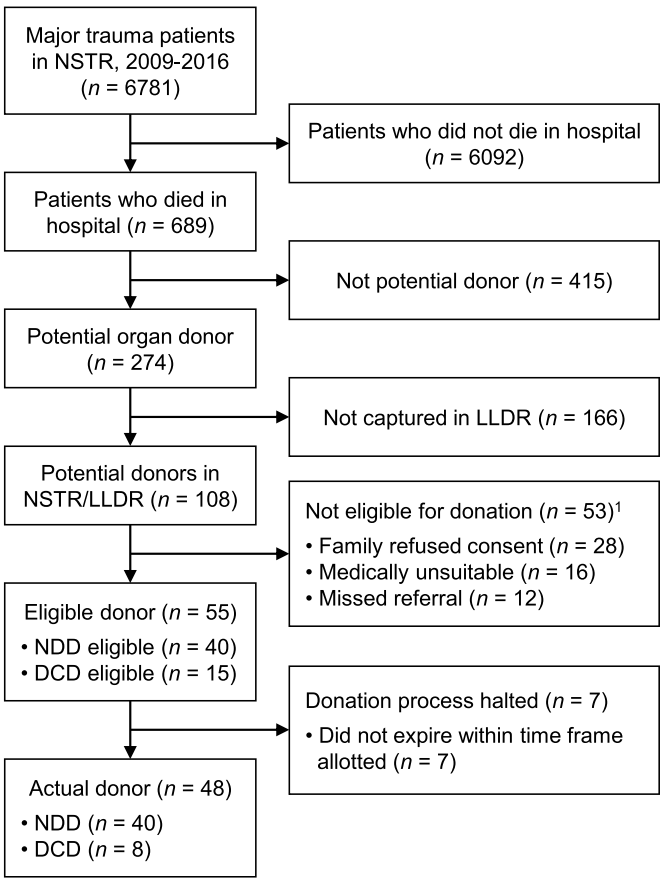

Figure 1. Flowchart of trauma victims who donated organs in Nova Scotia, 2009–2016. OPO, organ procurement organization. A potential donor in the NSTR was defined as a trauma patient who died in hospital, had an appropriate ICD-10-CA injury code (see supplementary material), and received mechanical ventilation during their hospital stay. The LLDR definition of a POD is a patient who meets the following four criteria: (1) grave prognosis of GCS ≤ 5 T, (2) injured brain or nonrecoverable injury or illness, (3) patient is intubated and ventilator-dependent, and (4) end of life discussion has been held with family and decision made to withdraw life sustaining therapy.[1] Three patients were ineligible for more than one reason.

A total of 55 patients were eligible donors (i.e., medically eligible and consent obtained) of which 48 went on to become actual organ donors. Table 1 compares the characteristics of PODs who did or did not donate organs. Compared with nondonors, organ donors were significantly younger, had a higher head AIS and a lower scene GCS, were more likely to have suffered ischemia from drowning/asphyxia and to be transported by air, and were less likely to have comorbidities. There was no significant correlation with sex, injury location, residence, time of injury, ISS, time to final destination at the QEII HSC, TTA, day of the week or season of the year. Regression analysis showed the likelihood of OD decreased as patient age increased (OR, 0.97; 95% CI, 0.95–0.99). Trauma patients injured within HRM were over four times more likely to become donors compared to those injured outside HRM (OR, 4.64; 95% CI, 1.42–15.10). Organ donors were more likely to have a lower scene GCS score (OR, 0.76; 95% CI, 0.66–0.88). In addition, the odds of OD were over six times higher in trauma patients who were transported by a combination of land and air ambulance (OR, 6.11; 95% CI, 1.09–34.15) and over eight times higher in patients transported by air alone (OR, 8.27; 95% CI, 2.07–33.08) compared with patients transported by land ambulance. Organ donation was not associated with sex, residence, injury type, intermediate facilities, prehospital time, TTA, comorbidities, day of the week or season of the year. The results of the Hosmer-Lemeshow test indicated a good fit for the model ($p = 0.88$).

Among the 108 PODs referred to the Legacy of Life Program, the most common diagnoses were traumatic brain injury (54/108; 50%) and anoxic brain injury (23 [21.3%] of 108). Of the 55 patients who were eligible for donation, 40 were NDD eligible and all went on to donate, while 15 were DCD eligible and 8 became donors. The remaining seven DCD eligible donors did not expire within the allotted 2-hour period following withdrawal of life support. Table 2 compares the characteristics of eligible donors who did or did not become actual organ donors; no differences in characteristics were observed between these two groups. A total of 203 organs were procured from the 48 donors (4.2 organs/donor). Procurement was greater in NDD (187 organs total; 4.7 organs/donor) than DCD (16 organs total, 2.0 organs/donor). Kidney and liver were the organ types procured most frequently. The consent rate was 68.7% (57 of 83) and the conversion rate was 84.2% (48 of 57). In 35.2% (38 of 108) of these cases, the patient had provided their intent to become a donor by signing their MSI card; 57.9% (22 of 38) of these willing donors became actual donors.

Among the 60 potential donors who did not donate, family members refused to consent in 46.7% (28 of 60) of these cases. The most frequent reasons for family refusal of consent were not wanting to wait for the donation process (11 [39.3%] of 28) and expressing family belief against OD (8 [28.6%] of 28). A further 26.7% (16 of 60) of nondonors were found to be medically unsuitable (i.e., unable to donate due to medical contraindication, including cancer, multisystem organ failure, advanced age (age limit for DCD was <55 years prior to June 2010 and <65 years after June 2010), human immunodeficiency virus, untreated/uncontrolled infection, or being medically unstable). Seven potential donors did not pass away within the time frame allotted (i.e., within 2 hours following withdrawal of life support). There were 12 missed referrals during the study period.

TABLE 1. Characteristics of Trauma Patients Who Were PODs

Characteristics	Organ Donors (n = 48)	Nondonors (n = 226)	*p*
Age, mean ± SD	39.8 ± 20.5	58.4 ± 23.3	<0.001
Male, n (%)	34 (70.8)	161 (71.2)	0.96
Residence, n (%)			0.52
Urban	35 (72.9)	151 (66.8)	
Rural	13 (27.1)	71 (31.4)	
Missing	0 (0)	n < 5	
Injury type, n (%)			0.007
Blunt	36 (75.0)	203 (89.8)	
Drowning/asphyxia	10 (20.8)	15 (6.6)	
Missing	n < 5	8 (3.5)	
Injury location, *n* (%)			0.83
Inside HRM	17 (35.4)	76 (33.6)	
Outside HRM	28 (58.3)	130 (57.5)	
Missing	n < 5	20 (8.8)	
ISS, mean ± SD	29.1 ± 12.5	28.4 ± 12.0	0.72
AIS Head, mean ± SD	4.8 ± 0.4	4.5 ± 0.8	0.006
Scene GCS, mean ± SD	4.2 ± 2.7	7.6 ± 4.8	<0.001
Transport mode, *n* (%)			0.005
Land ambulance	24 (50.0)	168 (82.5)	
Air*	18 (38.0)	36 (7.5)	
Both land and air	6 (12.0)	17 (4.4)	
Private vehicle or walk in	0 (0)	n < 5	
Missing	0 (0)	n < 5	
Time to final institution in hours, mean ± SD	4.8 ± 6.6	3.8 ± 4.9	0.21
TTA, n (%)	23 (47.9)	88 (38.9)	0.25
Day of the week, n (%)			0.80
Monday to Friday	30 (62.5)	149 (65.9)	
Saturday to Sunday	18 (37.5)	76 (33.6)	
Missing	0 (0)	n < 5	
Season of the year, n (%)			0.89
Spring/Summer	26 (54.2)	124 (54.9)	
Fall/Winter	22 (45.8)	101 (44.7)	
Missing	0 (0)	n < 5	
Comorbidities, n (%)			<0.001
Cardiac/vascular	5 (10.4)	98 (43.4)	
Neurological	12 (25.0)	38 (16.8)	
Neoplastic	0 (0)	17 (7.5)	
Renal	0 (0)	21 (9.3)	
Gastrointestinal	0 (0)	9 (4.0)	
Infectious disease	0 (0)	17 (7.5)	
Other	22 (45.8)	86 (38.1)	

*Includes helicopter and fixed-wing aircraft.

There were 16 nondonors who had indicated their consent to become an organ donor by signing their MSI card. The most common reasons for nondonation among these 16 willing patients were missed referral (7/16; 43.7%) and refusal of consent by their family (5/16; 31.2%).

DISCUSSION

This is the first Canadian study to examine factors that influence OD specifically in the trauma population. We found that the likelihood of being an organ donor was higher among trauma patients who were younger, injured within HRM, had a lower GCS, and who were transported by air ambulance. Importantly, we identified 166 PODs in the NSTR who were not referred to the Legacy of Life Program. The results of our study indicate that there are opportunities for improvement in OD rates and that the trauma population may be an underutilized source of donors.

In the United States, trauma patients represent approximately 30% of deceased organ donors,[16] and research suggests there are opportunities to increase conversion rates among these patients including the availability of OD coordinators,[17] improving rates of OD after circulatory death,[4] and raising awareness among rescue teams that patients with out-of-hospital traumatic cardiac arrest should be considered PODs.[18] Other research has also demonstrated that trauma centers have a higher percentage of eligible donors and higher numbers of organs transplanted per donor compared with nontrauma centers.[7] As in previous reports,[3,6,10] we found that family refusal of consent was the most common reason for nondonation in trauma patients. The QEII HSC is a teaching hospital, and there is evidence that consent rates are higher in academic hospitals compared with nonacademic hospitals.[19] Although family members are more likely to consent if the patient expresses their wish to donate,[20] we observed that family refusal was the most common reason for

TABLE 2. Comparison of Characteristics Among Eligible Donors Who Did or Did Not Donate Organs

Characteristics	Donors (n = 48)	Nondonors (n = 7)	p
Age, mean ± SD	39.8 ± 20.5	38.3 ± 18.4	0.86
Male sex, n (%)	34 (70.8)	6 (85.7)	0.66
Injury type, n (%)			0.26
Blunt	36 (75.0)	6 (85.7)	
Drowning/asphyxia	10 (20.8)	0 (0)	
Missing	n < 5	n < 5	
Injury location, n (%)			0.71
HRM	17	n < 5	
Outside HRM	28	5 (71)	
Missing	n < 5	0 (0)	
AIS head, mean ± SD	4.8 ± 0.4	5.0 ± 0.0	0.37
Scene GCS, mean ± SD	4.2 ± 2.7	4.7 ± 2.2	0.65
Transport mode, n (%)			0.55
Land ambulance	24 (50.0)	n < 5	
Air*	18 (38.0)	n < 5	
Both land and air	6 (12.0)	n < 5	
Private vehicle or walk in	0 (0)	0 (0)	
Comorbidities, n (%)			0.09
Cardiac/vascular	5 (10.4)	n < 5	
Neurological	12 (25.0)	0 (0)	
Neoplastic	0 (0)	0 (0)	
Renal	0 (0)	0 (0)	
Gastrointestinal	0 (0)	0 (0)	
Infectious disease	0 (0)	0 (0)	
Other	22 (45.8)	6 (85.7)	
Prehospital time,	291.1 ± 394.7	168.6 ± 149.0	0.42
TTA	23 (47.9)	5 (71.4)	0.24

*Includes helicopter and fixed-wing aircraft.

nondonation among eligible PODs who had expressed their intent to donate by signing their MSI card. Modifiable factors that impact consent rates include the approach and skill of the individual making the request, the setting in which the request is made, the specific timing of the request, the information discussed during the request, the perceived quality of care of the donor, and an understanding of brainstem death.[21]

An important finding of our study is that 61% of PODs identified in the NSTR were not referred to the Legacy of Life Program for donation. Unfortunately, there is no information available in the NSTR or other hospital sources on why these potential donors (n = 166) were not referred for OD. We do know that over half (53%) of these patients died in the ED at the QEII HSC. Since emergency physicians are tasked with the short-term goal of resuscitating patients and treating their life-threatening injuries, they often have little time in this high-paced environment to consider what happens if their efforts are unsuccessful. Logistic and ethical issues in the emergency setting can make it challenging for the ED to be an active part of the OD system.[22] Although several Canadian provinces have various types of systems in place with clinical triggers for mandatory referral, such a system does not exist in Nova Scotia. Health officials in Canada credit a 23% increase in overall donations over the past decade in part to the implementation of these mandatory referral systems, and there is ongoing review to determine which model is optimal.[2] There are also initiatives underway exploring advanced processes through which missed referrals are reportable and tracked similar to other serious medical errors.[2] In Nova Scotia, we have "required request" which is an expectation that health professionals are required to advise potential donors about OD. Establishing consistent clinical triggers for mandatory referral in all provinces could help to minimize the number of missed referrals and increase the national donation rate.

The OD model in Spain is widely regarded as the most successful one in practice, achieving 34 to 35 deceased organ donors per million population and having an 85% consent rate.[23] Spain does not have an opt-out registry, and the presumed consent legislation in Spain is in effect dormant. The success of the "Spanish Model" is likely attributable to the leadership of the critical care community in advocating for donation with the development of a positive social climate regarding OD, fostering trust in the donation system, and using trained requestors to approach the family. Spanish guidelines recommend that while the patient's physician should lead the end-of-life discussion with the family, the request for consent should be made by the transplant coordinator after first verifying the family understands that death is imminent.[24] Most of these transplant coordinators are intensive care consultants who coordinate OD part-time, and there is a national training program for these transplant coordinators which covers all aspects of the donation process including communication skills and approaching the family.[23] Developing a similar program at the national level in Canada may improve the performance of our OD and transplantation system.

As this study was a retrospective analysis of data collected from a population-based trauma registry and a provincial organ procurement organization, our findings cannot be used to imply causality. The results of our study may not be generalizable to other locations or facilities with different criteria for OD or definitions of major trauma. Some of the information in the NSTR and LLDR was unknown or incomplete. Of the 274 patients who met the NSTR criteria of a POD, only 108 patients were referred to the Legacy of Life Program; we did not have any information on why the remaining 166 PODs were not referred. Although we based the NSTR definition of a POD on recommendations from the Canadian Blood Services Deceased Donor Data Working Group,[13] the working group included ventilation within 24 hours of death as criteria for being a potential donor, yet the NSTR only contains data on whether ventilation was required at any time during hospital stay. Therefore, we may have overestimated the number of PODs in the NSTR. Furthermore, we were unable to assess for some factors reportedly associated with OD (e.g., income level, details regarding the consent discussion [experience level of requestor, setting and timing of the request, information discussed]) since these variables were not captured in the NSTR or LLDR.

CONCLUSION

In our population-based study, there was greater likelihood of donation in patients who were younger in age, had lower scene GCS scores, were injured within the transplant hospital area, and who were transported by air ambulance. We identified a high number of PODs who were not consulted for consideration of OD, as well as a high rate of family refusal among referred patients. Success in other programs (e.g., Spain, Croatia, Australia) demonstrates that further refinement of our OD practices is required to improve conversion rates and the overall number of donations in the province.

AUTHORSHIP

This study was conceived and designed by R.S.G., S. D. B., and M.E. Data acquisition was performed by A.H., S.L., and A.C. Data analysis was performed by M.E. All authors contributed to interpreting the data, drafting and critically revising the article. R.S.G. takes overall responsibility for the article.

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DISCLOSURE

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The authors declare no conflicts of interest.

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