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The association between rural or urban setting and outcomes in geriatric trauma patients in South Africa: a retrospective cohort study

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ABSTRACT

Introduction: This study compares outcomes between rural and urban geriatric trauma patients at a major trauma centre in South Africa.

Materials and Methods: This retrospective cohort study from a prospectively entered data set, reviewed all patients aged 65 years or above admitted between January 2013 to December 2020 to our trauma centre at Grey's Hospital, South Africa.

Results: Over the 8-year study period, a total of 323 patients aged ≥ 65 years were included (201 males (62%), mean age: 72 years. Mechanism of injury: 257 blunt (80%), 52 penetrating (16%) and 14 others (4%). The median Injury Severity Score (ISS) was 9. The median Charlson Comorbidity Index (CCI) for all 323 cases was 3. The median length of hospital stay was two days. The overall mortality was 12%. The crude odds ratio (OR) for death in rural vs urban patients was 2.51 (95% CI 1.27 – 4.94). After propensity score stratification for ISS, heart rate (HR), respiratory rate (RR), Glasgow Coma Scale (GCS) and temperature, and adjustment for mechanism, operation, Intensive Care Unit (ICU) and need for mechanical ventilation, the risk of death among the rural patients remained higher than in urban patients at 2.46 times (p=0.063), however, it was not statistically significant. Those who were operated on were significantly less likely to die after adjustment for confounding factors. Admission to ICU and the need for mechanical ventilation were significantly associated with mortality.

Conclusion: Rural geriatric trauma patients have worse outcomes than urban geriatric trauma even after adjustment for differences in demographic and injury profile.

Introduction

South Africa experiences a huge burden of trauma and in the three decades since the country's democratic transition, there has been little progress in reducing this burden [1]. There has been a sustained academic output describing this burden and analysing its various constituent parts. Despite this significant and laudable effort, there remain hidden epidemics within the larger pandemic of trauma. These include the impact of trauma on women [2], children [3], those with mental health issues [4], the aged [5] and those who do not live near major urban trauma centres [6–7]. Each of these subgroups experiences a major burden of trauma, which is exacerbated by their unique vulnerabilities. These vulnerable groups may also encounter a form of double jeopardy or cumulative harm when they belong to more than one vulnerable group [8–9].

The world is currently experiencing major demographic changes and there appears to be an emerging dichotomy between high-income countries with a rapidly aging populations and low and middle-income countries which are experiencing a massive population increase [10]. There is an accompanying relentless urbanisation as rural areas depopulate and urban areas expand. This urban expansion is often accompanied by a dramatic overwhelming of available resources [11].

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These social determinants of health all impact on outcomes in these various populations.

The literature has consistently demonstrated that rural trauma patients have higher mortality rates than their urban counterparts for a range of injuries [11–15]. There is a similar body of evidence showing that trauma outcomes in the aged, are also less than optimal. This is a result of comorbidities, reduced physiological reserve associated with aging and polypharmacy in these patients [16–17]. This study, set out to investigate whether belonging to more than one vulnerable category has a cumulative impact on outcome, by interrogating the impact of rurality as compared to urban status, on the outcome of trauma in the geriatric population in Kwa-Zulu Natal province, South Africa.

Materials and Methods

Clinical Setting

This was a retrospective cohort study undertaken at the Pietermaritzburg Metropolitan Trauma Service (PMTS), Pietermaritzburg, South Africa. The PMTS provides definitive trauma care to the city of Pietermaritzburg, the capital of KwaZulu-Natal (KZN) province. KwaZulu-Natal is located on the east coast of the country and has a population of over 11 million people. Fifty per cent of the population lives in rural areas. PMTS is the largest academic trauma centre in western KZN and is the tertiary trauma referral centre covering a total catchment population of over three million people. The catchment area is divided into two distinct health districts. The urban district (UD) includes the city of Pietermaritzburg and the surrounding suburban areas. The rural district (RD) includes all areas outside the geographical boundaries of the city of Pietermaritzburg. Each year, approximately 5000 trauma cases are admitted to the PMTS with over half of these due to penetrating trauma. The PMTS maintains a formal regional trauma registry, known as the Hybrid Electronic Medical Registry (HEMR). Ethics approval for this study and maintenance of the registry was obtained from the Biomedical Research Ethics Committee (BREC) of the University of Kwa Zulu Natal (reference: BE 207/09 and BE215/17).

The Study

All patients who were aged 65 years or above admitted to our trauma centres from January 2013 to December 2020 were included. The data captured included demographic details, injury mechanism, clinical progress and clinical outcome. Patients were stratified into two distinct groups, either from the urban district (UD) or rural district (RD). A comparison of outcomes, namely morbidity and mortality was made between those from UD and those from RD.

Statistical Analysis

Statistical analysis was completed using Stata MP 7 for Windows (StataCorp LLC, TX, USA). Normality of data was investigated using the Shapiro-Wilk test and by graphical inspection. Normally distributed continuous variables were compared using an independent, two-tailed t-test, whereas categorical data groups were compared using Chi-squared two-sided asymptotic significance or Fisher's exact test where appropriate. Non-normally distributed continuous variables were compared using Mann-Whitney U. Since this was a retrospective review of medical records, there were instances where data were missing, and assumed to be missing at random. Available data for each variable were analysed, and the total available sample size per group was reported in the tables for each variable. Propensity scores were generated using the method of Rosenbaum and Rubin [18] based on ISS, HR, RR, GCS and temperature. These variables were used to generate the propensity scores since they were highly associated with both the exposure of interest (Rural or Urban) and the outcome of mortality. Odds ratios and 95% confidence intervals were estimated using crude and adjusted binary logistic regression analysis. The adjusted model used propensity scores in 5 strata, as well as other independent variables chosen on the basis of their clinical association with mortality. The final model did not exclude any non-statistically significant predictors. A p-value of <0.05 was regarded as statistically significant. The sample size of 323 was used as the total number of patients who presented during the eight-year period and met the inclusion criteria for the study.

Results

Overview

Over the eight-year study period, a total of 323 patients aged $\geq$ 65 years were admitted to our trauma centre. There were 201 males (62%) and the mean age was 72 years (range 65 – 97). Of the 323 cases in the study, 68% (219) were from urban areas and the remaining 32% (104) were from rural areas. Table 1A and 1B show demographic and baseline characteristics including comorbidities of the two groups. There was little difference between the groups, apart from Injury Severity Score (ISS) which was significantly higher in the rural patients ($p<0.001$). There was no significant difference in comorbidities between urban or rural patients. There were 257 cases of blunt trauma (80%), 52 cases of penetrating trauma (16%) and 14 cases of other types of injury (4%), summarised in Table 2. The median ISS was 9. The body regions injured were summarised in Table 2. The median Charlson Comorbidity Index (CCI) for all 323 cases was 3. A total of 76 patients (24%) required surgical intervention and 27 (8%) patients experienced one or more complications during their stay. Forty-five patients (14%) were admitted to Intensive Care Unit (ICU) and 81 patients required mechanical ventilation during their admission (25%). The median length of hospital stay was two days. The overall mortality was 12%.

Mechanism of injury and Body Region Injured

The body region injured, and mechanism of injury are summarized and compared by area in Table 2. There was a significant difference in the mechanism of injury with penetrating injuries being more common in the rural cohort and blunt injuries more frequent in the urban group ($p=0.006$). Body regions injured did not differ significantly different the two cohorts.

Clinical Outcomes

Rural patients were more likely to require operative intervention ($p=0.001$), however, among those who were operated on, the complication rate was the same. Rural patients were more likely to require ICU ($p=0.042$), had a longer hospital stay on average ($p<0.001$), and had higher mortality ($p=0.007$) than urban patients. These were summarised in Table 3. The crude odds ratio (OR) for death in rural vs urban was 2.51 (95% CI 1.27 – 4.94). After propensity score stratification and adjustment for other confounding variables in the model, the risk of death among the rural patients remained higher than in urban patients at 2.46 times, although it was not statistically significant ($p=0.063$). There was no difference between the risk of death for the blunt or penetrating mechanism of injury, however, those with other mechanisms of injury were significantly more likely to die after accounting for confounding factors ($OR=11.92$, $p=0.022$) although the confidence intervals were wide. Those who were operated on were significantly less likely to die after adjustment for confounding variables (OR 0.24, $p=0.027$). ICU admission and the need for mechanical were significant risk factors for mortality. These were summarised in Table 4.

Discussion

There is an increased awareness of how external factors impact surgical outcomes. The term *social determinants of health*, which is taken

Table 1
A: Comparison of Demographics and Baseline Characteristics of Geriatric Trauma Cases between UD and RD.

	Urban or Rural Area						p-value
	Urban (n=219, 68%)		Rural (n=104, 32%)		Total (n=323, 100%)		
Age in years (mean, standard deviation) n=219, 104	72.4	7.0	71.8	6.8	72.2	6.9	0.482
Sex: female (n, %)	84	38.4	38	36.5	122	37.8	0.753
Male (n, %)	135	61.6	66	63.5	201	62.2	
Total (n)	219	100	104	100	323	100	
Heart Rate bpm (mean, standard deviation) n=217, 103	85	18.1	88	16.6	86	17.7	0.067
Systolic blood pressure mmHg (mean, standard deviation) n=215, 104	141	27.91	139	28.86	140	28.19	0.451
Shock Index (mean, standard deviation) n=215. 104	0.63	0.17	0.65	0.19	0.63	0.18	0.106
Respiratory rate breaths/minute (mean, standard deviation) n=202, 99	18	3.98	18	4.39	18	4.12	0.665
GCS (mean, standard deviation) 216, 102	13	3.18	13	3.36	13	3.24	0.578
Temperature°C (mean, standard deviation) n=211, 100	36.2	.79	36.4	.89	36.3	0.83	0.068
pH (mean, standard deviation) n=150, 70	7.39	.10	7.41	.09	7.40	0.09	0.132
Lactate mmol/L (mean, standard deviation) n=131, 67	3.08	4.07	4.07	7.41	3.42	5.43	0.416
Haemoglobin g/dL (mean, standard deviation) n=168, 86	12.11	2.31	11.55	2.81	11.92	2.50	0.165
ISS (mean, standard deviation) n=219, 104	8	7.10	13	11.38	10	8.99	<0.001
Table 1 B							
Comorbidities (total n)	200		91		291		
Myocardial Infarction (n, %)	12	6.0	3	3.3	15	5.2	0.334
Congestive heart failure	0		0		0		
Peripheral vascular disease	1	0.5	0	0.0	1	0.3	1
CVA/TIA	12	6.0	4	4.4	16	5.5	0.578
Dementia	11	5.5	1	1.1	12	4.1	0.112
COPD	19	9.5	4	4.4	23	7.9	0.135
Connective tissue disease	1	0.5	0	0.0	1	0.3	1
Peptic Ulcer Disease	2	1.0	1	1.1	3	1.0	1
Liver disease	1	0.5	0	0.0	1	0.3	1
Diabetes	39	19.5	14	15.4	53	18.2	0.536
Hemiplegia	7	3.5	1	1.1	8	2.7	0.442
CKD	5	2.5	1	1.1	6	2.1	0.669
Solid Tumour	7	3.5	3	3.3	10	3.4	0.789
Leukaemia	1	0.5	0	0.0	1	0.3	1
Lymphoma	0		0		0		
AIDS	7	3.5	8	8.8	15	5.2	0.058
Hypertension	97	48.5	47	52.2	144	49.7	0.558

bpm = beats per minute; GCS = Glasgow Coma Score; ISS = Injury Severity Score; CVA/TIA = cerebrovascular accident/transient ischaemic attack; COPD = chronic obstructive pulmonary disease; CKD = chronic kidney disease; AIDS = acquired immunodeficiency syndrome.

Table 2
Comparison of injury mechanism and body region injured between UD and RD.

		Urban or Rural Area						p-value
		Urban (n=219, 68%)		Rural (n=104, 32%)		Total (n=323, 100%)		
		n	%	n	%	n	%	
Mechanism	Penetrating	26	11.9%	26	25.0%	52	16.1%	0.006
	Blunt	185	84.5%	72	69.2%	257	79.6%	
	Other	8	3.7%	6	5.8%	14	4.3%	
	Total	219	100.0%	104	100.0%	323	100.0%	
Head		139	63.5%	56	53.8%	195	60.4%	0.098
Face		39	17.8%	22	21.2%	61	18.9%	0.473
Neck		29	13.2%	15	14.4%	44	13.6%	0.772
Thorax		53	24.2%	29	27.9%	82	25.4%	0.477
Abdomen		28	12.8%	22	21.2%	50	15.5%	0.052
Pelvis		11	5.1%	12	11.5%	23	7.1%	0.054
Urogenital		5	2.3%	3	2.9%	8	2.5%	0.745
Upper limb		39	17.8%	14	13.5%	53	16.4%	0.324
Lower Limb		48	29.1	28	26.9	76	23.5	0.322

directly from the public health literature, which refers to issues around the interaction between wealth and health, might be too narrow. There are numerous barriers to accessing healthcare, and within health systems themselves. These may exist as inefficiencies which contribute to less-than-optimal health outcomes. The term *intersectionality* is often used to describe how multiple factors have a cumulative impact on individuals who experience sub-optimal outcomes [8–9].

The result shown in our study is a good example of this cumulative or intersectional effect, on health outcomes in a group of patients with multiple vulnerabilities. Geriatric trauma is challenging to manage and resource-intensive and must be seen as a significant vulnerability. The combination of increased frailty, comorbidities and decreased physical reserve all place older patients at particular risk of poor outcomes [16–17]. This has been shown in previous work from our institution. The mortality rate for geriatric trauma in our setting is three times higher than that of younger patients [5]. We have also demonstrated that outcomes for several acute surgical and traumatic conditions, may vary, depending on whether the patient resides in an urban or a rural area. These conditions include acute appendicitis [13], gunshot wounds to the head [6] and injuries sustained during motor vehicle hijackings [7]. This is not unique to South Africa. In a study from over a quarter of a century ago, it was found that the overall crude mortality rate for patients in

Table 3
Comparison of operative intervention and clinical outcomes between Urban and Rural.

			Urban or Rural						p-value
			urban		rural		Total		
			n	%	n	%	n	%	
Operation		Not operated	179	81.7%	68	65.4%	247	76.5%	0.001
		Operated	40	18.3%	36	34.6%	76	23.5%	
		Total	219	100.0%	104	100.0%	323	100.0%	
Any Complication (among those operated)		No	27	67.5%	22	61.1%	49	64.5%	0.882
		Yes	13	32.5%	14	38.9%	27	35.5%	
		Total	40	100.0%	36	100.0%	76	100.0%	
Clavien Dindo (among those who were operated)		0	27	67.5%	22	61.1%	49	64.5%	0.138 (Fisher's exact 2-sided test)
		1	0	0.0%	1	2.8%	1	1.3%	
		2	6	15%	1	2.8%	7	9.2%	
		3	1	2.5%	1	2.8%	2	2.6%	
		4	1	2.5%	8	22.2%	9	11.8%	
		5	5	12.5%	3	8.3%	8	10.5%	
		total	40	100.0%	36	100.0%	76	100.0%	
ICU	No		191	88.4%	79	79.8%	270	85.7%	0.042
	Yes		25	11.6%	20	20.2%	45	14.3%	
	Total		216	100.0%	99	100.0%	315	100.0%	
Ventilation	No		169	79.3%	61	62.2%	230	74.0%	0.001
	Yes		44	20.7%	37	37.8%	81	26.0%	
	Total		213	100.0%	98	100.0%	311	100.0%	
Total stay (days) median, IQR (n=207, 100)			1	1-3	3	1-8	2	1-4	<0.001
mortality	survived		200	91.3%	84	80.8%	284	87.9%	0.007
	died		19	8.7%	20	19.2%	39	12.1%	
	Total		219	100.0%	104	100.0%	323	100.0%	

Table 4
Crude and adjusted effects of risk factors for mortality in geriatric trauma patients from KZN.

Exposure	level	Crude			Adjusted (n=279)		
		OR	95% CI	p-value	OR	95% CI	p-value
Area (n=323)	Urban	-	-	-	-	-	-
	Rural	2.506	1.273- 4.935	0.008	2.457	0.956 – 6.337	0.063
Mechanism (n=323)	Penetrating	-	-	-	-		
	Blunt	0.619	0.263 – 1.458	0.272	2.642	0.522 – 13.360	0.240
	Other	3.056	0.810 – 11.526	0.099	11.920	1.424 – 99.724	0.022
Operation (n=316)	No	-	-	-	-	-	-
	yes	2.213	1.094 – 4.479	0.027	0.235	0.065 – 0.848	0.027
ICU (n=315)	No	-	-	-	-	-	-
	Yes	7.589	3.566 – 16.153	<0.001	3.330	1.052 – 10.543	0.041
Ventilation (n=311)	No	-	-	-	-	-	-
	Yes	7.895	3.639 – 17.130	<0.001	5.784	2.066 – 16.195	0.001
Age (n=323)	years	0.987	0.928 – 1.031	0.407	1.016	0.951 – 1.084	0.639
Sex (n=323)	Male	1.633	0.782 – 3.413	0.192	1.057	0.399 – 2.797	0.911
	Female	-	-	-	-		
HR (n=320)	(beats per minute)	1.028	1.008 – 1.048	0.006	Used in propensity scoring and stratification		
SBP (n=319)	(mmHg)	0.991	0.978 – 1.003	0.141			
RR (n=301)	(breaths per minute)	1.209	1.114 – 1.311	<0.001			
GCS (n=318)	(score)	0.765	0.703 – 0.833	<0.001			
Temp (n=311)	(°C)	0.582	0.392 – 0.864	0.007			

OR = odds ratio
CI = confidence interval
- = reference category

rural settings in North America was three times that of urban areas [14]. A more recent study from Ontario showed that in those rural patients who survived long enough to reach the hospital, there was a three-fold increase in mortality among those injured in a region with limited access to specialist trauma care [15]. North America has seen significant changes in terms of the development of rural and urban trauma systems over the last three decades. Despite this, it appears that these discrepant outcomes persist. More recent overviews of geriatric trauma have identified several independent risk factors for poor outcomes [15–17]. These include gender, type of injury, the presence of co-morbidities, polypharmacy and the use of anticoagulants. Very few of these reviews have considered rurality as an independent factor. South Africa has been developing its trauma systems over the last three decades. We have now shown a discrepancy in outcomes for geriatric trauma patients as compared to their urban counterparts. Rural geriatric trauma patients have a significantly higher mortality rate, as well as longer lengths of stay, and higher rates of ICU admission than their urban counterparts. This difference persists even when accounting for differences in mechanism between the two groups.

There are several potential explanations for this discrepancy in outcome. Trauma patients should be taken directly to an institution capable of delivering the appropriate surgical care. This has been shown by the development of level one trauma centres in the United States and around the world [19]. Trauma care is the antithesis of the graded primary health care approach [20]. The primary health care approach makes patients follow a system of increasing complexity, from local clinic to district hospital, to regional and tertiary institution. This is not appropriate in trauma care. The ideal in trauma care is for the most

severely injured patient to be transported directly to the well-resourced tertiary institution which can resuscitate and investigate the patient and proceed to treat all injuries definitively. Delay to definitive care in trauma is associated with worse outcomes [19,21]. This is almost certainly the explanation for the observation that grade for grade rural geriatric trauma patients have worse outcomes than their urban counterparts. South Africa has made considerable progress in developing urban trauma systems over the last two decades. There needs to be a focus now on trying to improve rural trauma care in South Africa.

This paper has several limitations. The use of retrospective analysis is always associated with issues around missing data sets. In this paper, the missing data sets were dealt with as described in the methods section. The HEMR is however extensively quality-controlled and has been validated in numerous publications over the last decade. Further work and study are required to confirm the conclusions of this project.

Conclusion

Rural geriatric trauma patients have worse outcomes than urban geriatric trauma patients. This is an example of the intersectionality of vulnerabilities negatively influencing health care outcomes. Ongoing strengthening of urban and rural trauma systems in South Africa is required. More detailed analysis is needed to better understand the potential relationship between rurality and poor outcome, which this study has identified.

CRediT authorship contribution statement

Bogo Lee: Data collection and analysis, literature review, manuscript drafting/proofreading. **Victor Kong**: Concept, manuscript drafting/proofreading. **Cynthia Cheung**: Data management and capture. **Nigel Rajaretnam**: Data analysis. **John Bruce**: Data management and capture. **Vassil Manchev**: Data management and capture. **Robert Mills**: Data management and capture. **Damian Clarke**: Senior author, manuscript drafting/overseeing.

Ethics approval

Ethics approval for this study and maintenance of the registry was obtained from the Biomedical Research Ethics Committee (BREC) of the University of Kwa Zulu Natal (reference: BE 207/09 and BE215/17).

Clinical trial registration

Not applicable.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] Hardcastle T, Oosthuizen G, Clarke DL, Lutge E. Chapter 15: Trauma a preventable burden of disease in South Africa: review of the evidence with a focus on KwaZuluNatal. SAHR; 2016. p. 179–89.
[2] Zsilavecz A, Wain H, Bruce JL, Smith MTD, Bekker W, Laing GL, Lutge E, Clarke DL. Trauma patterns during the COVID-19 lockdown in South Africa expose vulnerability of women. S Afr Med J 2020;110(11):1110–2. https://doi.org/10.7196/SAMJ.2020.v110i11.15124. PMID: 33403988.
[3] Khumalo-Mugabi L, Moffatt S, Bekker W, Smith M, Bruce JL, Laing G, Manchev V, Kong V, Clarke DL. Penetrating trauma in children and adolescents in Pietermaritzburg. S Afr J Surg 2020;58(1):33–6. PMID: 32243113.
[4] Wyatt GE, Thames A, Simbayi L, Stein DJ, Burns J, Maselesele M. Trauma and mental health in South Africa: Overview. Psychol Trauma 2017;9(3):249–51. https://doi.org/10.1037/tra0000144. PMID: 28459266; PMCID: PMC5492952.
[5] Da Costa JP, Laing J, Kong VY, Bruce JL, Laing GL, Clarke DL. A review of geriatric injuries at a major trauma centre in South Africa. S Afr Med J 2019;110(1):44–8. https://doi.org/10.7196/SAMJ.2019.v110i1.14100. PMID: 31865942.
[6] Kong VY, Bruce JL, Sartorius B, Laing GL, Odendaal J, Brysiewicz P, Clarke DL. Civilian cerebral gunshot wounds in rural South African patients are associated with significantly higher mortality rates than in urban patients. Eur J Trauma Emerg Surg 2019;45(1):145–50. https://doi.org/10.1007/s00068-017-0800-z. Epub 2017 Jun 13. PMID: 28612168.
[7] Kong VY, Blodgett JM, Weale R, Bruce JL, Laing GL, Smith M, Bekker W, Clarke DL. Discrepancy in clinical outcomes of patients with gunshot wounds in car hijacking: a South African experience. S Afr J Surg 2019;57(4):25–8. PMID: 31773928.
[8] Northwood M, Ploeg J, Markle-Reid M, Sherifali D. Integrative review of the social determinants of health in older adults with multimorbidity. J Adv Nurs 2018;74(1):45–60. https://doi.org/10.1111/jan.13408. Epub 2017 Oct 5. PMID: 28771854.
[9] Gkiouleka A, Huijts T, Beckfield J, Bambra C. Understanding the micro and macro politics of health: Inequalities, intersectionality & institutions - A research agenda. Soc Sci Med 2018;200:92–8. https://doi.org/10.1016/j.socscimed.2018.01.025. PMID: 29421476.
[10] United Nations. World Population Prospects (2019): Highlights. Department of Economic and Social Affairs, Population Division. ST/ESA/SER.A/423.
[11] Alanazy ARM, Wark S, Fraser J, Nagle A. Factors Impacting Patient Outcomes Associated with Use of Emergency Medical Services Operating in Urban Versus Rural Areas: A Systematic Review. Int J Environ Res Public Health 2019;16(10):1728. https://doi.org/10.3390/ijerph16101728. PMID: 31100851; PMCID: PMC6572626.
[12] Hsia R, Shen YC. Possible geographical barriers to trauma center access for vulnerable patients in the United States: an analysis of urban and rural communities. Arch Surg 2011;146(1):46–52. https://doi.org/10.1001/archsurg.2010.299. PMID: 21242445; PMCID: PMC3121679.
[13] Hernandez MC, Finnesgaard E, Aho JM, Kong VY, Bruce JL, Polites SF, Laing GL, Clarke DL, Zielinski MD. Appendicitis: Rural Patient Status is Associated with Increased Duration of Prehospital Symptoms and Worse Outcomes in High- and Low-Middle-Income Countries. World J Surg 2018;42(6):1573–80. https://doi.org/10.1007/s00268-017-4344-5. PMID: 29134308.
[14] Esposito TJ, Maier RV, Rivara FP, Pilcher S, Griffith J, Lazear S, Hogan S. The impact of variation in trauma care times: urban versus rural. Prehosp Disaster Med 1995;10(3):161–6. https://doi.org/10.1017/s1049023x00041947. discussion 166-7 PMID: 10155424.
[15] Gomez D, Berube M, Xiong W, Ahmed N, Haas B, Schuurman N, Nathens AB. Identifying targets for potential interventions to reduce rural trauma deaths: a population-based analysis. J Trauma 2010;69(3):633–9. https://doi.org/10.1097/TA.0b013e3181b8ef81. PMID: 20016384.
[16] Hashmi A, Ibrahim-Zada I, Rhee P, Aziz H, Fain MJ, Friese RS, Joseph B. Predictors of mortality in geriatric trauma patients: a systematic review and meta-analysis. J Trauma Acute Care Surg 2014;76(3):894–901. https://doi.org/10.1097/TA.0b013e3182ab0763. PMID: 24553567.
[17] Braun BJ, Holstein J, Fritz T, Veith NT, Herath S, Mörsdorf P, Pohlemann T. Polytrauma in the elderly: a review. EFORT Open Rev 2017;1(5):146–51. https://doi.org/10.1302/2058-5241.1.160002. PMID: 28461941; PMCID: PMC5367536.
[18] Rosenbaum PR, Rubin DB. The central role of the propensity score in observational studies for causal effects. Biometrika 1983;70:41–55. https://doi.org/10.1093/biomet/70.1.41.
[19] Glance LG, Osler TM, Mukamel DB, Dick AW. Impact of trauma center designation on outcomes: is there a difference between Level I and Level II trauma centers? J Am Coll Surg 2012;215:372–8. https://doi.org/10.1016/j.jamcollsurg.2012.03.018. PMID: 22632909.
[20] Van Damme WI, Van Lerberghe WI, Boelaert M. Primary health care vs. emergency medical assistance: a conceptual framework. Health Policy Plan 2002;17(1):49–60. https://doi.org/10.1093/heapol/17.1.49. PMID: 11861586.
[21] Jarman MP, Castillo RC, Carlini AR, Kodadek LM, Haider AH. Rural risk: Geographic disparities in trauma mortality. Surgery 2016;160(6):1551–9. https://doi.org/10.1016/j.surg.2016.06.020. PMID: 27506860.