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ORIGINAL RESEARCH

Adolescent and Young Adult Injuries in Developing Economies: A Comparative Analysis from Oman and Kenya

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Abstract

BACKGROUND Adolescence is a distinct period of rapid and dramatic biological, cognitive, psychological, and social development. The burden of injuries among young people (aged 10-24) is both substantial and maldistributed across regions and levels of economic development.

OBJECTIVES Our objective was to compare sociodemographic correlates of injury cause, intentionality, and mortality between Kenya and Oman, 2 countries with different levels of economic development and position in the demographic and epidemiologic transitions.

METHODS Data on 566 patients in Oman and 5859 in Kenya between 10 and 24 years old were extracted from 2 separate multicenter trauma registries. Multivariable log binomial and Poisson regressions were used to evaluate social and demographic factors associated with injury cause, intentionality, and mortality. Literature on adolescent development was used to parameterize variables, and Akaike information criteria were used in the final model selections.

FINDINGS The trauma registry data indicated a substantial burden of adolescent and young adult injury in both Oman and Kenya, particularly among males. The data indicated significant differences between countries ($P < .001$) in age category, gender distributions, level of education, occupation, cause of injury, and place where injury occurred. Consistent with other literature, road traffic injuries emerged as the most common type of injury as well as the most severe and fatal, with interpersonal violence also resulting in severe injury across contexts. Both road traffic injuries and interpersonal violence were more common among older adolescents and young adults. Education and being in school were protective against injury, after controlling for gender, age category, occupation, and country.

CONCLUSIONS A rising burden of injuries among young people has been documented in every region of the world, irrespective on income status or level of development. Cost-effective injury control measures targeting this age group exist, including involvement in educational, vocational, and other prosocial activities; environmental alterations; and road safety measures.

KEY WORDS adolescent injuries; Africa; Kenya; LMIC; Oman; trauma registry.

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INTRODUCTION

Adolescence is a distinct phase of development through the life course, a period of rapid and dramatic biological, cognitive, psychological, and social development marking the transition between childhood and adulthood. As a transitional phase, its boundaries are not consistently defined across cultures or societies or through history.[1] The social and environmental contexts in which young people grow and develop are particularly complex as a result of adolescence being a transitional stage of life: Family of origin gives way to family of formation; peers assume an increasing influence; school contexts change and then give way to work environments; and legal contexts are fraught with tensions between protection and personal responsibility.[1] Adolescence is therefore a fluidly defined period characterized by the progressive adoption of adult roles, legal responsibility, autonomous decision making, and social and financial independence from one's family of origin.[1]

Injuries, including unintentional injuries, intentional violence, and intentional self-harm, are among the major causes of death among young people and contribute significantly to loss of disability-adjusted life years, particularly among older adolescents and young adults.[2,3] Road traffic injuries are the leading cause of death among adolescents worldwide, with intentional self-harm and interpersonal violence the third and fifth leading causes.[4] Cognitive and psychosocial development factors unique to young people contribute to this disease burden because adolescence is characterized by present bias, poor risk evaluation, and susceptibility to peer influence.[1] However, almost all deaths among young people—97%—occur in low- and middle-income countries (LMICs), with those deaths further unequally distributed across world regions.[2] This extreme maldistribution of morbidity and mortality among young people demands attention to the socioeconomic factors and the social determinants of health.

Africa and the Eastern Mediterranean have the first and third highest rates of mortality among young people, but profiles of disease burden differ greatly among regions and national contexts.[2] Kenya, a lower-middle income country in East Africa, is classified as a *multiburden country* in which disability-adjusted life years and deaths for young people are due not only to diseases of poverty, such as infectious disease, nutritional deficits, and maternal mortality, but also to noncommunicable diseases, such as mental disorders or substance abuse, as well as injuries.[1,5] The Sultanate of Oman, by contrast, is a high-income country in the Eastern Mediterranean classified as an *injury excess country*, with the greatest number of deaths caused by high levels of injury, and in which other sources of morbidity and mortality have decreased.[1,5] Injuries often affect young, economically productive individuals, leading not only to untimely death but also lifelong disability. Nonfatal injuries therefore can have consequences that extend beyond the individual, affecting entire families. In addition to medical costs, there may be loss of wages or productivity of the patient or of household members who have to change roles to care for the patient. For adolescents and young adults, injury and disability may impede continuing education.[6] Injuries may not only affect work and education but can be affected by them. Road traffic injury, intentional self-harm, and intentional violence are among the most common mechanisms of injury in this age group, but the nature and direction of associations between each of these types of injuries and sociodemographics are difficult to tease out.

In this study we compared the injury and trauma profiles among young people in Kenya and Oman to compare and contrast these 2 contexts. Although *adolescence* is often recognized as the period between 10-19 years old—the World Health Organization, for example, refers to the "second decade of life"—this paper will follow a more expansive definition for *young people* to include the period of young adulthood, up to age 24, to facilitate comparisons across contexts.[7,8]

METHODS

The data for this study were collected from 2 separate multicenter trauma registries in Kenya and Oman, details of which have been described elsewhere.[9] In Kenya, to ensure a diverse representation of the population, 3 major county hospitals and a tertiary hospital were selected to participate in trauma registry data collection (Table 1). Meru, Thika, and Machakos are all level 5 secondary county hospitals, whereas Kenyatta National Hospital is an academic and national referral hospital in the capital city, Nairobi. These hospitals serve both residents of the cities where they are located, as well as the populations of the surrounding towns and villages. Two regional hospitals in Oman participated in a pilot study of the implementation of an electronic trauma registry, enrolling participants between November 1, 2014, and April 30, 2015. Khoula Hospital, a tertiary care hospital in the Sultanate's coastal urban capital of Muscat, hosts the national trauma referral center, whereas Nizwa Hospital is a regional trauma referral center

located in the interior and rural region of Oman in the city of Nizwa.

This study included patients aged 10-24 years presenting to the emergency departments of participating hospitals after an injury. These patients were identified by triage nurses or clinical officers depending on the country and setting.[9] Verbal consent was obtained directly from all enrolled adult patients. For children and adults who were unable to give consent, consent was obtained from an adult family member or next of kin. Cases included all eligible patients regardless of sex, mechanism of injury, prehospital time (ie, duration from time of injury to first hospital), and transfer status. Dedicated research assistants collected the data in both Kenya and Oman. Research assistants received 3 days of formal training on electronic data collection, data abstraction from medical charts, injury coding, research ethics, patient confidentiality, and consent. Research assistants were supervised by a local task force and research program coordinators who were responsible for data consistency and accuracy.

Data were recorded in an injury registry using a standardized digital data collection tool, which was deployed on password-protected and encrypted Android tablets using Open Data Kit in the case of Oman and the use of Form Entry Version 2.4 software on password-protected iPads (Apple, Cupertino, CA) in Kenya.[10-12] Both the Kenya and Oman registries included variables detailing the patients' demographics; injury mechanism and intent; date, time, and location where injury occurred; prehospital assessment, care, and transport time to facility; initial assessment of patient's vital signs, level of pain, and injury severity score (ISS); anatomic and pathologic locations of injury; emergency department assessment, treatment, and disposition; in-hospital treatment; and final outcome.[13] The Oman registry additionally included information on abbreviated injury score and *International Statistical Classification of Diseases and Related Health Problems* injury codes. All enrolled patients were followed until discharge or death.

Submitted data were entered in Excel (Microsoft Corp., Redmond, WA), and statistical analysis was performed using Stata SE14.1 (StataCorp LLC, College Station, TX).[14] Descriptive statistics and tabulations were generated on sociodemographic characteristics and outcomes. Sociodemographics include gender, occupation, highest level of education, and age categorized according to developmental stage: early adolescence (10-14 years old), late adolescence (15-19 years old), and young adulthood (20-24 years old).[1] Student was considered an occupation exclusive of other occupations; in Kenya, patients who were younger than the legal working age were listed as being "student/child." Pearson's χ^2 test was used to assess the sample distribution among categories.

Simple log binomial regressions were modeled to explore the relationship between mortality by country and hospital with injury, each characteristic of injury, and ISS. Multivariable log binomial regression models were constructed to assess conditional risk of mortality by hospital and the risk of death by country.[15] To evaluate the conditional risk of road traffic injuries in both countries, and the conditional risk of assault injuries in Kenya alone, multivariable Poisson regression models with robust variance estimates were used, because log binomial regressions failed to converge when regressing road traffic injuries versus other injury onto sociodemographic covariates.[16] Where log binomial regressions have been used, the results are presented as adjusted risk ratios (aRRs), and where Poisson regressions have been used, the results are presented as adjusted incidence rate ratios. The independent contribution of each selected variable after adjustment was expressed as the adjusted incidence rate ratio, as an approximation of the risk ratio. Akaike information criterion, Bayesian information criterion, and log likelihood ratio tests were used to estimate model fit.[17-19]

This study was approved by the Institutional Review Boards of the Johns Hopkins Bloomberg School of Public Health, the Kenya Ministry of

Table 1. Selected Study Centers for Kenya and Oman

Country	Type	Location	Period of Data Collection
Kenya	Tertiary	Nairobi	January 2014 to January 2016
	Secondary	63 km southeast of Nairobi	January 2014 to December 2015
	Secondary	50 km northeast of Nairobi	January 2014 to January 2015
	Secondary	287 km northeast of Nairobi	February 2015 to January 2016
Oman	Tertiary	Muscat	November 1, 2014 to April 30, 2015
	Secondary	Nizwa (Ad-Dakhliya)	November 1, 2014 to April 30, 2015

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Health, Kenyatta National Hospital–University of Nairobi Ethics Review Committee, and the Oman Ministry of Health.

RESULTS

In total there were 566 patients in Oman and 5859 patients in Kenya between 10 and 24 years old, with the overwhelming majority of patients in each country being male (84.28% in Oman and 77.08% in Kenya) (Table 2). Patients skewed older, with the 20- to 24-year-old age group being the most common among both men and women in both countries. In Oman, 54.95% adolescents were still students versus 46.80% in Kenya. Almost a quarter (24.82%) of patients were casual or daily wage laborers in Kenya, whereas this figure was only 2.30% in Oman. In both countries the proportion of patients currently in school decreased with increasing age category. In Kenya this was due in part to the fact that the same category was used for students and for children under the legal working age: "student/child." In almost every age category, girls and young women in the sample were more likely to be in school compared with their male counterparts; the exception being 15-19 year olds in Oman; however, the sample sizes between the genders were not equivalent, given that the vast majority of the sample was male. Pearson's χ^2 tests comparing Kenya and Oman had statistically significant differences across all sociodemographic variables ($P < .001$ for all).

In both Oman and Kenya, road traffic injuries were the most common cause of injury, followed by falls (Table 2). In Oman, the third most common cause of injury was inanimate mechanical forces, which includes common household as well as workplace injuries. In Kenya, by contrast, interpersonal violence was the third most common cause, with 22.08% of all injuries caused by assault. In both countries, burns, drowning or suffocation, poisoning, and intentional self-harm formed less than 5% each.

In both countries, the number and of patients injured as a result of road traffic accidents increased with increasing age category, whereas the number of injuries caused by falls decreased with increasing age category (Fig. 1). The exception is among the oldest male participants in Oman, among whom road traffic injuries as a percentage of overall injury decreased as inanimate mechanical forces increased dramatically. In Oman the biggest increase in road traffic injuries among men and boys occurred between early adolescence (10-14 years old) and late adolescence (15-19 years old), with little change between late adolescence and early adulthood (20-24 years old). In Kenya there was a more dramatic increase in the number of road traffic injuries among men and boys between late adolescence and early adulthood (an increase of 15.63 percentage points, from 15.19% of all injuries to 30.82%) compared with between early and late adolescence (an increase of 11.67 percentage points, to 42.49% of all injuries). Oman and Kenya also had differing patterns in road user type among victims of road traffic injuries. The Global Status Report on Road Safety 2015 indicates that 66% of road traffic injury victims are vulnerable road users, such as pedestrians, cyclists, and passengers of motorized 2-wheelers.[20] Although this trend holds for Kenya where 69.97% of road traffic injury victims were vulnerable road users, the situation in Oman is different, where only 26.04% of vulnerable road users among the victims of road traffic injury (Fig. 2).

In both Oman and Kenya, the locations where injuries most commonly occurred were on a public roadway or in the patient's own home. In Oman, 92.93% of injuries that occurred on a public roadway were due to road traffic injury and 4.59% were due to falls on the road, with the remaining 2.48% caused by other injury mechanisms. In Kenya, by contrast, 70.55% of the injuries that took place on a public roadway were due to road traffic injuries, 20.15% were due to intentional violence, 6.88% were due to falls, and the remaining 2.42 were distributed among other injury mechanisms. Because road traffic injuries were the most common type of injury overall in these datasets, it is not surprising that the most common location for injury occurrence was public roadways. However, it is of note that intentional violence was a major cause of injuries on public roadways in Kenya, standing in contrast to Oman.

On average, injuries presenting at the hospitals in Oman were more severe, with an ISS of 6.01 (standard deviation [SD] = 6.39), compared with Kenya (ISS: 4.05, SD = 4.13) (t test statistic = 10.13, df = 6253, $P < .0001$). Male patients had more severe injuries compared with female patients, with the exception of early adolescents in Kenya. Road traffic injury was the most fatal in both countries: All 6 deaths in this age group in Oman were due to road traffic injuries, which also caused the most deaths in Kenya (n = 48; 55.81% of all deaths), with interpersonal violence being the second most fatal (n = 24; 27.91% of all deaths) (Table 3). In Oman, road traffic injuries and interpersonal violence had the highest injury severity scores, although there were very few instances of interpersonal violence. In Kenya, burns and interpersonal violence had the highest injury severity scores.

Table 2. Description of Patients Enrolled in Trauma Registries in Oman and Kenya

	Oman (n = 566)		Kenya (n = 5859)		Pearson's χ^2 test: *P* value
	n	%	n	%	
Gender					<.001
Female	89	15.72	1343	22.92	
Male	477	84.28	4615	77.08	
Age Category					.006
10-14	149	26.33	1295	22.10	
15-19	166	29.33	1561	26.64	
20-24	251	44.35	3003	51.25	
Highest Level of Education Attained					<.001
None or informal	5	0.88	95	1.62	
Primary school	210	37.10	2803	47.86	
Secondary school	197	34.81	2239	38.23	
Tertiary/college or higher	28	4.95	652	11.13	
Unknown	126	22.26	68	1.16	
Occupation					<.001
Student/not working	329	58.13	3340	57.01	
Casual/daily wage laborer	98	17.31	335	5.72	
Office, technical, government	9	1.59	104	1.78	
Works in the house	3	0.53	538	9.18	
Self-employed	114	20.14	88	1.50	
Other/unknown	329	58.13	3340	57.01	
Cause of Injury					<.001
Road traffic	266	47.00	1996	34.09	
Burns	24	4.24	97	1.66	
Drowning/suffocation	0	0.00	1	0.02	
Poisoning	3	0.53	7	0.12	
Falls	151	26.68	1758	30.03	
Inanimate mechanical forces	102	18.02	551	9.41	
Interpersonal violence	11	1.94	1293	22.08	
Intentional self-harm	6	1.06	81	1.38	
Other/unknown	3	0.53	71	1.21	
Place of Injury					<.001
Own home or other's home	126	22.34	1265	21.59	
School/public administrative area	23	4.08	751	12.82	
Street, highway, paved roadway	283	50.18	2617	44.67	
Sports grounds	53	9.40	239	4.08	
Industrial or construction area	24	4.26	206	3.52	
Farm	10	1.77	138	2.36	
Commercial, trade, or service area	4	0.71	483	8.24	
Other or unspecified	43	7.60	160	2.73	
Transport Time to Hospital					<.001
0-30 min	68	12.01	1,137	19.41	
>30 min-1 h	95	16.78	1,069	18.25	
>1 h - 2 h	75	13.25	965	16.47	
>2 h-6 h	64	11.31	1,267	21.62	
>6 h-24 h	28	4.95	813	13.88	
>24 h	31	5.48	507	8.650	
Unknown	72	12.72	101	1.720	
Transferred from another facility	133	23.50	0	0.00	

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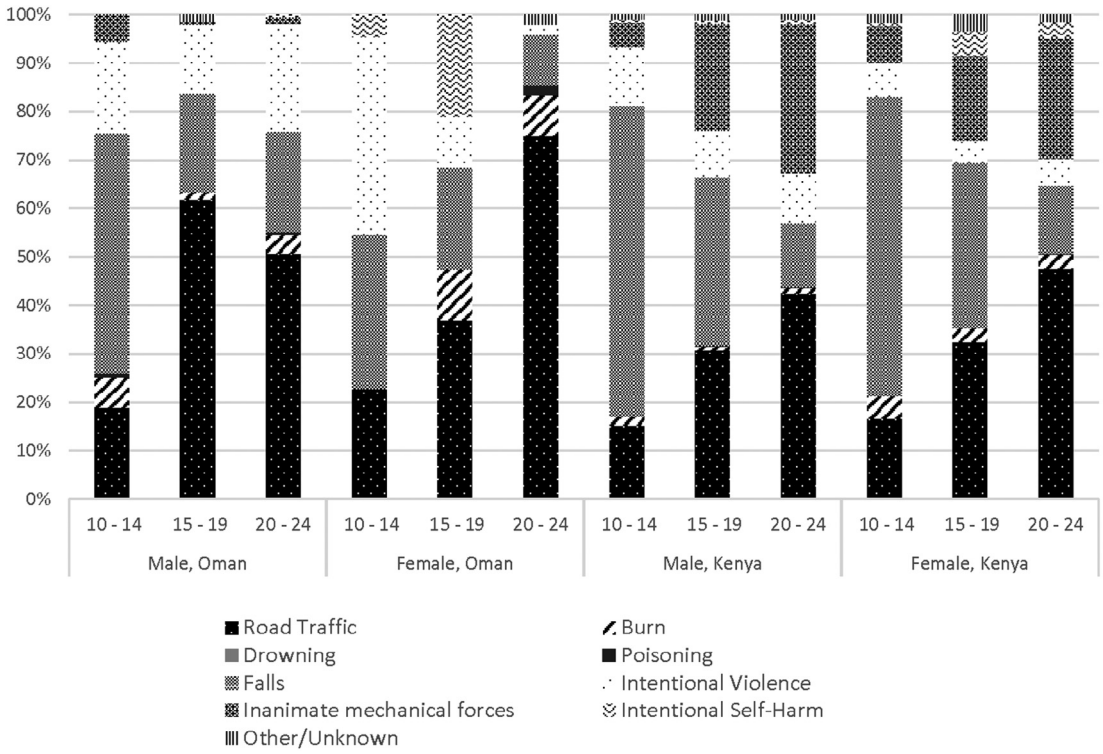

Figure 1. **Injury mechanism by age, gender, and country.**

Multivariable log binomial regression was used to evaluate the relationship between the outcome of death from injury and sex, age category, estimated ISS category, transport time from injury site to hospital, arrival mode, injury cause, and country (Table 4). Postestimation analysis using Wald tests indicated that arrival mode was unrelated to the outcome ($\chi^2 = 11.07$, $P = 19.76$). Although neither age category nor country were found to be statistically significantly associated with death with all the other variables in the model, they remained in the model because they are important predictors in the literature. Drowning and suffocation as causes of injury were omitted from the regression model because there were too few cases.

Higher ISS category was associated with increased risk of death; patients in the third highest and second highest ISS categories had 3.30 and 5.38 times the risk of death compared with the lowest ISS category, controlling for all other variables (Table 4). The highest ISS category indicated 56.01 (10.27, 305.32) times the risk of death compared with the lower category; however, there were only 10 individuals with ISS higher than 25, indicating that these estimates are unstable because of small sample size. It is of note that of these 10 individuals, 8 died in the hospital as a result of injuries. Additionally, having an injury caused by road traffic collision, burns, interpersonal violence, and intentional self-harm was associated with a higher risk of death compared with falls. Male patients were also at a greater risk for death (aRR: 3.63, $P = .002$) as a result of injury compared with female patients, controlling for age category, injury severity, transport time, injury cause, and country.

To account for different injury patterns, separate regressions were run for each of the 3 age categories (Table 5). When regressing covariates onto road traffic injury versus other injury mechanisms, log binomial models failed to converge for each of the 3 regressions. We therefore ran Poisson regressions with robust variance estimates and present our results in Table 5 as incidence rate ratios instead of risk ratios. These incidence rate ratios are intended to approximate risk ratios.[16] Different relationships between sociodemographic variables and road traffic injury appear by age category, controlling for other variables in the model. Except in the youngest age category, road traffic injuries were more common in Oman compared with Kenya. Additionally, among

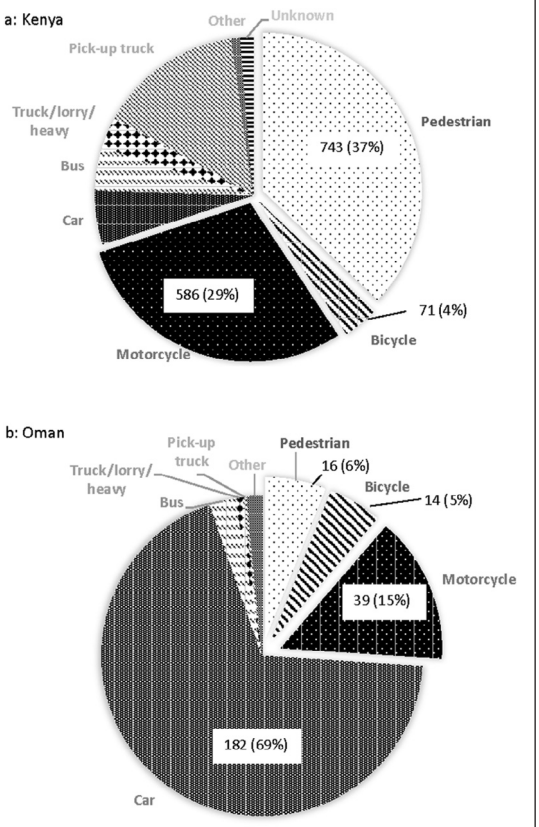

Figure 2. Road traffic injuries by type of vehicle and country.

older adolescents and young adults, being out of school or working increased risk for road traffic injury, as did being a government of office worker or being self-employed. Finally, gender differences in risk of road traffic injury only appear among the oldest age category.

Given the high proportion of patients affected by interpersonal violence in Kenya, we further examined factors associated with it using a Poisson regression model with robust variance estimates, results of which are presented in Table 6. Controlling for gender, occupation, education, and country, each successively older age group was between 3.80 and 5.02 times as likely to be injured through violence compared with the next younger age group. The increased risk among men and boys was not statistically significant, but being a homemaker or being self-employed increased the risk for violent assault compared with being an office worker. Being an office or government worker seemed to have a protective effect. Higher levels of education were protective against involvement in interpersonal violence, controlling for gender, age category, occupation, and country.

DISCUSSION

This study highlights the significant burden of injuries among young people in Oman and Kenya. Injuries and violence among this age group have the potential of long-term physical and mental health consequences.[21,22] In addition to short- and long-term physical disabilities, these problems may range from sleep disturbances, cognitive difficulties, and posttraumatic stress disorder, to psychosocial and behavioral issues.[23-25] This comparative study examines the types of injuries presenting at major hospitals in each country, their severity, and their distribution by sociodemographic characteristic, which are all critical issues to understand for designing effective strategies to reduce this burden.

Oman has undergone a rapid epidemiologic transition since 1970, and a major focus on primary health care has resulted in substantial gains in child and maternal mortality and fewer deaths caused by communicable diseases.[26] Injuries, especially road traffic injuries, are ranked the sixth leading cause of death in Arab countries and the leading cause of loss of disability-adjusted life years for men in the region's Gulf Cooperation Council countries, which includes the Sultanate of Oman.[27] This is reflected in our results from trauma registries implemented in 2 major trauma centers in the country. On the other hand, Kenya is a lower-middle income country in East Africa with a large, young population. Although few studies exist on the burden of injuries in Kenya, the ones that do indicate a significant burden of road traffic injuries, as found in our study.[28-31] Studies examining incidence of and mortality from road traffic injuries in Kenya between 1962 and 1998 identified a dramatic increase of 300% for road traffic injury incidence and 400% for road traffic injury mortality rates.[32-34] As of 2010, Kenya has an exceptionally high rate of road traffic deaths: At 11 per 100,000 population, it is among the highest in Africa.[35]

The present study has highlighted some interesting patterns and differences in the injury burden in both countries. Almost half of all the adolescent and young adult patients presenting to the selected hospitals with injuries were categorized as being in school or a student, with this proportion declining significantly with increasing age—a trend one would expect in this demographic. What was interesting, however, was that female participants were more likely to be school-going in almost all age groups

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Table 3. Injury Severity by Cause: Oman and Kenya

	Average ISS*	ISS < 10		ISS 10-15		ISS 16-25		ISS > 25		% Mortality†	
Oman	Mean	n	%‡	n	%	n	%	n	%	n	%
Road traffic	7.51	203	76.32	36	13.53	19	7.14	8	3.01	6	2.26
Burn	5.54	22	91.67	0	0.00	1	4.17	1	4.17	0	0.00
Poisoning	NA	3	100.00	0	0.00	0	0.00	0	0.00	0	0.00
Falls	5.01	137	90.73	8	5.30	6	3.97	0	0.00	0	0.00
Inanimate mechanical forces	3.79	100	98.04	1	0.98	1	0.98	0	0.00	0	0.00
Interpersonal violence	8.54	8	72.73	1	9.09	1	9.09	1	9.09	0	0.00
Intentional self-harm	0.50	6	100.00	0	0.00	0	0.00	0	0.00	0	0.00
Other/unknown	7.67	2	66.67	1	33.33	0	0.00	0	0.00	0	0.00
Kenya§											
Road traffic	4.11	1849	93.76	55	2.79	66	3.35	2	0.10	48	2.42
Burn	10.48	63	64.95	17	17.53	10	10.31	7	7.22	4	4.17
Drowning	NA	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
Poisoning	NA	3	100.00	0	0.00	0	0.00	0	0.00	0	0.00
Falls	3.79	1705	97.93	4	0.23	31	1.78	1	0.06	3	0.17
Inanimate mechanical forces	2.93	536	97.99	5	0.91	6	1.10	0	0	1	0.18
Interpersonal violence	4.39	1086	88.73	27	2.21	102	8.33	9	0.74	24	1.86
Intentional self-harm	1.71	33	94.29	1	2.86	1	2.86	0	0	5	6.17
Other/unknown	4.22	61	93.85	0	0.00	4	6.15	0	0	1	1.41

NA, not applicable.

* Injury Severity Score (ISS) is a standardized assessment of injury severity based on anatomy and location of injuries.

† Proportion of patients with each type of injury who died.

‡ Percentages are given by injury type (rows) rather than by column.

§ ISS was missing for 170 patients in Kenya, including 24 road traffic injury patients, 4 poisoning patients, 17 patients with injuries from falls, 4 with injuries from inanimate mechanical forces, 69 victims of intentional violence, 46 patients injured through intentional self-harm, and 6 other injury types. All patients in Oman were assigned ISSs.

compared with male participants, except in the 15- to 19-year-old category in Oman. Because in Oman a greater proportion of girls are enrolled in secondary school compared with boys, this result likely is due to an overrepresentation of boys and men in the trauma registry.[36] Being in school was found to be somewhat protective against the risk of road traffic injuries in both countries in the older age groups, and therefore programs that increase educational opportunities and encourage school attendance for all young people, but particularly boys and men, may be beneficial in reducing exposure to risks for injuries in this population, in addition to all the other well-documented benefits of acquiring education. The Omani government, for example, has already been working in this direction through the promotion of education in both male and female populations but also creating job opportunities for young Omanis in government and technical sectors through a comprehensive policy of Omanization.[37] Additionally, Kenya has adopted some policies to improve school enrollment rates, including the abolition of school fees in both primary and secondary education.[38]

Road traffic injuries stood out as the most common cause of fatal injuries in adolescents, especially as they gradually become more independent and get into the more economically productive age range. This trend has also been noted in other Gulf countries and likely points toward common road safety attitudes and practices in the region.[39,40] As mentioned, vulnerable road users form the bulk of injury patients in Kenya, but only 26% of patients were vulnerable road users in Oman. This differing pattern of road traffic injury between the countries reflects a chronic but unresolved problem that calls for effective, contextually appropriate road safety interventions. In Oman this could include targeting adolescents and young adults to promote safe driving, whereas in Kenya potential interventions could focus on legal, behavioral, and environmental changes to protect vulnerable road users.[20] Oman can explore legal interventions such as graduated driving license programs, as well as social marketing campaigns targeted toward young road users focusing on speed control and seat belt compliance. Although vulnerable road users are the majority of road traffic injury victims in Kenya, these road users still comprise more than 1 in 4 road traffic injury victims in Oman; both countries could focus on vulnerable road users to prevent death and long-term disability as a result of road traffic injuries among young people.

Table 4. Results of Log-Binomial Regression Evaluating the Association Among Injury Mechanism, Severity, Sociodemographic Variables, and Death in Hospital After Injury in 6015 Adolescents and Young Adults in Kenya and Oman

	aRR*	SE	*P*	95% CI	
Sex					
Female	Ref				
Male	3.629	1.547	.002	1.574	8.370
Age Category†					
10-14 years old	Ref				
15-19 years old	1.043	0.171	.800	0.755	1.439
20-24 years old	1.087	0.357	.800	0.571	2.071
Injury Severity Score (ISS) Categories					
ISS <10	Ref				
ISS 10-15	3.298	0.835	<.001	2.008	5.417
ISS 16-25	5.379	1.551	<.001	3.057	9.465
ISS >25	56.005	48.46	<.001	10.273	305.324
Transport Time					
<30 min	Ref				
30 min-1 h	0.696	0.198	.203	0.399	1.216
>1 h-2 h	0.881	0.254	.661	0.501	1.551
>2 h-6 h	0.203	0.098	.001	0.078	0.525
>6 h-24 h	0.349	0.214	.086	0.105	1.159
>24 h	0.230	0.234	.149	0.031	1.694
Unknown	3.027	1.076	.002	1.507	6.077
Cause of Injury					
Falls	Ref				
Road traffic injury	8.195	5.005	0.001	2.476	27.124
Burn	10.58	8.093	0.002	2.363	47.376
Inanimate mechanical forces	0.834	0.964	0.875	0.086	8.044
Interpersonal violence	5.890	3.727	0.005	1.704	20.358
Intentional self-harm	17.355	19.794	0.012	1.856	162.283
Other/unknown	4.626	5.314	0.182	0.487	43.949
Country					
Oman	Ref				
Kenya	2.661	1.897	0.170	0.658	10.758

CI, confidence interval; SE, standard error.

* aRR refers to the adjusted risk ratio for a particular variable, adjusted for all other variables in the model.

† Age category was parameterized as an incremental variable rather than as a disjoint categorical. For clarity, results are presented for each of the 2 older age groups in reference to the youngest.

Falls and common exposures to inanimate mechanical forces[1] largely contribute to injuries in the youngest age category across countries. Although these injuries were lower in severity, they clearly represent a burden on the health system and could be reduced through existing and cost-effective injury control measures focused on safe homes, schools, and playgrounds.[41] Among older adolescents and young adults, interpersonal violence emerged as a leading contributor to severe and fatal injuries in Kenya but not Oman. Unfortunately, these findings are not surprising, and a comparative study looking at mortality among adolescent and young adults highlighted similar trends in other countries in Africa as well.[2] Compared with office, technical, or government workers, young people who were students or not working, engaged in casual/daily labor, self-employed, or homemakers had an elevated risk of injury from interpersonal violence; however, the elevated risk to students, those not working, and casual laborers did not meet the threshold for statistical significance. As expected, older individuals were also more affected, and higher levels of education were found to be protective against violence. Among children and young people, violence

[1]The *International Statistical Classification of Diseases and Related Health Problems,* 10th revision, category of "exposure to inanimate mechanical forces" includes, for example, being struck or being thrown against an object or jammed, crushed, or caught in between 2 objects. It excludes contact or collision with transport vehicles, animate objects (animals or persons), intentional violence, and intentional self-harm.

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Table 5. Results From 3 Poisson Regressions With Robust Variance Estimates Examining the Association Between Road Traffic Injury Compared With Other Injury Causes in Oman and Kenya

	Early Adolescence (10-14) n = 1430					Late Adolescence (15-19) n = 1689					Young Adulthood (20-24) n = 3106				
Variable	aIRR*	SE	*P*	95% CI		aIRR	SE	*P*	95% CI		aIRR	SE	*P*	95% CI	
Sex															
Female	Ref					Ref					Ref				
Male	0.879	0.117	.330	0.677	1.140	0.910	0.077	.266	0.771	1.074	.860	0.042	.002	0.782	0.947
Occupation															
Office, technical, government	Ref					Ref					Ref				
Student/not working	0.319	0.220	.098	0.082	1.235	0.637	0.096	.003	0.474	0.856	.784	0.048	<.001	0.695	0.885
Casual/daily wage laborer	0.760	0.573	.716	0.173	3.333	1.088	0.186	.621	0.779	1.520	.826	0.055	.004	0.725	0.942
Works in the house/ homemaker											.662	0.092	.003	0.504	0.87
Self-employed	0.731	0.783	.770	0.090	5.963	1.335	0.258	.136	0.914	1.950	1.013	0.071	.856	0.883	1.162
Other/unknown	1.066	1.029	.947	0.161	7.073	0.768	0.289	.483	0.367	1.607	.828	0.191	.412	0.527	1.3
Highest level of education															
None or informal†	Ref					Ref					Ref				
Primary school	1.068	0.585	.904	0.365	3.125	2.000	0.831	.095	0.886	4.516	1.038	0.194	.843	0.719	1.497
Secondary school	1.126	0.669	.842	0.352	3.607	2.360	0.977	.038	1.048	5.313	1.099	0.204	.613	0.763	1.582
Tertiary/college or higher	(empty)					3.418	1.467	.004	1.474	7.927	1.109	0.212	.587	0.763	1.613
Country															
Oman	Ref					Ref					Ref				
Kenya	0.755	0.139	.127	0.526	1.083	0.456	0.037	<.001	0.390	0.534	.726	0.051	<.001	0.632	0.834

CI, confidence interval; SE, standard error.

* aIRR refers to the adjusted incidence rate ratio; exponentiated coefficients of multivariable Poisson regression with robust variance can be interpreted as incidence rate ratios, adjusted for all other variables in the model.

† There were no individuals in the youngest age category with tertiary education or higher; for this regression, none/informal has been used as the reference category.

Table 6. Results of Poisson Regression With Robust Variance Estimates Exploring the Association Between Sociodemographic Variables and Injury From Interpersonal Violence Compared With other Injury Causes Among 5853 Individuals Aged 10-24 in Kenya

Variable	aIRR*	SE	*P*	95% CI	
Sex					
Female	Ref				
Male	1.112	0.074	.11	0.976	1.267
Age Category					
10-14 years old	Ref				
15-19 years old	3.792	0.483	<.001	2.955	4.866
20-24 years old	5.020	0.659	<.001	3.881	6.493
Occupation					
Office, technical, government	Ref				
Student/not working	1.247	0.151	.068	0.983	1.581
Casual/daily wage laborer	1.242	0.260	.300	0.824	1.872
Works in the house/homemaker	1.466	0.193	.004	1.133	1.897
Self-employed	1.782	0.449	.022	1.087	2.919
Other/unknown	1.247	0.151	.068	0.983	1.581
Highest Level of Education					
None or informal	Ref				
Primary school	0.635	0.085	.001	0.488	0.827
Secondary school	0.523	0.071	<.001	0.401	0.682
Tertiary/college or higher	0.546	0.083	<.001	0.404	0.737
Other/unknown					

CI, confidence interval; SE, standard error.

* aIRR is the adjusted incidence rate ratio; the exponentiated coefficients of Poisson regression may be interpreted as incidence rate ratios, adjusted for all other variables in the model.

is associated with poor social skills, school attendance, and achievement and poverty.[42] Vocational training programs, remedial education, psychosocial support programs, and family-strengthening initiatives are viable options for reducing the burden of interpersonal violence among young people.[42]

One strength of basing this analysis on trauma registry data was that we were able to decipher the relative severity of injuries presenting at the major hospitals in each of these countries and assess outcomes related to that. We found that the risk of death was significantly higher for male patients; those being involved in road injury; patients with intentional injuries inflicted by oneself or others; or patients with burns. This was mainly due to the higher severity of these injuries. This information could be directly used by the respective hospitals and local or national authorities to determine the level of resources (human, equipment, and infrastructural) necessary to better treat the case mix presenting at the hospitals, as well as implement quality improvement programs. An interesting finding was that mortality in Oman was significantly lower compared with Kenya, and further studies may be warranted to examine whether level or quality of care was a factor.

This strength was also, however, a limitation of the study. Although we were able to assess outcomes based on factors such as transport time from injury to hospital, only cursory information about the type of care provided at the scene of the injury or before coming to the hospital was available. Our results indicated a trend that largely reflects a protective effect of longer transport time to death; however, this might be indicative of the fact that only those who have survivable injuries and are in stable condition usually make it to the hospitals.[43] Indeed, a major limitation of this study is that individuals captured by each trauma registry do not necessarily reflect the general public but only those individuals who have accessed hospital care. Although hospitals that participated in the trauma registry pilot were selected to obtain a geographically representative sample in each country, a geographic or socioeconomic selection bias is still possible. A further limitation is that any socioeconomic selection bias cannot be assessed because the trauma registries do not capture information about individual or household income. Factors such as being a student or an office worker, which were protective against interpersonal violence being the cause of injury, might be confounded by household income or socioeconomic status.

A further limitation of using trauma registry data is that information about the mechanism of injury collected during interviews could have led to underreporting of intentional violence or intentional self-harm. There may be misclassification of injury mechanism as a result. Additionally, there may be misclassification of education and occupation. Categories of education and occupation were not identical between Oman and Kenya, requiring the aggregation of several smaller categories. Primary and secondary education had a protective effect against interpersonal violence compared with no education or only informal education, controlling for the other sociodemographics under investigation in this paper. However, tertiary education did not have a statistically significant protective effect against assault. It may be that aggregating education and occupation obscured contextually relevant distinctions between, say, an individual in a technical job and an office worker in Oman. Finally, there were low or empty cell counts for some injury mechanisms in this data, and for the highest ISS category, making statistical analysis on the association between the highest ISS category and mortality problematic.

This study also provides evidence of the need for and ability to develop and implement injury surveillance systems in different contexts—from low income such as Kenya to high income but rapidly developing like Oman. Trauma registries in both contexts add to the existing global experience of such surveillance systems to provide good evidence that such data are important for injury prevention and control and can be collected within reasonable effort and infrastructure. The rising burden of injuries among young people has been documented in every region of the world, irrespective of income status or development. However, examining patterns and distribution of this burden reveals striking differences with respect to level of education, employment conditions, sex differences, and political environment.[2,27] Gaining a deeper understanding of these underlying array of social, cultural, and economic factors that predispose young individuals to injuries and their consequences is vital in designing effective injury prevention measures, which may have wider benefits to the society.

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