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Exploring characteristics and severity of road traffic injuries in Lebanon using emergency department hospital-based data

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In Lebanon, the lack of quality data on road traffic injuries (RTIs) led to the implementation of a hospital-based RTI surveillance system by the Ministry of Health in in private and public-run hospitals in the Bekaa governorate. This paper aims to describe the characteristics and severity of RTIs recorded over two years during the pilot phase. It also assesses the strengths and challenges of the surveillance system, highlighting areas for enhancement. The data collected from the Emergency department (ED) was used to conduct a retrospective analysis of population-based injuries hospitalized for road traffic crashes (RTC). Designated focal persons reported injuries weekly using a standardized form, which included demographic and crash-related variables, body lesions, and vital signs. Data were coded per the International Classification of Diseases (ICD-10), entered into Epidata, and analyzed using SPSS. The RTI surveillance system was assessed using Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis. Over two years, a total of 1576 cases of RTIs were reported. The male-to-female ratio was 2.16 and the majority of RTIs (44.4%) were recorded among those aged between 15 and 29 years old. From 2013 to 2015, a decrease of 0.7% in the revised trauma score (RTS < 4) was recorded. On the contrary, an increase of 3.9% in injury severity score (ISS) that ranged between 15 and 75 was reported. The probability of survival of an injured individual at one month was improved. The hospital-based surveillance system demonstrated strengths in structured data collection and ethical considerations but faced challenges like underreporting, limited coverage, and resource constraints. Recommendations for improvement include enhancing data quality and timely reporting, ultimately supporting evidence-based road safety interventions.

Keywords Hospital-based, Road traffic injuries, Surveillance, SWOT, Lebanon

Globally, road traffic crashes (RTCs) are a major cause of death and disability[1,2]. According to the World Health Organization (WHO), the annual worldwide death toll due to RTC has reached 1.35 million with millions suffering from life-altering injuries. Currently, road traffic injury (RTI) is ranked the eighth leading cause of death for people of all ages and it is predicted to shift to the seventh rank by 2030. Furthermore, RTI is considered the first leading killer of children and young adults aged between 5 and 29 years old[3].

The highest regional rates of road traffic death (RTD) are recorded in Africa and South-East Asia at 26.6 and 20.7 deaths per 100,000 population respectively followed by the Eastern Mediterranean region (EMR) with 18 deaths per 100,000 population[3,4]. It is noteworthy that injury prevention has not been a high priority within the region, and many countries in the EMR lacked simple measures to reduce road traffic injuries[5,6].

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One of the major barriers to RTI prevention is the lack of actual and accurate data[7,8] particularly in Low- and Middle-Income Countries (LMICs) as they often bear a high burden of RTIs, yet interventions are frequently not evidence-based[9,10]. In LMICs, road traffic data, typically gathered from various sources, often suffers from under-reporting. Unlike high-income countries with well-established surveillance systems, most LMICs lack trauma registries or have incomplete ones. These systems may encounter challenges such as inadequate data on pre- and post-hospital deaths, and ambiguity in defining variables in injury registries[11–13]. Consequently, injury surveillance holds the potential to identify trends, populations at risk, injury mechanisms, and risk factors, thus informing priorities in injury prevention and evaluating intervention effectiveness. Despite its importance, few examples exist of establishing road traffic surveillance systems, which often suffer from underreporting[9,10].

Throughout its history, Lebanon, this small Eastern Mediterranean country, has endured perpetual political turmoil including civil wars, conflicts, instability, and a lack of safety norms. All these factors have constituted a fertile soil for aggravating the epidemiology of injury in Lebanon and its resulting human and financial burden. Yet, RTIs have been a neglected epidemic in Lebanon, with studies on RTIs constituting only 5.5% of the injury literature. This figure is based on a scoping review of 467 documents, including articles, conference proceedings, theses and dissertations, and government and media reports. These studies provide only sporadic assessments of this significant health issue in Lebanon[14].

According to the Directorate of the internal security forces, 6137 RTI and 649 RTD were recorded in 2013[15]. The estimated Gross Domestic Product (GDP) lost due to RTC is 3.2–4.8%[16]. Moreover, it was estimated that at least 7% of all reported hospital deaths were due to external causes including transportation-related injuries, falls, and accidental poisoning. Thus, injuries resulting from RTC have become a burden on the health sector in Lebanon. Despite the significant burdens of RTIs, research in this area remains limited, resulting in a lack of understanding and effective management of RTIs. This deficiency, compounded by incomplete and rudimentary RTI police data, has hindered preventative efforts, exacerbating the toll on human lives and the country's well-being, especially considering that effective RTI prevention relies on.

In response to this critical gap in RTI data, the Ministry of Public Health's Epidemiological Surveillance Unit (ESU) embarked on a transformative journey in 2013. Its aim extends beyond simply delineating the characteristics of RTIs, identifying vulnerable comprehensive knowledge of RTI patterns and associated risk factors[17]. Remarkably, prior to 2013, Lebanon remained devoid of an inclusive surveillance system dedicated to monitoring injuries, including RTIs. The imperative to establish an RTI surveillance system in Lebanon arises from a complex interplay of historical legacies, epidemiological necessities, and societal demands. demographics, and assessing RTI severity through meticulous data collection from hospitals in the Bekaa governorate. Notably, the Bekaa was chosen as the pilot region for several compelling reasons. Firstly, it has a diverse population, including both Lebanese citizens and a significant number of Syrian refugees. This demographic diversity provided a robust testing ground for evaluating the surveillance system's feasibility and efficacy in addressing various health concerns across different communities. Additionally, the Bekaa's central geographical location within Lebanon played a key role in its selection. Lastly, the availability of a sufficient number of epidemiologists at the ESU in Bekaa, compared to other governorates, ensured adequate support and expertise for the successful deployment and operation of the system. Moreover, this surveillance system aims to promote best practices in epidemiological monitoring and facilitate evidence-driven interventions and policy formulation. This involves implementing methods and procedures that are recognized as effective and efficient in collecting, analyzing, and interpreting data related to RTIs. By fostering best practices in epidemiological surveillance, this initiative seeks to ensure that the data collected is of high quality, accurate, and reliable. This, in turn, enables policymakers, public health officials, and other stakeholders to make informed decisions and develop targeted interventions to prevent and mitigate the impact of RTIs.

Aims of the study

The objective of this study is twofold. First, it aims to describe the characteristics of RTIs, identify high-risk groups, and explore the severity of RTIs using data collected round-the-clock from the Emergency Department (ED) of both private and public-run hospitals in the Bekaa governorate. The second objective is to assess the strengths and challenges of the hospital-based surveillance system for RTIs in Lebanon using Strengths, Weaknesses, Opportunities, and Threats (SWOT) with a focus on opportunities for enhancement.

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Methods

1. Study 1: Exploring characteristics and severity of road traffic injuries in Lebanon using emergency department hospital-based data

Study design

A retrospective analysis of population-based injuries resulting from road traffic crashes (RTC) was conducted using data collected round-the-clock from the pilot implementation of an ED-based RTI surveillance system initiated by the Lebanese Ministry of Public Health in 2013. This system was operational in both private and publicly-run hospitals in Bekaa, one of Lebanon's largest governorates, centrally located in the country and inhabited by a Lebanese population of 574 465, with an additional 581 843 Syrian refugees. In 2013, a total of 25 hospitals were operating across five districts within the Bekaa governorate (Hermel, Baalbeck, Zahle, West Bekaa, and Rashaya). Notably, the completeness of reported data may vary from hospital to another based on factors such as resources, infrastructure, and capacity, with larger hospitals with emergency departments more willing to report RTIs.

It's important to acknowledge that this surveillance system may have missed certain categories, such as property damage only (PDO) accidents, minor injuries not requiring medical attention, and road traffic fatalities that arises because the system predominantly captures individuals who sought medical attention at the Emergency Department (ED), potentially excluding those who died at the scene and were not transferred to the hospital. In compliance with national legislation issued by the Ministry of Public Health, no ethical approval is required as the data analysis falls under public health surveillance. This report conforms to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Study population

This study included all individuals with a history of fatal or non-fatal injuries stemming from RTCs between March 2013 and December 2015, who presented to the EDs of hospitals in the Bekaa and were recorded by the RTI surveillance system. The choice of the study period likely reflects the completion of a significant phase in the pilot surveillance system's implementation and evaluation. By that time, sufficient data had been collected, and insights from stakeholders were gathered to assess the system's performance and identify areas for improvement. An RTC was defined as a traffic collision that occured on a public roadway, that involved at least one motor vehicle (2, 3 or 4 wheels) and resulting in either death or injury to at least one involved person or property damage exceeding a specified monetary value[18]. These accidents typically occur on public roads and involve various factors such as vehicle speed, driver behavior, road conditions, and environmental factors.

An RTI person was defined as a person involved in a RTC who suffered from a nonfatal injury or injuries[19]. A road traffic fatality (RTF) was defined as a person involved in a RTC who either died immediately or within 30 days due to the crash[18,19].

The study accounted for multiple visits by the same injured individual to the same hospital or referrals to different hospitals, considering them as single cases. Exclusions were made for injured individuals who visited the ED for reasons other than RTCs such as accidents at home or workplace injuries. RTFs that occurred more than 30 days after the RTC were excluded. This aligns with the definition of RTF mentioned above[18,19]. The study protocol adhered to relevant guidelines, and as it falls under the purview of public health surveillance, it received exemption from ethical approval by the Ministry of Public Health.

Data collection

Data was collected a standardized one-page Arabic form. This form was structured with closed-ended queries and thoughtfully designed to encompass both the core minimum and optional data recommended by international organizations[20], as well as data relevant to RTIs[21]. The form encompassed key sections, including hospital identification, demographic details of the injured individuals, information regarding the accident (date, time, location, and type), medical information about the injury such as nature of the injury, vital status, and anatomic lesions, and details about case management including the type of rescue, hospitalization, and outcome. Furthermore, this form integrated essential medical information required for the subsequent calculation of injury severity scores, as outlined in Annex A1.

In compliance with national legislation issued by the MOPH, data collection falls under routine public health surveillance. Therefore, hospitals can report RTIs without getting the consent of the patients. However, participants were informed about the surveillance system and its objectives whenever possible, as additional investigations will be conducted later by the MOPH. Measures were implemented to safeguard the privacy and confidentiality of participants' data, including secure storage, restricted access to sensitive information, and data-sharing protocols that prevent individual identification. It was ensured that the benefits of the surveillance system outweighed any potential risks to participants. Ethical responsibility was upheld by ensuring the accuracy and validity of collected data through rigorous methodologies, appropriate data collection techniques, and regular quality checks. Transparency regarding the purposes, methods, and findings of the surveillance system was maintained, with accountability mechanisms in place to address any ethical concerns.

Data management

Data were reported passively from the emergency departments of Bekaa hospitals to the Epidemiological Surveillance Unit (ESU), entity responsible for diseases surveillance at the MOPH, using the provided standardized form. Typically, a physician or nurse completed the form, which was then sent via fax to the ESU for verification of completeness and clarity. Regular data quality checks conducted at the ESU identify missing data. To address missing data, follow-up with the focal person at the hospital involves reviewing data entries for completeness and accuracy and correcting any discrepancies or omissions. Additionally, some information can be obtained by contacting the patient directly. When missing data could not be addressed, Transparent documentation of missing data is essential for interpreting study findings accurately. Storage and processing of data were taken into account to protect the privacy of the patients and the confidentiality of the data collected. Measures were implemented to ensure that data handling procedures adhered to strict privacy and confidentiality protocols. These measures included secure storage systems and limited access to authorized personnel only.

The collected data were classified and coded according to the International Classification of Diseases 10th version (ICD-10) coding system, with a specific focus on Chapter XIX, "Injury, poisoning, and certain other consequences of external causes," and Chapter XX, "External causes of morbidity and mortality." Stringent measures were taken to protect patient anonymity and the confidentiality of information. Data entry and cleaning were conducted using Epidata Software (Fig. 1).

Statistical analysis

Data from the Epidata software were generated and collected in Excel sheets, then transferred to SPSS version 21.0 for analysis. The data underwent cleaning and were subjected to descriptive statistical analysis to elucidate

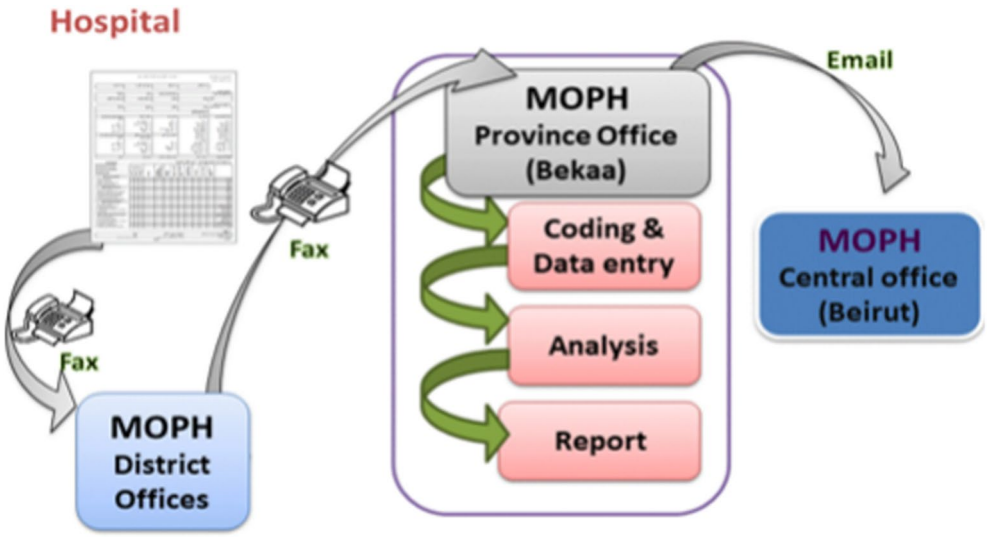


Figure 1. Data flow of the hospital-based road traffic surveillance.

patterns of RTI injuries. Frequencies and percentages were utilized for categorical variables. Geographical analyses, employing a geographical information system (GIS), were conducted to illustrate the spatial distribution of traffic crashes.

In terms of assessing injury severity, the study calculated the following trauma scores to rank the severity of RTIs:

1. **The Revised Trauma Score (RTS)**: This physiological scoring system, known for its high reliability and accuracy in predicting death, was computed using primary patient data, including the Glasgow Coma Scale (GCS), Systolic Blood Pressure (SBP), and Respiratory Rate (RR). The RTS formula is as follows: $RTS = 0.9368\ GCS + 0.7326\ SBP + 0.2908\ RR$. The RTS values ranged from 0 to 7.8408, with a proposed threshold of $RTS < 4$ indicating the need for treatment at a trauma center[22].
2. **The Injury Severity Score (ISS)**: An anatomical scoring system that provides an overall score for patients with multiple injuries across various body regions. Each injury is assigned an Abbreviated Injury Scale (AIS) score, categorized into one of six body regions (Head, Face, Chest, Abdomen, Extremities, including Pelvis and external). The AIS score is a numerical representation of the severity of an injury, typically ranging from 1 to 6, with 1 being minor and 6 being unsurvivable. The AIS score for each body region is determined based on the extent and severity of injuries observed in that particular region of the body. This determination is typically made by healthcare professionals, such as emergency department physicians, who assess the injuries based on clinical examination, diagnostic tests, and medical imaging. The highest AIS score in each body region is considered to evaluate the overall severity of injuries sustained by individuals involved in RTC. Then, the scores of the three most severely injured body regions are squared and then summed to calculate the ISS score, which ranges from 0 to 75. If an injury is deemed non-survivable with AIS of 6, the ISS score automatically becomes 75. Major trauma is considered when $ISS > 15$. The ISS score is a widely used anatomical scoring system, linearly correlating with mortality, morbidity, hospital stay, and other measures of severity[22]. Bolorunduro et al. established and confirmed the categorization of the ISS as: less than 9 for mild, 9 to 15 for moderate, 16 to 24 for severe, and 25 or higher for profound[23]. Nonetheless, a significant drawback of the ISS is its limitation to assessing only one injury per body region. Consequently, this can result in the neglect of certain injuries and the inclusion of less severe injuries from other body regions in the calculation, potentially overshadowing more serious ones within the same body region[24].
3. **The Trauma Injury Severity Score (TRISS)**: This score determines the probability of survival (Ps) for a patient, based on both the ISS and RTS, using the following formula: $Ps = 1/(1 + e^{-b})$, where 'b' is calculated from $b = b0 + b1(RTS) + b2(ISS) + b3\ (AgeIndex)$[22].

2. Hospital-Based RTI surveillance system assessment using a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis

The SWOT analysis was conducted through a meticulous process that involved gathering diverse data sources and engaging with key stakeholders. Initially, a comprehensive collection of data pertaining to the hospital-based surveillance system in Lebanon was undertaken. This included accessing RTI records, reviewing existing reports, and conducting interviews with relevant healthcare professionals involved in RTI surveillance and management. These interviews were conducted to assess operational and implementation factors related to the RTI system with a range of 13 stakeholders, including emergency room physicians, nurses (focal person), hospital administrators, and public health officials. This qualitative component of the analysis was exempt from ethical approval, as it

poses no plausible harm or stigma to participants. Individual participants cannot be identified from the collected data, as all information is gathered anonymously, without any identifiers, and were kept strictly confidential.

The selected interviewees were involved either in the planning or implementation of RTI surveillance system or reporting and analysis. The exclusion criteria were lack of interest in the interview or being incapable of sharing their experiences. Initially, four exploratory, non-structured interviews were conducted. Subsequently, ten semi-structured interviews were carried out to gather more detailed data. An interview guide was utilized to delve into the barriers associated with establishing a RTI surveillance system, addressing questions such as personal experiences with the system, challenges and solutions for implementing a national traffic surveillance system, and the desired characteristics of an effective RTI surveillance system in Lebanon. Participants were contacted directly by the principal investigator via phone calls to schedule online interviews. The interviews were conducted in Arabic. Throughout the interviews, notes were taken to refine questions for subsequent interviews. Data collection continued until saturation of questions and concepts was achieved. Interview durations ranged from 30 to 40 min. These interviews aimed to gather insights into various aspects of the surveillance system, including data collection methods, challenges faced, resource allocation, and perceptions of its effectiveness. Subsequently, a SWOT analysis of the surveillance system was conducted, systematically evaluating its strengths, weaknesses, opportunities, and threats. Strengths encompassed the system's internal positive attributes, while Weaknesses shed light on limitations and areas requiring improvement. Opportunities explored external factors that could enhance the system's effectiveness, and threats identified external challenges that could impede its performance. The culmination of the analysis was a SWOT matrix, highlighting key findings, prioritized based on their significance and potential impact. These insights served as the foundation for actionable recommendations aimed at addressing weaknesses, capitalizing on strengths, seizing opportunities, and mitigating threats within the RTI surveillance system.

Results

During the selected period, a total of 1 576 cases of RTIs were reported by the EDs of the hospitals to the ESU. Among these, 614 RTI cases were recorded in 2013, 500 in 2014, and 462 in 2015. There was a decrease in the number of reported RTIs and RTFs in Bekaa between 2013 and 2015 (Table 1). In comparison, there has been an increase in the population during that period, rising from 552,559 in 2013 to 1,156,308 in 2015.

Characteristics of the study population

Male predominance was evident in RTIs across all three years (2013, 2014, and 2015), with males comprising 68.4% of cases in 2015. The male-to-female ratio remained consistently higher each year (2.44 in 2013, 3.03 in 2014, and 2.16 in 2015). The highest proportion of victims fell within the 15 to 29 age group (44.4% in 2015), followed by those aged 30 to 39. Approximately 65.4% of victims were under 40 years old, while only 6.3% were over 60 years old in 2015. Age group distribution remained relatively stable between 2013 and 2015, with a slight 2% decrease observed in the [0–4] age group (Fig. 2). There was an increase in cases in the[5–14] age group in 2015, warranting further investigation. Lebanese individuals constituted 80% of RTI cases, followed by Syrians at 16%, with a slight decrease in Syrian involvement over the years.

RTI case characteristics

The majority of RTI cases (43%) were drivers, followed by passengers (39%) and pedestrians (18%) in the year 2015. The percentage of cases involving drivers increased over the years (from 35% in 2013 to 43% in 2015) while the percentage of occupants decreased. However, the percentage of affected pedestrians remained relatively stable.

Transport means

The most commonly used transport means were private cars (59% for drivers and 67% for passengers), followed by motorcycle drivers (26%) and passengers (13%) (Fig. 3).

Type of collision

The recorded RTIs in 2015 were primarily the result of four types of collisions: car occupants injured in collisions with a fixed object (25.8%), car occupants injured in collisions with cars or trucks (23.2%), pedestrians injured in collisions with cars or trucks (15.2%),, and motorcycle riders in collisions with cars and trucks (12.1%). These main collision types remained predominant throughout the three-year period (Annex A2).

Place of the accident

The GIS map identified Baalbeck as a significant hotspot, where more than 100 RTI cases stemmed from accidents in this city (Fig. 4). Additionally, various other localities, including Zahleh, Douris, Bouday, and Aadous, demonstrated notable RTI figures. Baalbeck witnessed a decline in reported RTIs, decreasing from 100 cases in 2013 to 73 in 2015. In contrast, Zahleh city experienced an increase in RTIs, with the numbers rising from 20 to 30 RTIs in 2013 to a higher range of 30 to 50 RTIs in 2015. Furthermore, not all reported accidents were confined to the Bekaa governorate, as some road traffic crashes originating from other governorates were directed to nearby hospitals in Bekaa for medical treatment.

Time of accident

In 2013, there was a relatively low percentage of cases during the first quarter (2.7%), while the majority occurred in the second (37.5%) and third (35.8%) quarters (Table 2: Distribution of RTI by day-time and season of occurrence). In contrast, 2014 witnessed a notable increase in cases during the first quarter (21.8%),

Year						
	2013		2014		2015	
	N	%	N	%	N	%
Gender						
Male	436	71.0%	376	75.20%	316	68.40%
Female	178	29.0%	124	24.80%	146	31.60%
Sex Ratio	**2.44**	**3.03**	**2.16**			
Age groups (years)						
[0-4]	26	4.2%	17	3.40%	10	2.16%
[5-14]	68	11.1%	48	9.60%	65	14.07%
[15-29]	276	44.9%	227	45.40%	205	44.37%
[30-44]	138	22.5%	121	24.20%	103	22.30%
[45-59]	68	11.1%	43	8.60%	49	10.61%
[60-69]	15	2.4%	22	4.40%	11	2.38%
>70	23	3.7%	22	4.40%	19	4.11%
Nationality						
Lebanese	498	81.11%	405	81.00%	397	85.93%
Syrian	104	16.94%	86	17.20%	60	12.99%
Other	12	1.95%	9	1.80%	5	1.10%
Patient status						
Pedestrian	117	19%	90	18%	83	18%
Occupant	282	46%	215	43%	180	39%
Driver	215	35%	195	39%	199	43%
Mean of rescue						
Alone	15	2.40%	15	3%	4	0.90%
Relatives	231	37.60%	195	39%	153	33.10%
Rescue	280	45.60%	268	53.60%	295	63.90%
Other	88	14.3%	22	4.40%	10	2.10%
ER decision						
ER then home	258	42.02%	227	45.40%	192	41.60%
Admission	253	41.21%	205	41.00%	220	47.60%
Death	38	6.19%	24	4.80%	21	4.50%
Refusal	29	4.72%	15	3.00%	9	2.00%
Referral	28	4.56%	26	5.20%	19	4.10%
Other	8	1.30%	3	0.60%	1	0.20%
Outcome of the crash						
Injuries	576	93.81%	476	95.20%	441	95.45%
Deaths	38	6.19%	24	4.80%	21	4.55%
Total	614		500		462	

Table 1. Characteristics of the RTI cases admitted to the ED of the hospitals in Bekaa governorate. *N: frequency, %: Percentage, ER: emergency room*

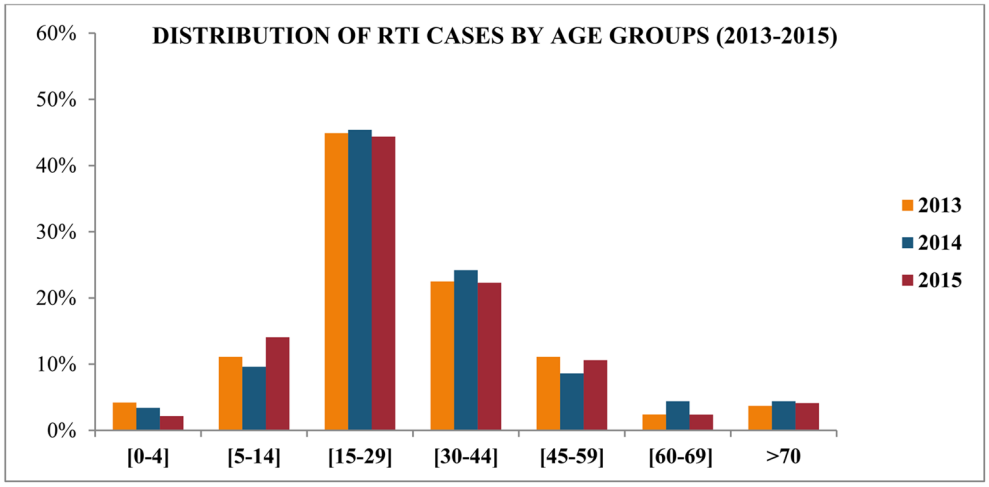


Figure 2. Distribution of RTI cases by age groups.

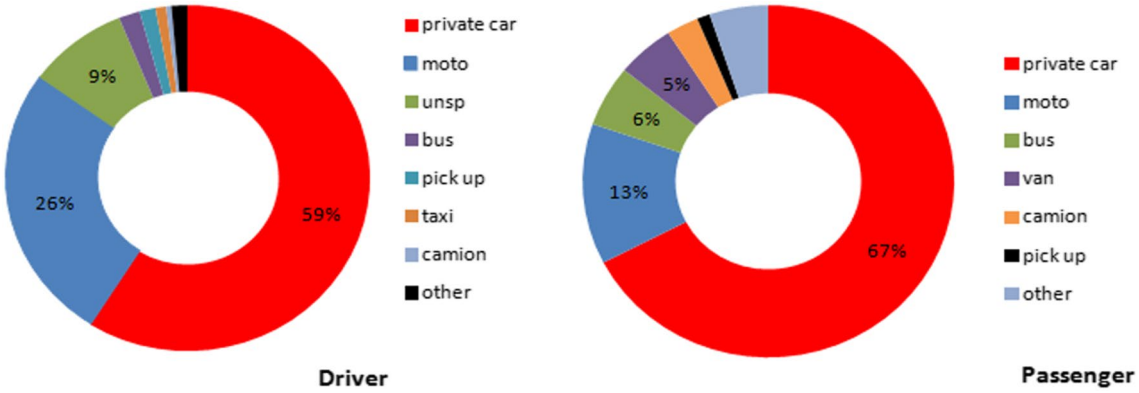


Figure 3. Transport means used by RTI (Drivers vs. passengers).

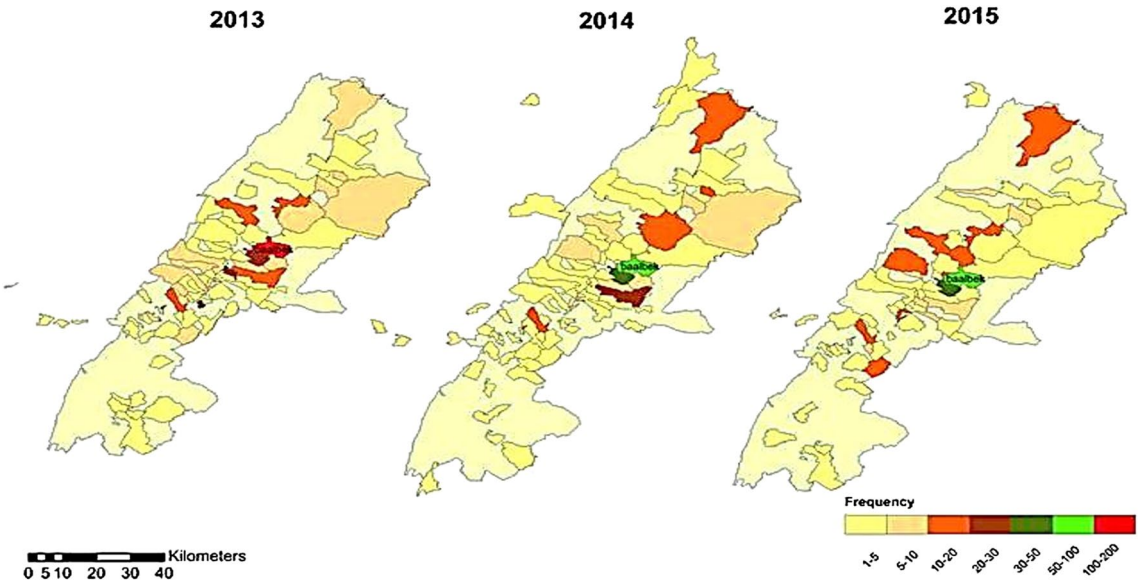


Figure 4. Distribution of RTI in Bekaa, Lebanon (2013–2015). Legend 1:The pale yellow color represents territories that are not reporting RTI.

	2013		2014		2015	
	N	%	N	%	N	%
Quarter of the year						
First quarter	16	2.7%	109	21.8%	121	26.3%
Second quarter	222	37.5%	128	25.7%	92	20.0%
Third quarter	212	35.8%	99	19.8%	197	42.7%
fourth quarter	142	24.0%	163	32.7%	51	11.0%
Total	592	100%	499	100%	461	100%
Period						
1am-6 am	27	4.8%	7	1.7%	9	1.9%
6am-12am	96	16.9%	96	23.2%	113	24.6%
1pm-6 pm	276	48.8%	166	40.1%	248	53.9%
6 pm-12 pm	167	29.5%	145	35.0%	90	19.6%
Total	566	100%	414	100%	460	100%

Table 2. Distribution of RTI by day-time and season of occurrence. N:frequency, %: Percentage. First quarter: January, February, March, Second quarter: April, May, and June,Third quarter: July, August, and September, Fourth quarter: October, November & December.

accompanied by a decline in the second (25.6%) and third (19.8%) quarters. The year 2015 marked a substantial surge in cases during the third quarter (42.7%), with fewer cases in the first (26.2%) and second (20.0%) quarters. There was a noticeable decrease in cases during the fourth quarter (11.1%).

The highest number of cases occurred in the afternoon (1 pm − 6 pm), constituting 48.8% in 2013, 40.1% in 2014, and a significant increase to 53.9% in 2015. The evening period (6 pm − 12 am) also featured a substantial share of cases in 2013 (29.5%) and 2014 (35.0%), but this percentage decreased in 2015 (19.6%). In contrast, the early morning period (1 am − 6 am) consistently reported the lowest percentage of cases across the three years, ranging from 1.7 to 4.8%. The morning period (6 am − 12 pm) demonstrated relative stability in its share of cases.

Type of rescue

The most common rescue means used was the professional rescue (emergency transport services mainly Red Cross) (63.9%) followed by being transported by relatives (33.1%). There was a notable increase in the percentage of cases being rescued by the rescue services in 2015, indicating potential shifts in the methods used to respond to road traffic injuries (RTIs) (Table 3).

Outcome of RTIs

The majority of injured people were managed in the ER then discharged to their home. There were a rising percentage of cases admitted to hospitals over the years. Only 1.9% of RTIs cases refused to be treated (2015).

The majority of cases resulted in injuries, underscoring the predominantly non-fatal nature of RTIs. A decrease in reported death was observed between 2013 (6.2%) and 2015 (4.1%). The majority of deaths occurred among pedestrians (10%) (Fig. 5).

Anatomical site of injury

Head injuries constituted the most prevalent type of injury across the majority of cases, accounting for 36.4% in 2013, 45.1% in 2014, and 46.3% in 2015. Following closely, lower extremity injuries, which encompass injuries to the knees, legs, hips, and ankles, ranked as the second most common (40.1% in 2015). Upper extremity injuries, affecting areas like the shoulders, arms, wrists, hands, elbows, and forearms, stood as the third most frequently observed injury type in road traffic crashes (35.2% of patients experienced upper extremity injuries in 2015). Abdominal injuries (13.4%) and chest injuries (13.1%) collectively accounted for 26% of cases. There were no significant differences in the distribution of injury sites observed during the study period. Head injuries exhibited a 10% increase among RTI cases between 2013 and 2015 (Fig. 6).

Severity of injury

The majority of cases had an RTS of more than 4, with 96.7% in 2013, 95.8% in 2014, and 97.4% in 2015. A significant majority of cases had an ISS of less than 15, accounting for 91.1% in 2013, 91.3% in 2014, and 87.2% in 2015. For the Trauma Injury Severity Score (TRISS), the highest percentage of cases fell within the [0.9-1] range, which indicates a high probability of survival. Specifically, 86.1% fell within this range in 2013, 92.3% in 2014, and 94.1% in 2015 (Table 3). This pattern suggests that the majority of RTI cases had a favorable prognosis for survival, with only a small percentage falling into lower TRISS ranges, indicating a lower likelihood of survival.

Injury severity score by road user type

The distribution of patient status based on Injury Severity Score (ISS) categories is presented in Fig. 7. Pedestrians and occupants had higher ISS scores, indicative of more severe injuries, comprised a larger proportion compared

	2013		2014		2015	
	N	%	N	%	N	%
Trauma score						
RTS						
less than 4	20	3.3	21	4.2	12	2.6
more than 4	579	96.7	475	95.8	449	97.4
Total	599	100	496	100	461	100
ISS						
less than 15	555	91.1	454	91.3	402	87.2
more than 15	54	8.9	43	8.7	59	12.8
Total	609	100	497	100	461	100
TRISS						
[0-0.1[	19	3.2	20	4.0	13	2.8
[0.1-0.2[	3	0.5	1	0.2	0	0.0
[0.2-0.3[	4	0.7	1	0.2	3	0.7
[0.3-0.4[	31	5.3	8	1.6	1	0.2
[0.4-0.5[	4	0.7	2	0.4	0	0.0
[0.5-0.6[	2	0.3	0	0.0	2	0.4
[0.6-0.7[	3	0.5	0	0.0	3	0.7
[0.7-0.8[	7	1.2	4	0.8	3	0.7
[0.8-0.9[	9	1.5	2	0.4	2	0.4
[0.9-1[	507	86.1	458	92.3	434	94.1
Total	589	100.0	496	100.0	461	100.0

Table 3. Severity of injuries using trauma scores RTS, ISS and TRISS. N:frequency, : Percentage.

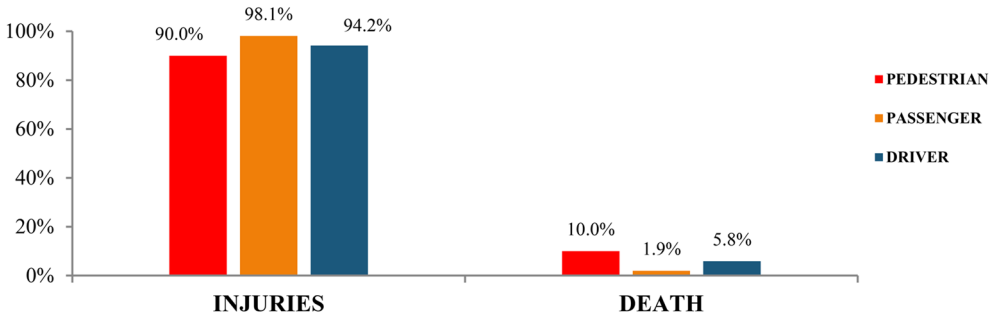


Figure 5. Outcome of the road traffic crashes by road user.

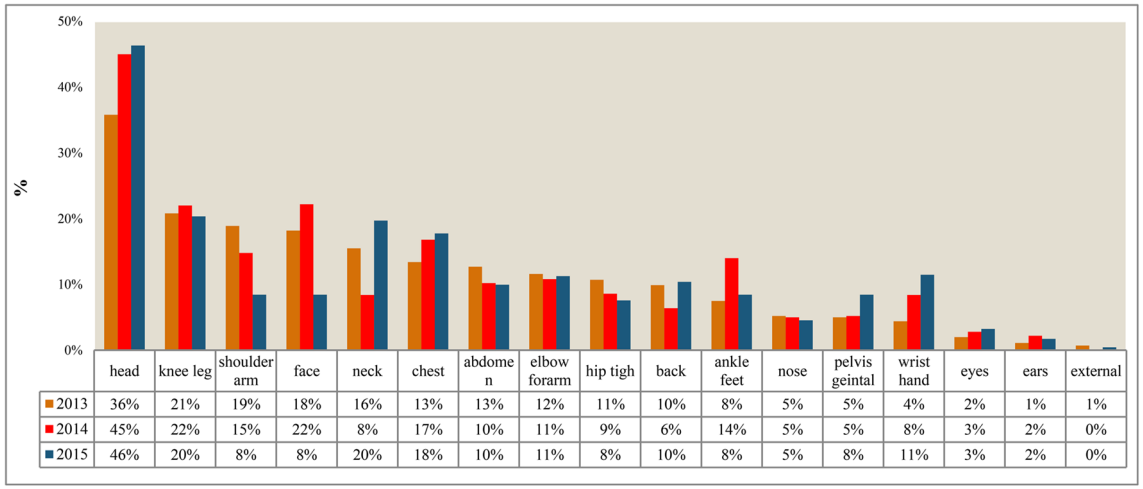
to those with lower ISS scores. Conversely, a higher proportion of drivers had ISS scores of 15 or less, suggesting comparatively less severe injuries among this group.

Strengths and challenges of hospital-based RTI surveillance system in Lebanon: opportunities for enhancement

The SWOT analysis for the RTI surveillance system in Lebanon reveals a comprehensive overview of its current status and potential areas for improvement (Table 4).

Strengths

The RTI surveillance system in Lebanon demonstrates a structured approach to gathering data related to RTIs, This systematic method ensures consistency and reliability in the data, facilitating accurate analysis and interpretation of trends over time. Moreover, utilizing spatial analysis techniques allows for a comprehensive examination of RTI patterns and distribution across geographical areas. By identifying hotspots and areas with higher incidence rates, targeted interventions and resource allocation can be implemented effectively to address specific needs. Furthermore, the system employs standardized methods for assessing the severity of injuries sustained in RTC. These objective assessment criteria ensure consistency and accuracy in categorizing injuries, which is vital for providing appropriate treatment and allocating resources efficiently. Ethical principles and guidelines are integrated into the data collection and reporting processes of the surveillance system. This includes maintaining patient confidentiality, and ensuring the ethical use of data for research and policy purposes, demonstrating a commitment to ethical standards. Finally, the presence of a skilled and trained



	head	knee leg	shoulder arm	face	neck	chest	abdomen	elbow forarm	hip tigh	back	ankle feet	nose	pelvis geintal	wrist hand	eyes	ears	external
2013	36%	21%	19%	18%	16%	13%	13%	12%	11%	10%	8%	5%	5%	4%	2%	1%	1%
2014	45%	22%	15%	22%	8%	17%	10%	11%	9%	6%	14%	5%	5%	8%	3%	2%	0%
2015	46%	20%	8%	8%	20%	18%	10%	11%	8%	10%	8%	5%	8%	11%	3%	2%	0%

Figure 6. Distribution of RTI by site of injuries.

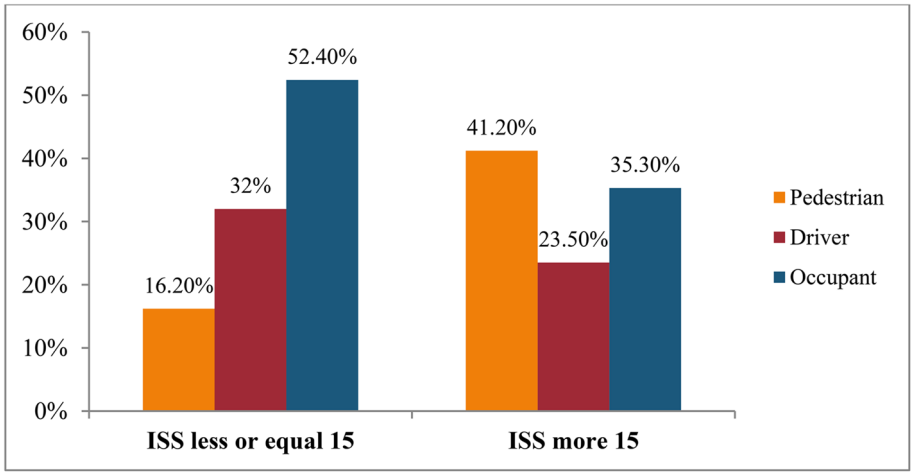


Figure 7. Injury severity by road user.

Strengths	Weaknesses
• Structured Data Collection • Spatial Analysis • Objective Injury Severity Assessment| • Ethical Considerations • Skilled Workforce	• Underreporting Bias • Passive Reporting • Information Bias • Limited Geographical Coverage • Resource Constraints • Lack of Real-time Data
Opportunities	Threats
• Enhanced Data Quality • Data Integration • Resource-Efficient Strategies • Addressing Cultural Sensitivity • Leveraging Technological Advancements • National and International Collaborations	• Limited Coverage • Legislative Changes • Resource Attrition • External Disruptions • Persistent Underreporting Bias • Data Collection Biases

Table 4. SWOT matrix for RTI surveillance sysetm.

workforce contributes to the efficiency and effectiveness of the RTI surveillance system. These trained personnel are equipped to collect, analyze, and interpret data accurately, leading to more informed decision-making and improved outcomes in RTI prevention and management efforts.

Weaknesses

Despite the structured approach to data collection, underreporting bias remains a challenge within the system. Not all RTIs are reported, leading to an incomplete picture of the true burden of RTIs in the population and impacting the accuracy of data and subsequent interventions. Additionally, reliance on passive reporting mechanisms, where RTIs are voluntarily reported by healthcare facilities or individuals, contributes to underreporting bias. Passive reporting may result in missed cases and delays in data collection, affecting the timeliness and completeness of surveillance data. Furthermore, Inaccuracies or errors in the data collected, known as information bias, can arise from various sources such as incomplete medical records or misclassification of RTI. These biases can distort the interpretation of RTI trends and undermine the reliability of surveillance data. The RTI surveillance system may have limited coverage in terms of geographic areas (limited to Bekaa region). This limited coverage hinders the identification of disparities in RTI rates and the implementation of targeted interventions in underserved communities. Lastly, resource constraints, including limited funding, personnel, and infrastructure, pose challenges to the functioning of the RTI surveillance system. Insufficient resources may impact data collection efforts, data quality, and the implementation of preventive measures.

Opportunities

Opportunities exist to improve the quality of RTI surveillance data through measures such as training and capacity building for data collectors, standardizing data collection tools and procedures, and implementing quality assurance protocols. Furthermore, integrating RTI surveillance data with other health information systems can enhance data completeness, accuracy, and utility, providing a more comprehensive understanding of the burden of RTIs and facilitating coordinated responses across different sectors. Exploring resource-efficient strategies such as leveraging existing infrastructure and technologies, streamlining data collection processes, and promoting multi-sectoral collaboration can optimize the use of available resources for RTI surveillance. Recognizing and addressing cultural sensitivities in data collection and reporting processes can improve community engagement and participation in RTI surveillance activities, enhancing the acceptability and effectiveness of interventions among diverse populations. Culturally tailored approaches can enhance the acceptability and effectiveness of interventions among diverse hospitals (private vs. public/ university vs. non university, urban vs. rural, large vs. small). In addition, harnessing technological advancements such as mobile health applications, electronic reporting tools can enhance the efficiency, accuracy, and timeliness of RTI surveillance activities.

Lastly, collaborating with national and international partners, including government agencies, academic institutions, and non-governmental organizations, can provide opportunities for knowledge sharing, capacity building, and resource mobilization to strengthen RTI surveillance efforts.

Threats

The threat of limited coverage refers to the risk of incomplete or uneven surveillance coverage across geographic areas. Limited coverage compromises the representativeness and reliability of surveillance data, hindering effective decision-making and resource allocation. In addition, changes in legislation or policies related to RTI reporting, data sharing, or privacy regulations can impact the functioning of the surveillance system, requiring adjustments to data collection and reporting procedures. Resource attrition, including funding cuts or staff turnover, can undermine the sustainability and effectiveness of RTI surveillance efforts, leading to gaps in data collection, decreased data quality, and challenges in maintaining surveillance activities over time. External disruptions such as, political instability, or public health emergencies can disrupt RTI surveillance activities and compromise data collection efforts, requiring rapid adaptation and resource allocation to ensure continuity of operations. The ongoing challenge of accurately capturing all RTIs within the surveillance system highlights the threat of persistent underreporting bias. Addressing this bias requires targeted strategies to improve reporting mechanisms, enhance community awareness, and strengthen data collection efforts. Biases in data collection processes can introduce inaccuracies and distortions in surveillance data, undermining the reliability and utility of the data for informing decision-making and policy development.

Discussion

This study described the magnitude and the characteristics of RTI in Bekaa-Lebanon, based on the pilot phase of an ED injury surveillance during the period extended from 2013 to 2015. The piloting of such system could be the first step towards establishing a national hospital-based RTI surveillance system that could be one of the data sources of an integrated RTI surveillance system.

This study provides valuable insights into the critical issue of RTIs in Lebanon, particularly within the Bekaa governorate. It highlights a pronounced gender disparity, with males being disproportionately affected, and identifies young and middle-aged individuals as the most vulnerable demographic. The study emphasizes specific areas for targeted prevention efforts, such as addressing private car usage patterns and specific collision types. Geographically, the findings pinpoint hotspots like Baalbeck and Zahleh that require focused attention. Furthermore, the temporal distribution of RTCs, with an increase in the afternoon, informs strategies for timely interventions. The shift towards professional rescue services underscores evolving responses to RTIs. The prevalence of head injuries and their increasing occurrence warrant further investigation and intervention. Additionally, the study sheds light on evolving demographic trends in RTIs, including changing roles of drivers and occupants. The assessment of injury severity through trauma scores provides valuable insights, with most cases indicating a high probability of survival, but a subset requiring more intensive care.

Based on ESU data, a notable decline in the incidence of RTIs and RTD was observed in the Bekaa region between 2013 and 2015. It's worth noting that there was a slight increase in the population during this same period. One plausible explanation for this positive shift could be attributed to the implementation of the new traffic law, which was introduced in 2015. However, it is important to emphasize that further studies are needed to assess the effectiveness of the traffic law's implementation.

The study illuminated a pronounced gender disparity in RTI involvement, aligning with prevailing global patterns. This finding could be attributed to the fact that most drivers are typically men. In fact, men often take on the role of being the primary earners in their families, which may lead to their increased participation in activities such as driving. In addition, extensive literature underscores the inclination of males toward riskier behaviors while driving, including a heightened propensity for dangerous activities like speeding and neglecting seat belt usage. Furthermore, business and commercial vehicles usually recruited men[25]. Such pattern concerning gender disparity and predominance of RTIs among men have been revealed by many other researchers[25,26]. This gender-specific discrepancy underscores the critical need for targeted interventions within road safety campaigns, and tailoring strategies to address the distinct risky behaviors.

Our findings emphasize the heightened susceptibility of young individuals to RTIs, with those aged 15 to 29 years being the most affected, closely followed by individuals aged 30 to 39 years. This demographic distribution closely mirrors global trends[3]., where RTIs consistently rank among the top causes of death for individuals aged 5 to 44 years. Notably, RTIs become the primary cause of death for those aged 15 to 29 years and the second leading cause for those aged 5 to 14 years. This demographic pattern aligns with a life phase marked by increased physical activity and productivity, which may help explain the higher incidence of RTC in these age groups. Notably, the impact of RTDs within the 15 to 29 age group, representing the nation's youthful workforce, extends beyond public health, carrying significant economic implications as they affect the country's overall productivity. This underscores the urgent need for tailored educational and preventive initiatives targeting these age groups.

Conversely, RTIs are less prevalent among those aged 45 to 69 years and individuals aged 70 years or older. Thee relatively low percentage of RTIs among those aged 60 years and older can be attributed to reduced transportation activity in this age cohort. These findings underscore the pressing need for tailored educational and preventive initiatives directed at young and middle-aged individuals to mitigate the disproportionate burden of RTIs in these age groups.

When examining the impact of nationality on RTIs, it is noteworthy that Syrian refugees were also affected by RTCs. This occurrence can be attributed to several factors, including their potential lack of familiarity with Lebanese roads, traffic laws, and behaviors of other road users. However, it is essential to consider that despite their significant population in the Bekaa governorate, the number of reported RTIs among Syrian refugees was relatively low. Several factors could contribute to this phenomenon, including barriers to accessing healthcare services. It is plausible that Syrian refugees face challenges in accessing timely and appropriate medical care following an RTC, which might result in underreporting of RTIs within this population. Therefore, while the data indicates some level of RTI involvement among Syrian refugees, it should be interpreted cautiously, recognizing the potential complexities involved in accessing healthcare services and reporting incidents within this demographic. Of note, the primary factor contributing to the increased occurrence of RTIs among both the local population and refugees alike is the absence of effective road safety measures, compounded by insufficient adherence to and enforcement of these measures[27]. Further research and a deeper exploration of the barriers faced by Syrian refugees in the context of RTIs are warranted to gain a more comprehensive understanding of this issue.

Our study findings unveiled a notable concentration of RTIs within Baalbeck city. This phenomenon can be attributed to a confluence of factors, including road infrastructure, problematic driver behaviors, lax enforcement of traffic regulations, and a deficiency in fostering a road safety culture. These revelations underscore the pressing need for specific, targeted interventions aimed at enhancing road safety within this city.

When analyzing the seasonal distribution of RTCs, our investigation revealed patterns consistent with those found in a study conducted in Saudi Arabia[28]. In both studies, the majority of incidents occurred during the third quarter of the year. Several factors may contribute to this trend, including increased travel and road traffic volume during holiday seasons, variations in road traffic patterns related to specific local events or festivals, and potentially heightened risk-taking behavior among drivers during these periods.

In addition to seasonal variations, this study delved into the influence of temporal variation on the incidence of RTCs. We found that 51.3% of accidents occurred during the afternoon, with 24.6% occurring in the morning. This particular time frame aligns with heightened levels of human activity, such as people commuting to work, students heading to school, and the initiation of business operations in various commercial enterprises. It represents the most active phase of the day when roads experience increased traffic volume and heightened interactions among road users. The observed decrease in RTIs during night-time can be attributed to a reduction in mobility during these hours, as fewer individuals are typically on the roads. However, it's worth noting that previous studies have yielded contrasting findings, indicating a higher RTC risk during night-time compared to other times of the day. These studies, conducted in both developing and industrialized countries, have further highlighted that the case fatality rate tends to be higher for night-time crashes than those occurring during daylight hours[29,30]. Factors contributing to this increased risk at night include reduced visibility due to darkness, potentially impaired perception and reaction times, and the presence of other factors like fatigue and alcohol impairment. These disparate findings underscore the complex interplay of factors affecting RTCs at different times of the day and the importance of considering contextual variables unique to each region. While our study reflects the patterns of RTCs in our local context, it is crucial to recognize that factors influencing RTCs can exhibit substantial variability across regions and warrant further investigation to inform targeted road safety measures.

Our findings showed that head injuries is the most frequently affected area of the body among the majority of traffic injury cases, with lower extremity injuries (including the knees, legs, hips, and ankles) ranking as the second most commonly affected region, accounting for approximately 40% of injuries in 2015. These findings resonate with existing literature on the subject, where head and neck injuries have consistently emerged as prevalent in various global contexts [42]. For instance, studies conducted in Saudi Arabia reported that the head and neck region were injured in 49% of cases[31,32], while a study in Delhi documented a 31% occurrence of injuries in this region[33]. Similar trends have been observed in Nigeria[34], where head injuries featured prominently in road traffic injuries. The lower extremities were the most affected part of the body in Turkey[35]. However, it's important to note that the specific injured body part can vary among different road user groups, highlighting the need for tailored injury prevention strategies for distinct populations. For a more objective assessment of injury severity, our study recommends the consideration of additional indicators such as the length of hospital stay. These indicators can provide valuable insights into the extent and impact of injuries sustained in road traffic incidents, offering a more comprehensive perspective for injury assessment and management.

The analysis of severity scores for RTIs over the period from 2013 to 2015 revealed a notable improvement, marked by an increase in the RTS of more than 4. This positive trend in severity scores indicates a significant shift towards less severe injuries among the RTI cases studied. Such an improvement suggests that the majority of these cases may not necessitate specialized treatment in a trauma center. With a decreasing trend in the severity of injuries, healthcare providers and policymakers can reconsider resource allocation, ensuring that specialized hospitals are reserved for the most critical cases while streamlining care for less severe injuries through appropriate healthcare facilities.

Furthermore, the results obtained from the TRISS calculations also corroborated this trend, demonstrating an enhanced probability of survival between 2013 and 2015. This improvement in survival probabilities aligns with the reduction in injury severity, indicating a positive impact on patient outcomes. The continuous monitoring of injury severity scores, as suggested by this study, can serve as a valuable and objective method for assessing the effectiveness of various interventions aimed at improving road safety and reducing the severity of RTIs.

The observed improvement in injury severity and survival probabilities highlights the potential benefits of targeted road safety interventions, particularly the implementation of new traffic law in 2015. However, it's imperative to recognize that while these findings are promising, sustained efforts in road safety education, enforcement of traffic laws, and infrastructure improvements remain crucial to further mitigate the impact of RTIs and ensure the well-being of road users.

It is important to acknowledge that there were challenges in data collection during the initial quarter of the implementation of RTI surveillance program. These limitations may have impacted the completeness of the data, potentially influencing the interpretation of the study results. In summary, findings of this study collectively underscore the multifaceted nature of the RTI issue, emphasizing the need for comprehensive and targeted interventions to enhance road safety and reduce the burden of RTIs in Lebanon.

Comprehensive strategy encompassing multifaceted approach

On the other hand, the comprehensive SWOT analysis provides an in-depth assessment of the RTI surveillance system in Lebanon, identifying key strengths, weaknesses, opportunities, and threats. It serves as a foundation for informed decision-making and the development of strategies aimed at improving the system's success. To capitalize on strengths, address weaknesses, seize opportunities, and mitigate threats, a comprehensive strategy encompassing multifaceted approach is essential. Beginning with data quality and reporting, the implementation of a data quality improvement program is essential. This program should include regular data quality audits, validation checks, and standardized reporting protocols. Alongside this, healthcare professionals should be trained in accurate data collection, and incentives for timely reporting should be introduced to mitigate underreporting bias. Moreover, fostering collaboration and data sharing is a critical strategy. Exploring opportunities for data integration with relevant databases, such as police reports and insurance records, can significantly enhance data accuracy and comprehensiveness. The need for an integrated RTI system is paramount, particularly in light of the prevailing data fragmentation. Currently, RTI data is often scattered across various sources and databases, making it challenging to obtain a comprehensive and cohesive understanding of the road safety landscape. In addition, clear data-sharing agreements must be established, addressing privacy concerns and data ownership issues.

In an era of technological advancements, embracing technology for real-time data collection is imperative. Investments in real-time data solutions enable immediate responses to emerging trends and proactive measures to prevent RTIs.

Data analytics tools should be employed to identify patterns and predict RTI hotspots effectively. It is also essential to ensuring sustainable resource allocation. This can be achieved through resource-efficient strategies and prioritizing training and capacity building to maintain a skilled workforce capable of managing and analyzing data effectively.

Addressing cultural sensitivities is vital to reduce potential desirability bias in data collection and implementing culturally inclusive data collection protocols and collaborating with local communities and stakeholders can build trust and encourage accurate reporting. Furthermore, enhancing data security measures is crucial.

Moreover, seeking international partnerships and participating in knowledge-sharing networks are avenues to benchmark best practices. Advocating for supportive legislation and collaborating with government agencies to strengthen the legal framework for RTI surveillance is essential as well.

Finally, implementing ongoing monitoring and evaluation, including regular reviews of data quality, system performance, and coverage, ensures the continuous effectiveness of the system. These comprehensive strategies and recommendations form a holistic approach to address identified weaknesses, leverage strengths, seize

opportunities, and mitigate threats. Ultimately, this approach will enhance the hospital-based surveillance system for RTIs in Lebanon, contributing to improved road safety and reduced RTIs in the country.

Limitations

SWOT analysis presents a starting point in the evaluation process, but its inherent limitations necessitate a more comprehensive evaluation approach. Firstly, SWOT's assessment may overlook critical nuances vital for understanding system effectiveness, such as data quality and timeliness. Additionally, its subjective nature introduces bias, potentially skewing priorities and omitting essential factors. Moreover, its qualitative focus limits quantifying factors, hindering prioritization and actionability of recommendations. To address these limitations, a depth evaluation following Centers for Disease Control and Prevention (CDC) guidelines is crucial, utilizing both qualitative and quantitative methods. The quantitative assessment included sensitivity, positive predictive value, data quality, and timeliness through active case finding in paper-based and electronic sources. Unfortunately, due to several critical challenges, the use of such an approach wasn't feasible when performing this assessment. The pandemic redirected crucial healthcare resources to COVID-19 management, shifting healthcare priorities away from RTI surveillance. Disruptions in routine healthcare services, data collection, and reporting during the pandemic led to incomplete and less reliable RTI data. Safety concerns related to virus transmission made fieldwork (record reviews) challenging, hindering this aspect of the evaluation. By adhering to CDC guidelines, future can identify specific areas for improvement and develop targeted interventions, enhancing the effectiveness of road traffic injury surveillance systems.

Conclusion

The hospital-based surveillance system for RTIs in Lebanon has notable strengths in comprehensive data collection, geographical analysis, and objective injury severity assessment. However, it faces challenges related to underreporting, information bias, limited coverage, and resource constraints. Opportunities exist for data quality improvement, timely reporting, and fund acquisition. Sustainability is crucial for long-term effectiveness in understanding and addressing RTIs, which disproportionately affect Lebanon's youthful population. An integrated and multidisciplinary RTI surveillance system can provide a comprehensive view, supporting evidence-based road safety interventions.

Data availability

The data supporting study findings are the responsibility of the Epidemiological Surveillance Program of the Lebanese Ministry of Public Health (ESU-MOH). Thus, restrictions apply to the availability of these data, which were used under license for the current study and are not publicly available. Data are, however, available from the authors upon reasonable request and with permission of ESU-MOH.

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Author contributions
Conception and design: D.Y, and N.G. Analysis and interpretation of the data: D.Y., N.G., and W.A.S.Drafting of the article: D.Y., N.G. Critical revision of the article for important intellectual content: D.Y., L.R.S., W.A.S. and P.S.Final approval of the article: D.Y., N.G., P.S. W.A.S. and L.R.S.

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Declarations

Ethical considerations
In compliance with national legislation issued by the Ministry of Public Health, no ethical approval is required as the data analysis falls under public health surveillance. This report conforms to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Additional information
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Abbreviations

RTI	Road traffic injuries
RTD	Road traffic deaths
ED	Emergency department
RTF	Road traffic fatality
WHO	World Health Organization
SPSS	Statistical package for social sciences
MOPH	Ministry of Public Health
WHO	World Health Organization
GDP	Gross Domestic Product
EMR	Eastern Mediterranean Region
RTC	Road traffic crashes
ESU	Epidemiological surveillance unit
RTS	Revised Trauma Score
ISS	Injury Severity Score
AIS	Abbreviated Injury Scale
Ps	Probability of survival
GIS	Geographical Information System
GCS	Glasgow Coma Scale
SBP	the Systolic Blood Pressure
RR	Respiratory Rate
SWOT	Strengths, Weaknesses, Opportunities, and Threats