BRIEF REPORTS

Gaps in injury statistics: multiple injury profiles reveal them and provide a comprehensive account

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Objective: To demonstrate the benefit of using multiple injury profiles (MIP) as an alternative to ''primary diagnosis,'' for the presentation and analysis of multiple injuries in populations.
Methods: Retrospective analysis of national trauma registry data in Israel between 1 January 1998 and 31 December 2002. Multiple diagnoses per patient were recorded. A primary diagnosis was selected for each patient and data were presented twice: first by selecting a primary diagnosis and then using multiple injury profiles.
Results: 23 909 transport casualties were included. Findings show that MIP enable the identification of all patients with a specific injury, even where secondary. The proportion of additional injuries recorded when using MIP ranged from 12% in head injuries to 270% for facial injuries.
Based on the primary diagnosis patients with head, chest, and abdominal injuries had a 5–6% inpatient death rate each. Multiple injury profiles of the same population reveal that an isolated head injury has a 3% inpatient death rate, isolated chest and isolated abdomen have a 1% inpatient death rate, while combined head and chest casualties have a 21% inpatient death rate.
Conclusions: Multiple injury profiles are a new approach that enables presenting an improved picture of injury in a population.

Injuries are often characterized by multiple diagnoses. Multiple injuries are associated with greater severity, worse outcomes, and usually require treatment by a multidisciplinary team of physicians because of the involvement of several body regions or numerous injury natures.[1] Methods which estimate the increased risk to survival from multiple injury have been in use for years.[2–6] However, methods for presenting the details of multiple injury have not been standardized. As a result, statistical and epidemiological reports on hospital discharges often list the first listed/primary diagnosis,[7] losing information on the additional injuries. Alternatively, ''multiple injury'', with no further detail is reported,[8] and all information on injured body region is lost, again misrepresenting the true burden of injury.

Multiple injury profiles (MIP) are a new approach, used to record injury diagnosis combinations. MIP have been described by the authors using the Barell body region by nature of injury matrix[9] with a focus on the technical side of building the profiles[10] and the clinical aspects of using them.[1] The contribution of MIP application to the analysis and presentation of epidemiological data, and its benefits in comparison with using ''primary diagnosis'' are described here for the first time.

AIM

To demonstrate the benefit of using MIP as an alternative to ''primary diagnosis'' for the presentation and analysis of multiple injuries in populations.

MATERIALS AND METHODS

The study population consisted of casualties of transport accidents recorded in the Israeli national trauma registry between 1 January 1998 and 31 December 2002. The registry comprises all trauma admissions to eight hospitals from 1998–2000 and nine hospitals in 2001–2002 (all six level I trauma centers in Israel were recorded throughout the study period). Emergency department deaths (excluding Dead On Arrivals), and transfers to other hospitals were included. Information was retrieved from the registry and included, among other items: patient diagnoses, age, sex, external cause of injury, Injury Severity Score[2] (ISS), length of hospitalization, stay in the intensive care unit, and disposition. Transport casualties were defined as patients with an ICD-9-CM external cause of injury code from E800 to E848. Body region of injury was defined on the basis of the six body regions identified by Abbreviated Injury Scale (AIS). Up to 10 diagnoses per patient were extracted from the database. Body region of injury data for the study cohort was summarized using two methods, thus the same data are presented twice: once when a primary diagnosis was selected and then using MIP.

As no ''primary diagnosis'' was predefined in the Israeli dataset, this choice was simulated. Simulation was performed by selecting one most severe injury per patient (based on AIS severity digit) and where there were multiple injuries of identical severity in one patient, the selection was based on priority as follows (from highest to lowest priority): head (H), chest (C), abdomen (A), extremities (X), face (F), external (E).

Multiple injury profiles were built by creating vectors which take into account all injuries a patient sustained. Using the above mentioned six AIS body regions, a patient with an isolated head injury would have a profile of H-----, while a patient with a head and chest injury would have a profile of H-C---. The frequency distribution of these profiles in the population can be studied and analyzed as any other categorical population characteristic.

Data analysis was conducted using SAS software (SAS Institute, Cary, NC, USA).

RESULTS

The study population included 23 909 patients. This population was predominantly male (68%) and younger than 30 years (61%). Severe injuries (ISS ⩾16) were present in 18%, 14% had stayed in the intensive care unit (ICU), and 3.1% died in the hospital. The median length of stay was three days (interquartile range of 1–7 days). Forty six percent of the patients had multiple diagnoses. These patients were the more severely injured: 18% had critical injuries (ISS 25+) compared with only 2% in patients with isolated injuries.

Figure 1 presents the distribution of injured body regions using the two approaches. The grey area represents the

Abbreviations: AIS, Abbreviated Injury Scale; ICU, intensive care unit; ISS, Injury Severity Score; MIP, multiple injury profiles.

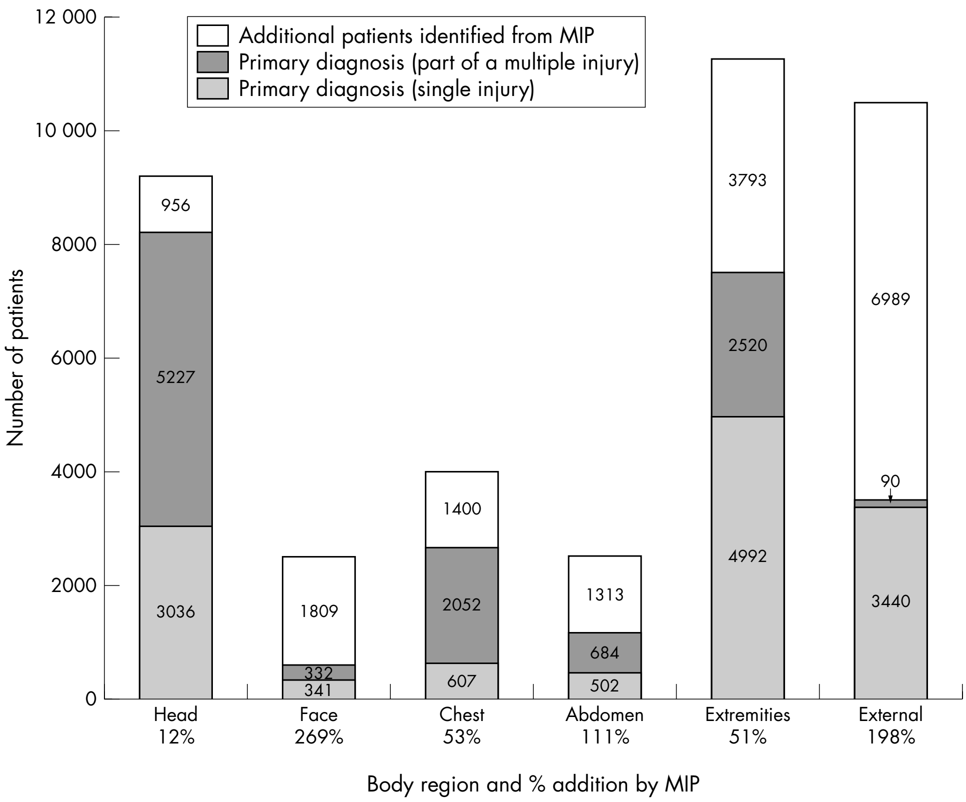

Figure 1 Percentages represent proportion of injuries which would be added if MIP is used, in relation to original number selected by primary diagnosis methodology (the total of single and multiple injuries selected by primary diagnosis).

distribution of diagnoses that would be identified when using primary diagnosis only, by body region. This grey area is separated into two where the light grey area shows how many of the injuries were single and thus would not be affected by the method, and how many of the injuries were part of a multiple injury (dark grey), and thus could benefit from MIP. The white area represents additional injuries identified by MIP. The proportion of additional injuries ranged from 12% in head injuries to 270% for facial injuries. The figure demonstrates that MIP enables identification of all patients with a specific injury—even if not primary—providing a better description of the hospital workload.

The significance of presenting the multiple injury profile is fortified by the results presented in table 1. Based on the primary diagnosis, observing inpatient death rate by body region suggests a 5–6% death rate each for patients with head injuries, chest injuries, and abdominal injuries. An examination of the MIP of the same population reveals that the death rate of patients with an isolated head injury is in fact 3%, isolated chest and isolated abdomen have a 1% inpatient death rate, while combined head and chest casualties are characterized by a 21% inpatient death rate.

The proportion of patients staying in an ICU was 22.5% among patients with a primary injury to the head. However, examination of MIP revealed that isolated head injuries resulted in 13% ICU care whereas this figure was 24% among patients with multiple injuries to the head and extremities, 50% among patients with injuries to the head and chest, and

Table 1 A comparison of results obtained by ''primary diagnosis'' methodology compared with selected results obtained by multiple injury profiles (MIP) using a full distribution of injury profiles

	Primary diagnosis				Multiple injury profiles (MIP)			
	Frequency distribution				Frequency distribution			
Injured body region	n	%	ICU(%)	Inpatient death (%)	n	%	ICU (%)	Inpatient death (%)
Total	23823	100.0	14.3	3.1	23823	100.0		
Head	8263	34.7	22.5	5.8	3036	12.7	13.1	3.1
Face	673	2.8	5.2	0.2	341	1.4	3.2	0.3
Chest	2659	11.2	32.0	5.3	607	2.6	8.1	1.2
Abdomen	1186	5.0	23.0	5.1	502	2.1	7.4	1.4
Extremities	7512	31.5	4.6	0.6	4992	21.0	2.7	0.3
External	3530	14.8	1.0	0.2	3440	14.4	0.8	0.2
Head and external					1949	8.2	9.2	1.1
Extremities and external					1656	6.9	3.7	0.2
Head and extremities					848	3.5	23.9	4.5
Head and chest					274	1.2	49.8	21.3
Head, chest, and extremities					254	1.1	64.2	22.6
Other combinations*					5924	24.9	33.8	7.1

86 patients (0.4% had no diagnosis recorded).
*Other combinations consists of a variety of combinations with three, four, five, and six regions involved.

64% among patients with injuries to the head, chest, and extremities.

DISCUSSION

This paper compares reports generated by using a primary diagnosis based on AIS to those produced by using MIP. MIP are shown to improve the completeness of injury statistics.

Previous work carried out by Aharonson-Daniel *et al* detailed the methodology for summarizing multiple injury diagnosis data into patient injury profiles using ICD-9-CM codes classified into the Barell body region by nature of injury diagnosis matrix.[1] The study concluded that profiles improve the understanding of casemix and can be useful for efficient staffing in multidisciplinary trauma teams and for various comparisons. The current paper takes this methodology and presents the benefits of using it in comparison with using a primary diagnosis to describe a population. AIS diagnoses were used as they enabled the choice of a most severe injury for the primary diagnosis using the severity digit attached to the AIS code.

Nearly half of transport casualties had multiple body regions injured. These are the patients for whom selecting a primary diagnosis results in loss of information. The use of a primary diagnosis associates outcomes with a certain injury even though these could in fact be a result of combination with another injury which was secondary and thus not presented. Furthermore, it is sometimes impractical to choose a ''primary diagnosis'', for example where two life threatening conditions exist, one to the brain and one to internal abdominal organs. Either one could be selected as the primary injury, but the truth is that the combination has more severe consequences than either single diagnosis alone. Results show that the association of severe outcomes to head or to chest injuries is wrong when in fact severe outcomes are due to the combination of head and chest injuries in one patient. The finding that the combination of head and chest, rather than each of them by itself, comprises the risk factor, may not surprise clinicians, but it stresses and validates the advantages of MIP to accurately present injury statistics, because this combination could not be shown using a single primary diagnosis method. MIP maintain information on the injuries sustained, enable the identification of injury patterns and combination of body regions injured, and eliminate the need to make choices as to which injury to include and which to not.

When presenting a primary injury rather than MIP, the injury picture may be incomplete. Later on, injury distributions may be used to decide on priorities for care or for prevention associated with certain injury mechanisms—using statistics that are not complete may lead to inappropriate plans. Knowing the precise pattern of injury incurred by crash victims is a key factor in being able to protect future casualties or improve their outcome. Although multiple injuries in one patient are a common occurrence, a review of the literature found that most studies that take into account multiple injuries either counted injuries regardless of how many patients had them,[11] or selected the group definition a priori, and divided the population into these predefined groups.[12] Bellamy recognized the complexity of this issue[13] but did not provide a solution. Methods of predefining and checking for expected combinations[12] could identify additional risks of multiple injuries; however, they are limited to the combinations anticipated by researchers. Furthermore, such predefined groups carry a subjective measure whereas MIP are structured so that they cover all options and can be easily replicated following standard AIS coding in this case, or ICD-9-CM as presented in earlier papers.[1 9 10] As shown by using these two coding classifications, the MIP concept can be further adopted for other classifications—be it the ICD-10, for which the Barell matrix will be available at a later point in time, ICD-9-AM (Australian modification), or other clinical modifications.[15]

Several limitations and issues that require further consideration still exist. The main issues are:

1. Patients with injuries to more than one body region are being referred to as a multiple injury while two injuries in the same region are being considered a single injury.
2. As a result of recording multiple injuries there is a possibility that minor injuries that do not have serious medical consequences are included. Excluding minor injuries and re-examining the dataset with the thought of accounting for multiple injuries within a region are among the next planned stages.
3. The categories used that represent AIS body regions here and Barell matrix unit in previous work[1] are very broad. Using more specific and detailed categories results in an increasingly large number of combinations of MIP, making the results hard to interpret. To cope with this problem, the methodology is demonstrated on the broader categories while the concept can be used for focused studies using more specific groups.

These issues and others have been discussed at the International Collaborative Effort (ICE) on Injury Statistics meeting.[14–16]

Key points

- Multiple injury profiles (MIP) summarize information on multiple injury and enable presentation of an improved picture of injury in a population.
- MIP maintain multiple injury detail, representing the true burden of injury. Increased inpatient mortality in specific injury combination groups is shown and benefits in comparison to ''primary diagnosis'' presentation are demonstrated.
- MIP enable identification of all patients with a specific injury, even when secondary.

CONCLUSION

Multiple injury profiles (MIPs) improve the ability to present injury in the individual and in a population. The use of MIPs facilitates the identification of all patients with a specific injury, even if secondary, providing a better description of the full pattern of injury.

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