Comparison of three different methods to estimate the burden of disease of burn injuries in Western Australia in 2011-2018

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Abstract

Background

Priority setting and resource allocation in health care, surveillance and interventions is based increasingly on burden of disease. Several methods exist to calculate the non-fatal burden of disease of burns expressed in years lived with disability (YLDs). The aim of this study was to assess the burden of disease due to burns in Western Australia 2011-2018 and compare YLD outcomes between three frequently used methods.

Methods

Data from the Burns Service of Western Australia was used. Three existing methods to assess YLDs were compared: the Global Burden of Disease (GBD) method, a method dedicated to assess injury YLDs (Injury-VIBES), and a method dedicated to assess burns YLDs (INTEGRIS-burns).

Results

Incidence data from 2,866 burn patients were used. Non-fatal burden of disease estimates differed substantially between the different methods. Estimates for 2011-2018 ranged between 610 and 1,085 YLDs per 100.000 based on the Injury-VIBES method; between 209 and 324 YLDs based on the INTEGRIS-burns method; and between 89 and 120 YLDs based on the GBD method. YLDs per case were three to nine times higher when the Injury-VIBES method was applied compared to the other methods. Also trends in time differed widely through application of the different methods. There was a strong increase in YLDs over the years when the Injury-VIBES method was applied, a slight increase when the INTEGRIS-burns method was applied and a stable pattern when the GBD method was applied.

Conclusion

This study showed that the choice for a specific method heavily influences the non-fatal burden of disease expressed in YLDs, both in terms of annual estimates as well as in trends over time. By addressing the methodological limitations evident in previous calculations of the non-fatal burden of disease, the INTEGRIS-burns seems to present a method to provide the most robust estimates to date, as it is the only method adapted to the nature of burn injuries and their recovery.

Introduction

Burden of disease calculations are an important resource in public health[1]. The burden of disease aggregates health consequences of a disease or injury in one metric and is increasingly used for priority setting and 'system level' resource allocation in health care, surveillance and interventions[2-4]. An important advantage of the burden of disease metric is that it allows quantification and comparison of the magnitude of health loss associated with different injuries and diseases. Burden of disease is often expressed in disability adjusted life years (DALYs)[5-7]. This metric is a composite measure that combines the years lost due to premature mortality (Years of Life Lost; YLL), and years of healthy life lost due to time lived in states of less than full health (Years Lived with Disability; YLD)[8,9].

In order to calculate YLDs, a set of disability weights is required as YLDs are derived by multiplying the number of cases of a disease or injury by a disability weight[10]. A disability weight reflects the health level that is associated with a non-fatal outcome, with zero representing perfect health and one representing death[2,11]. Several approaches exist to assess the burden of disease, which can lead to substantial differences in both YLDs and DALYs[12]. These approaches include eliciting disability weights and duration of disability by panel studies and expert opinion, and derivation of case-based disability weights from self-reported data from diseased or injured patients using a utility instrument[11]. Thus, it is important that researchers calculating DALYs and policy-makers that use DALYs for planning processes and priority setting in health care, are aware of impact of the parameters and assumptions on the number of DALYs of a certain disease or injury.

A key principle in calculating YLDs is to use case-based (i.e. based on self-reported patient data) disability weights to quantify the burden of disease of injuries[13,14]. Burn patients are a unique, identifiable group within injuries and it is well known that there is a wide variation of outcomes, varying from mild to severe consequences[15]. Within burn care related literature, several sets of case-based disability weights for burn injury exist[2,16-18], with one being recently developed[18] as older methods did not distinguish homogenous groupings of burns; and/or did not take the long period of recovery from burns into account. Differences among the available sets of disability weight relate to recovery phases and groupings for which disability weights were presented. Also differences exist in the definition of lifelong consequences of burns, particularly the time point at which health consequences that are considered to be lifelong[9,16,17].

In the global burden of diseases studies (GBD) burn DALYs are assessed[2]. The set of disability weights applied by the GBD differentiates six different disability weights for burns, based on burn size, body region involved and whether or not patients received treatment, for both short-term (0-12 months) and lifelong (>12 months) disability[2]. However, it is questionable if the GBD set of burn disability weights adequately captures the heterogeneity of burn injuries, allow for optimal linkage of data and disability weights, and whether methods used to assess lifelong consequences of injury are appropriate for burn injury[13]. This is exemplified by the greater proportion of patients with minor burns have lifelong consequences compared to patients with major burns, which is less plausible and contradicts previous available studies[19].

Another method that can be applied to assess burn DALYs is the INTREGRIS approach described by Haagsma et al.[16]. This approach aimed at improving the linkage between incidence data and disability weights by taking into account the heterogeneity among nature-of-injury groups. Gabbe et al. used a similar approach in the Injury-VIBES study to establish disability weights for injury[20]. This study used data from six injury studies to derive case-based disability weights for three of the burn injury groups defined by the GBD[17]. The Injury-VIBES study differentiated three disability weights for burns based on burn size and involvement of airways for both short-term (0-12 months) and lifelong (>12 months) disability. As burn patient outcomes are notoriously variable, a limitation of Gabbe et al.'s and Haagsma et al.'s study was the low number of burn patients that provided data to derive the burn injury disability weights. Therefore, the method developed by Haagsma et al. was adapted for burns recently[18]. In this INTEGRIS-burns study, outcomes from 3,401 burn patients were used to derive case-based disability weights and the proportion of burn patients with life-long consequences[18]. Fifteen disability weights were derived for three groups based on burn size and the proportion of patients who suffer from lifelong consequences was based on data collected at 24 months post-burn, as it was confirmed from literature that 12-months is too short to permit the complete recovery after burns? and, or for the maturation of scars[15,21]. Besides, the proportion of patients with life-long consequences was validated by experts in the field.

This adapted INTEGRIS-burns method is specifically tailored to burn injury and may be theoretically better substantiated; however, the impact on YLDs was not yet studied. Therefore, the aim of this study was to assess the burden of burns of Western Australia using the GBD, Injury-VIBES and INTEGRIS-burns methods and compare the resulting YLDs. The annual rates as well as trends in YLDs over time (2011-2018) were studied to explore the effect of applying the different methods on trends over time.

Methods

Dataset

Data were derived from the Burns Information Management System (BIMS) which is the registry of electronic health records of the Burns Service Western Australia[22]. The Burns Service Western Australia in Perth is the only adult burns unit in Western Australia and is located in the Fiona Stanley Hospital (FSH) in Perth. This burn unit is metropolitan based, but provides burn integrated statewide care for the whole burn-injured adult population, of which 80% live in and around the state capital city Perth. All patients who require surgery for their burn are referred to the FSH. All patients admitted to the burns service, including ambulatory patients managed at FSH, are included in the registry. Ambulatory patients who did not require surgery were not included in this study. Data from the registry was extracted by a data manager who anonymized the data. The non-identifiable nature of the data was checked by a second data manager before provision to the researchers. Data included all adult burn inpatients (≥18 years) irrespective of severity or percentage total body surface area (%TBSA) burned admitted between 2011 and 2018. Patients who died as a result of their burns were

excluded as we were interested in the non-fatal burden of disease of burns. Data recorded in the electronic health records and used in this study included information on patient and injury characteristics, including age at injury, gender, percentage total body surface area %TBSA burned, anatomical site(s) affected, number and type of surgeries, length of hospital stay (LOS), ICU length of stay, artificial ventilation, etiology and date of injury. This study was performed according to the principles of the Declaration of Helsinki and approved by the South Metropolitan Health Service Ethics Committee (registration number RGS2233-SP1). This data is accessed and analyzed with a waiver of consent based on the proviso of presentation of summarized or aggregated data.

Application of the three different methods

As described in the introduction, the three methods divided the burn population in different subgroups based on burn size (%TBSA burned), body region involved (including airways involved) and whether or not patients received treatment. Each of these subgroups was assigned a different disability weight for both the short-term and long-term, see Table 1. In order to calculate the non-fatal burden of disease of burns expressed in YLDs for the three methods, incidence data on subgroup level was combined with these pre-defined disability weights and with the pre-defined proportion of patients with lifelong consequences of each method. The following formula was used for the calculation of YLDs[23]:

$$\mathrm{YLD_x} = \sum \mathrm{i_x} \times \mathrm{t_x} \times \mathrm{dw_x}$$

Where the incident cases (i) for the category of burn patients (x) are multiplied by the duration of the consequences caused by burns (t) and the disability weight (dw) assigned to the certain group.

A proportion of patients with lifelong consequences was thus needed for each subgroup separately. The Injury-VIBES method presented updated disability weights for three groups defined by the GBD study; it did not assess the proportion of patients with lifelong consequences. Therefore, we used the proportion of patients with lifelong consequences from the GBD study to assess YLDs with the Injury-VIBES method. The GBD study calculated the proportion of lifelong consequences for the subgroups based on %TBSA burned; no proportion of lifelong consequences was presented for the subgroup based on lower airway burns. It was thus not possible to calculate the YLDs for the subgroup based on lower airway burns, therefore, all burn patients belonging to this subgroup were divided (based on their %TBSA) in the other subgroups (Table 1).

To define subgroups, age, gender, %TBSA and location of burn was needed. Age, gender, location of burn but not %TBSA was available for all patients; for 13% of the patients %TBSA burned was not registered. The Injury-VIBES method and the INTEGRIS-burns method described that patients without a known %TBSA should be included in the subgroup based on the lowest %TBSA burned, but this was not stated in the GBD method. In order to be able to include all patients in GBD method, this same rule was applied for the GBD method.

Table 1. Overview of the three different methods studied

Method	Subgroups	Short-term		Lifelong		
		Definition	**Disability weight[1]**	**Definition**	**Proportion with lifelong consequences**	**Disability weight**
GBD method	<20% TBSA burned without lower airway burns (with or without treatment)	≤12 months	0.154			
	<20% TBSA or <10% TBSA burned if head/neck or hands/wrist involved (with or without treatment)			>12 months	50%	0.019
	≥20% TBSA burned (with or without treatment)	≤12 months	0.262			
	≥20% TBSA or ≥10% TBSA burned if head/neck or hands/wrist involved (with treatment)			>12 months	22%	0.161
	≥20% TBSA or ≥10% TBSA burned if head/neck or hands/wrist involved (without treatment)[2]			*>12 months*	*NA*	*0.424*
	Lower airway burn: with or without treatment[3]	*ND*	*0.376*		*NA*	
Injury-VIBES method	Hospitalized; burn covering <20% TBSA or unspecified	≤12 months	0.131	>12 month	NA	0.110
	Hospitalized; burn covering ≥ 20% TBSA	≤12 months	0.176	>12 month	NA	0.156
	Hospitalized; lower airway burn[3]	*≤12 months*	*0.222*	*>12 month*	*NA*	*0.243*
INTEGRIS-burns method	<5% TBSA burned or %TBSA unknown	0-1 month >1-6 months >6-12 months >12-24 months	0.173 0.098 0.082 0.102	>24 months	20%	0.046
	5-20% TBSA burned	0-1 month >1-6 months >6-12 months >12-24 months	0.264 0.139 0.118 0.108	>24 months	25%	0.099
	>20% TBSA burned	0-1 month >1-6 months >6-12 months >12-24 months	0.497 0.262 0.231 0.163	>24 months	39%	0.122

[1]A disability weight reflects the health level that is associated with a non-fatal outcome, with zero representing perfect health and one representing death. [2]This subgroup was not used in present study as all patients received treatment. [3]It was not possible to apply these subgroups as no proportion with lifelong consequences was defined. Burn patients with lower airway burns were therefore divided in subgroups based on their %TBSA burned.
TBSA = total body surface area; ND = not defined; NA= not available

Calculation of the non-fatal burden of disease

YLDs were calculated by applying the before mentioned formula for each subgroup of each method separately (Table 1). For each subgroup, both the short-term (temporary) YLDs as well as the lifelong (long-term) YLDs were calculated and added to calculate the YLDs per subgroup. Subsequently, per method, the YLDs per subgroup were added to assess the total YLDs of burns. YLDs per case were calculated by dividing the total YLDs by the total number of patients in each year. YLD per case as well as the total YLDs were presented. Results of the three different methods were compared and trends in time from 2011 to 2018 were studied.

Results

Patients

In total, 2,866 adult patients were admitted and survived their admission to the burn center in Western Australia between 2011 and 2018. The yearly number of admitted patients ranged between 246 patients in 2011 to 457 patients in 2018. The mean age of the patients was 41.1 year (SD 16.9) and 68% were male. Mean %TBSA burned was 4.3% (SD 7.1) and range between 0 and 74%, with most patients (75%) having a minor burn (<5 %TBSA). The average time spend in hospital was 6.4 days (SD 9.9) and most patients underwent a surgical procedure (87.3%).

Table 2. Demographic characteristics dataset

Variable	Total sample (n=2,866)
Gender: male	1,949 (68.0%)
Age	41.1 (16.9)
%TBSA burned[1]	4.3 (7.1)
0-<5%	1,857 (74.8%)
5-20%	537 (21.6%)
>20%	90 (3.6%)
Length of hospital stay (LOS)	6.4 (9.9)
Number of surgeries[2]	1.1 (1.0)
0	303 (13.5%)
1	1,663 (73.9%)
>1	285 (12.7%)
Length of ICU stay	0.3 (2.6)
Mechanical ventilation, n(%)	83 (2.9%)
Anatomical site burned, n(%)	
Head/Face/Neck	576 (20.1%)
Trunk	638 (22.3%)
Arm/Hand	1,709 (59.7%)
Legs/Feet	1,735 (60.6%)
Etiology, n(%)[3]	
Scald	754 (28.2%)
Contact	442 (16.6%)
Flame	1,138 (42.6%)
Chemical	176 (6.6%)
Electrical	42 (1.6%)
Other	119 (4.5%)

Characteristics are presented as mean (SD) or number (%)
[1]382 missing; [2]615 missing; [3]195 missing. Unless otherwise noted, all data were complete.

YLDs per case for the three different methods

In 2018, the YLD per case was 0.3 when the GBD method was applied, 2.4 when the Injury-VIBES method was applied and 0.7 when the INTEGRIS-burns method was applied. The mean YLD per patient per year is displayed in Figure 1. The Injury-VIBES method resulted in the highest mean YLD per case and ranged between 2.5 in 2011 and 2.4 in 2018. The INTEGRIS-burns method ranged between 0.9 in 2011 and 0.7 in 2018 and the GBD method ranged between 0.4 in 2011 and 0.3 in 2018. Applying the Injury-VIBES method resulted in 6.8 to 9.0 times higher YLDs compared to the GBD method and in 2.9 to 3.3 times higher YLDs compared to the INTEGRIS-burns method. The INTEGRIS-burns on its turn resulted in 2.3 to 2.8 higher YLDs compared to the GBD method. Independently of the method applied, the YLD per case showed a downwards trend between 2011 and 2018 (Figure 1).

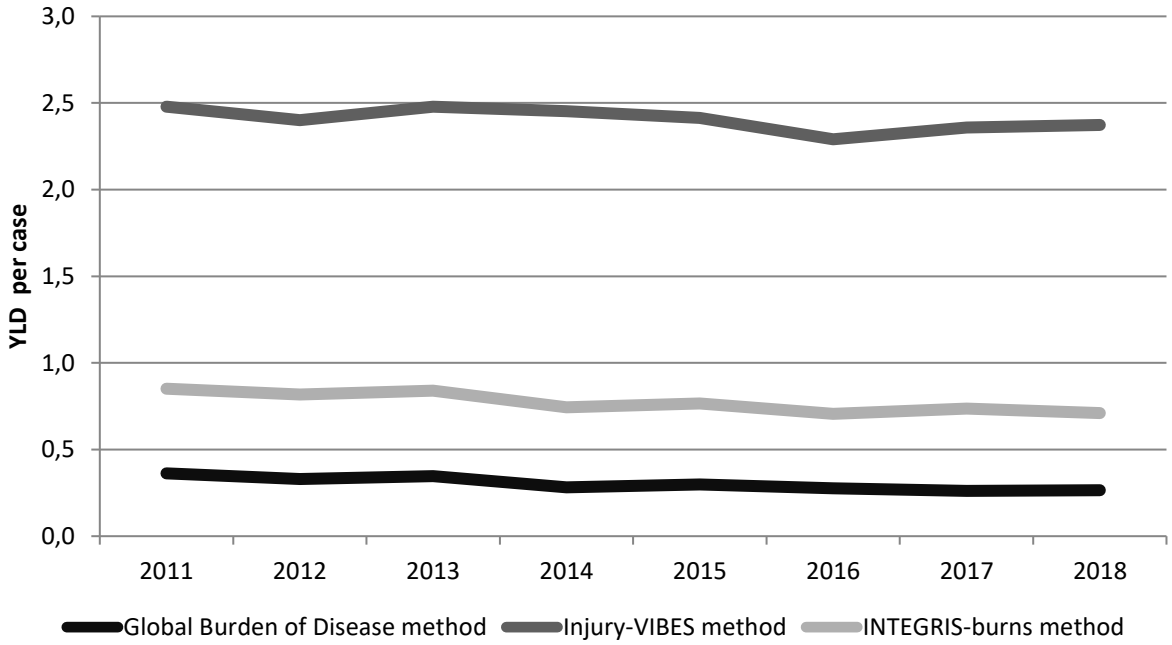

Figure 1. Estimates of the non-fatal burden of disease expressed as years lived with disability (YLD) per case for 2011-2018 based on the three different methods applied

Non-fatal burden of disease of burns of Western Australia

Figure 2 depicts the total YLDs for each method. The non-fatal burden of disease ranged between 609.8 YLDs in 2011 and 1084.8 YLDs in 2018 based on Injury-VIBES method; between 209.4 YLDs in 2011 and 324.3 YLDs in 2018 based on the INTEGRIS-burns method; and between 89.2 YLDs in 2011 and 120.8 YLDs in 2018 based on the GBD method. The method applied influences the trend in total YLDs seen between 2011 and 2018. Patterns of YLD over time varied by method. The Injury-VIBES approach resulted in a large increase of total YLDs over time, the INTEGRIS-burns method resulted in a slight increase in YLDs over time and the GBD method resulted in similar YLDs over time. The differences in trends are related to the distribution of %TBSA in the burn population (Figure 3). Especially the increasing number of patients with minor burns (<20% TBSA burned) lead to increasing YLDs over time for the Injury-VIBES method. The high percentage (50%) of patients in the <20 %TBSA group that are considered having lifelong consequences contributes to this increase.

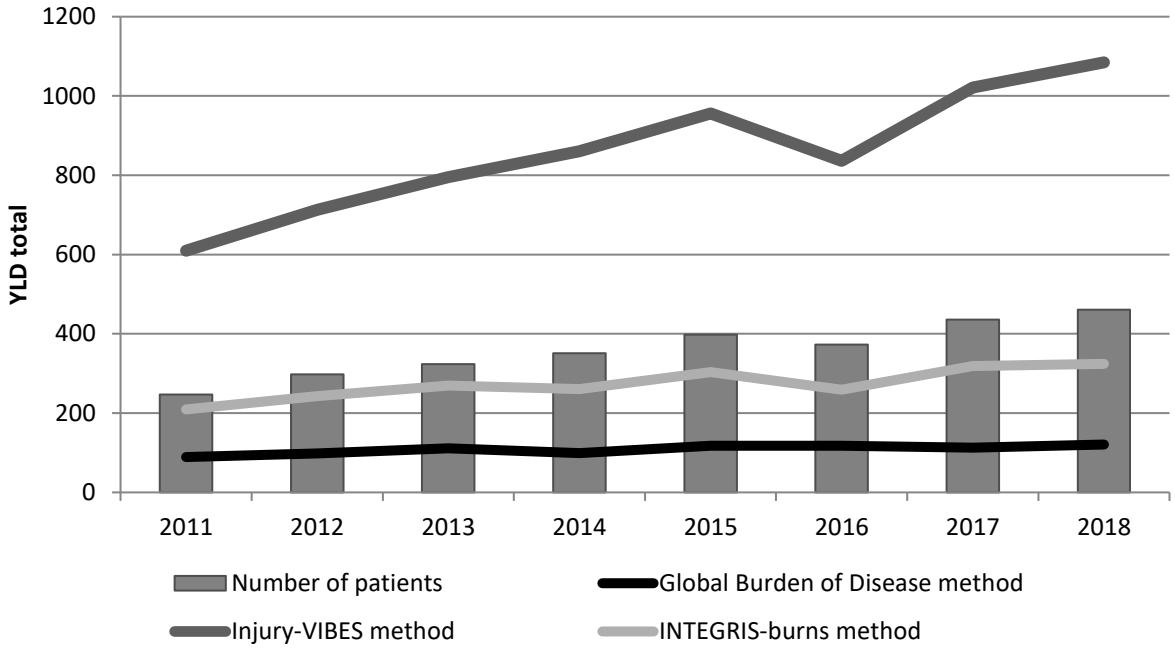

Figure 2. Estimates of the non-fatal burden of disease expressed as years lived with disability (YLD) for the total burn population of Western Australia in 2011-2018 based on the three different methods applied

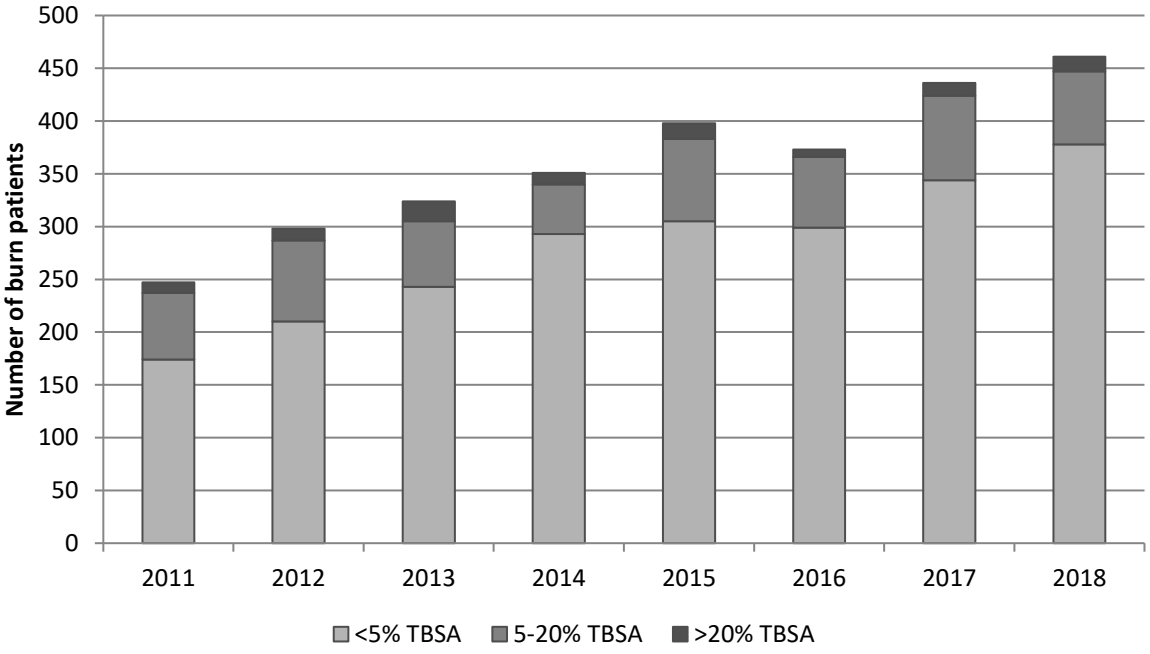

Figure 3. Number of burn patients according to %TBSA burned in Western Australia 2011-2018

Discussion

The aim of this study was to apply three methods to assess the burden of disease due to burns in Western Australia and compare the resulting YLDs. Application of the three methods resulted in large differences in the non-fatal burden of disease of burn injuries. YLDs per case assessed with the Injury-VIBES method were three to nine times higher compared to the other methods. Independent of the method applied, the YLD per patient showed a downwards trend between 2011 and 2018, showing that in general a greater proportion of the admitted burn patients were patients with minor burns. However, the total YLDs showed different trends depending on the method applied, with a high increase in YLDs over time when the Injury-VIBES method was applied, a slight increase when the INTEGRIS-burns method was applied, and a stable pattern when the GBD method was applied.

Main factors for the wide variation in mean YLD per case were the distribution over the burn categories, values of disability weights, and proportions of lifelong consequences. The proportion of lifelong consequences is not available for all subgroups in the GBD method; no proportion is available for the subgroup lower airway burns. Another remarkable component of this method is the fact that the proportion of patients with lifelong consequences is higher for patients with minor burns (<20% TBSA burned) compared to patients with major burns (≥20% TBSA burned): 50% versus 22%. This is contradicting to the general finding that major burns (higher %TBSA) are associated with a higher risk of long-term disability[19]. It is also highly contradicting with another study that assumed that none of the patients with minor burns have long-term disabilities[16], which is highly challengeable as well.

The estimates of the Injury-VIBES method and GBD method were based on the proportion lifelong consequences of the GBD method; though the YLDs calculated based on these two methods showed the largest differences. The differences are particularly caused the disability weights assigned to each subgroup by each of the two methods. Short-term disability weights are higher for the GBD method (0.154–0.262 vs. 0.131–0.176). However, long-term disability weights for the subgroup <20%TBSA burned are much higher (0.110 vs 0.019) for the Injury-VIBES method, whereas long-term disability weights for the group ≥20% TBSA burned are comparable (0.156 vs. 0.161). With most patients having mild and intermediate burns together with the high proportion (50%) considered having lifelong consequences in this group, the large difference in YLDs between the two methods are particularly caused by the long-term disability.

YLD estimations based on the INTEGRIS-burns method were in between the estimations of the other two methods. The INTEGRIS-burns method was developed specifically for burns to overcome the issues described above. This method divided the burn population in three easily identifiable groups and presented short-term (≤24 months) and long-term disability weights (>24 months) and the proportion of lifelong-disability for each of the three groups[18]. The proportions of patients with lifelong consequences were in line with the general idea that major burns (higher %TBSA) are associated with a higher risk of long-term consequences[19]. Next to differences in groups, disability weights and proportion of patients with lifelong proportions, disabilities caused by burns were considered as either resolved or permanent at

24 months, instead of 12 months, which was used in the other methods. We argue that this is a more plausible assumption as consequences of burns, including scar maturation and mental health problems, are frequently reported in the period beyond one year after burns[15,24]. Moreover, the newly derived disability weights were based on a sample of 3,401 patients compared to the small samples (n<100) used in the earlier studies. Both the more reliable recovery pattern as well as the better substantiated disability weights make the final YLD outcomes more robust based on the INTEGRIS-burns method than either of the other methods. However, in the absence of a gold standard, we are not able to come to conclusions on which method provides the most reliable estimates. Though, theoretically, we might argue that the INTEGRIS-burns method is better substantiated as it is the only one specifically adjusted for use in a burns cohort and based on a large number of burn patients across a broad spectrum of injury severity.

It should be noted that the present study had some limitations. It used a point proportion of patients with lifelong consequences for the GBD method, and consequently for the Injury-VIBES method. Whereas in fact the GBD proportion of patients with lifelong consequences is a probability distribution[25]. By using a point proportion estimate we have assumed that the proportion of patients with lifelong consequences was normally distributed, but it was not stated whether this was the case, which might slightly under- or overestimated the YLDs based on both the GBD method and the Injury-VIBES method. Besides, our study is limited by the inclusion of inpatients. As no outpatients have been included, we have presented the total non-fatal burden of disease of burns of those requiring inpatient care in Western Australia. As most outpatients have minor burns, a higher proportion of patients with minor burns might be expected. It is recommended that future studies assess the total non-fatal burden of burns by applying the most robust method. The inclusion of only inpatients did not influence the validity of the comparison of the three methods, which was the main aim of this study.

Conclusions

This study showed that the application of the three different methods resulted in large differences in the non-fatal burned of disease expressed in YLDs. The choice for a specific method heavily influenced the YLDs, both in terms of annual estimates as well as in trends over time. By addressing the methodological limitations evident in previous calculations of the non-fatal burden of disease, the INTEGRIS-burns method seems to present a method to provide the most robust estimates to date, as it is the only method adapted to the nature of burn injuries and their recovery.

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