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# The role of concomitant alcohol and drug use in increased risk for burn mortality outcomes

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ABSTRACT

*Background:* Burn injuries are a major cause of mortality and morbidity in low- and middle-income countries, with high rates in Sub-Saharan Africa. The risks may be heightened for persons who present with concomitant use of alcohol and illicit substances, which increase the risk for injury and severely compromise prognosis following injury.
*Methods:* This study utilised a national dataset on hospitalised burns in South Africa to explore the risk for mortality relative to morbidity. To assess the influence of alcohol and drugs in mortality outcomes, the analysis was restricted to adult cases, 18 years and older (N = 918). The primary statistical procedures used in the analysis were logistic regression models.
*Findings:* The results indicate that burn victims with full thickness and partial thickness burn degree and more than 30% TBSA had a significantly increased risk of mortality. In addition, the risk for mortality was increased ten times when concomitant alcohol and drugs were indicated compared to cases where these were absent. The length of stay in hospital diminished the risk for mortality by about 10%.
*Interpretation:* The findings may be explained by the role of skin as the main barrier against infections and the concurrent increase in risk of infection based on the degree and extent of any damage. The combined presence of both alcohol and drugs may predispose towards more severe burns and greatly compromise liver function with heightened risk for sepsis and death.


## 1. Introduction

### 1.1. *Alcohol and drug intoxication and risk for burn injury*

Burn injuries are a major cause of death and disability injury worldwide, accounting for almost 180,000 fatalities annually [1]. Low-to-middle-income countries (LMICs) carry the bulk of this burden [2] with almost two thirds of all burn injuries occurring in the African and South-East Asia regions [1].

When substance use and binge-drinking are involved, the risk for sustaining injury, including burn injury is increased because of impaired judgement, lack of inhibitory control and risk-taking behaviour [3]. The high-risk hypothesis has been proposed as a mechanism through which individuals are more likely to engage in unsafe behaviours, thereby increasing their risk for trauma exposure [3].

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South Africa is characterised by high prevalence of harmful and hazardous use of alcohol [4], alongside high consumption of illicit drugs [5]. Almost 40% of adults presenting with unintentional burns at a tertiary hospital in Bloemfontein, South Africa, reported the consumption of alcohol at the time of the incident [6]. Increasing levels of OTC addiction have been reported in recent years, especially the misuse of codeine-based drugs [7], with concurrent use of codeine and alcohol becoming increasingly problematic [7]. In addition to heightening risk for burn injury, burn injuries when alcohol and drugs are indicated tend to be more severe [8].

### 1.2. *Outcomes after burns in the presence of either alcohol or drugs*

The presence of either alcohol or drugs at the time of burn injury complicates the physiological recovery process and response to treatment, leading to increased risk for mortality. Alcohol presence at time of burn injury commonly results in pulmonary infection and liver damage, leading to depressed immunology and increased risk of sepsis, factors which interact negatively with the recovery process [9]. Resuscitation is more complicated for intoxicated individuals [8]. In the United States, alcohol use is indicated in over 50% of patients dying from burn injuries [10], while South African data for burn fatalities report high blood alcohol levels in 64.6% of males and 60.6% of females [11].

Unlike for alcohol, evidence examining the impact of drug use on burn mortality risk is conflicting. The risk for burn mortality was shown to be increased among poly-drug users compared to single-drug users [12]. Conversely, drug use was not found to impact mortality or the need for specialised care after burn trauma [13].

There is a paucity of research examining the concomitant use of alcohol and drugs in the context of burn injuries, and the role of both alcohol and drugs in immunomodulation and clinical outcomes [14–19]. The concurrent misuse of alcohol and drugs have been linked to higher incidences of bacteraemia and sepsis following burn injury compared to alcohol or drugs alone [14]. Though limited, the evidence does suggest a compound effect of alcohol and drug use on suppressing immunological responses and diminishing burn clinical outcomes.

### 1.3. *Treatment factors and burn mortality outcomes*

A delay in obtaining hospital treatment for burn victims is a major contributing factor to increased risk for contamination, infection, and death [20]. Risk for infection, blood loss, and mortality increase when essential antimicrobials and burn wound dressings are not promptly administered [20] and excision and grafting of the burn wound is delayed beyond 48 h of burn injury [20].

Studies suggest that longer length of stay (LOS) in hospital improves morbidity relative to mortality outcomes even in more severe cases [21]. This effect is amplified in the presence of specialised burn-care facilities, which assist in stabilizing the patient, preventing infection, and optimizing functional recovery [22].

### 1.4. *Burn injury characteristics as predictors of mortality*

Amongst the most robust predictors of mortality in burn injury are the burn injury characteristics. One of these is Total Body Surface Area (TBSA) covered by the burn [22]. Generally, burn trauma occurring over 20% TBSA or more leads to acute systemic physiological responses (burn shock) [22], while burn injury of 30% TBSA or more heightens the risk for mortality [9]. The second key criterion is the extent of thermal burn (degree and depth), with greater depth and degree of burn predictive of higher mortality outcomes [22].

The third criterion relates to the major type of burn injury, i.e. flame burn versus scalding. Flame burns are the leading causes of burn injury globally [23] and in South Africa [6]. Flame burn injuries have been associated with greater severity, greater body surface area and a higher risk for mortality [24].

### 1.5. *Age and gender as predictors of burn mortality*

Older persons have the highest risk of suffering a mortality outcome after burns [25]. This vulnerability is derived from the greater physiological impact as a result of diminished immunity and recuperative capacity [26], with poor tolerance for even small, shallow burns [27].

Gender differences in burn mortality vary considerably across and within regions and countries [26]. In HICs, male mortality rates are twice that of females in the 15–59 years age group, while the converse is observed in LMICs, especially in Southeast Asia and the Eastern Mediterranean [26]. In South Africa, Cape Town has reported the highest rates of burn mortality amongst adult males, nearly three times that of women [11].

The primary objective of this research was to examine the role of different burn injury characteristics, patient demographics, treatment variables and presence of alcohol and substance abuse in differentiating the risk of mortality relative to morbidity.

## 2. Methods

### 2.1. *Primary data collection*

This register-based study uses secondary data related to burn injuries for the period May 2006 to November 2012. Primary data was collected from 19 South African hospitals servicing primarily densely populated low-income settlements situated nearby major metropolitan areas in eight of the nine South African provinces. The data was collected as part of a larger study on household energy-related mortality and morbidity conducted by the Household Energy and Safety Association of South Africa (HESASA) [28].

Case records per admission included details on the cause, type and circumstances associated with admission and treatment for burn injuries. Additional data was collected through interviews with patients or caregivers at the time of admission, with all interviews conducted in the participant's first language. No names or any form of personal information were used that could identify participants. Due to low literacy levels amongst the participants, verbal informed consent was

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obtained. The study received clearance from the Health Research Ethics Committee (HREC) of the South African Medical Research Council.

### 2.2. Sample

The original dataset contains over 12 079 cases. Given the focus on alcohol and substance use, only adults 18 years and older were selected for the analysis, comprising less than 4000 cases. Of these, close to 1000 had complete data for all relevant analysis variables. This realised a final analysis sample of 918 cases.

### 2.3. Analysis

Descriptive statistics and logistic regression analysis were used to examine key sample characteristics and risk for mortality across a series of control and key explanatory factors. Analysis was performed using the Statistical Package for Social Sciences (SPSS) version 25, with a $p \leq 0.05$ significance level.

### 2.4. Outcome and explanatory variables

The outcome variable for the study was the occurrence of mortality as compared to morbidity. The following explanatory variables were employed:

Burn Injury Type — Burn injury categories were aligned to ICD-9 convention. Only external burns were considered due to attendant information on burn severity and extent of injury. The two predominant types were flame burns and scalds, with all other external burns excluded (less than 1% of sample).

Burn Degree — following general clinical convention, burn degree was differentiated into three categories in order of severity: superficial affecting only the epidermis, partial thickness affecting the epidermis and part of the dermis, and full thickness involving the epidermis, dermis and subcutaneous tissue [29].

Total Body Surface Area — TBSA was differentiated into two categories: less than 30% TBSA, and TBSA equal to or more than 30% [22]. The separation of TBSA into these two categories was due to mortality being the outcome of interest and the increased risk of mortality associated with TBSA of >30% [9].

Treatment Delay — the delay in days between occurrence of the burn injury and presentation of the patient at the hospital.

Length of Hospital Stay — the total number of days spent in hospital, in both specialised care and general wards.

Presence of Alcohol and Drugs: the presence of alcohol and drugs as reported or observed at admission. The variable comprised three categories: neither alcohol nor drugs, either alcohol or drugs, and both alcohol and drugs. Measurement of drugs included both illicit and OTC drugs.

Gender and age cohort were entered into the analysis as control variables.

## 3. Results

### 3.1. Descriptives

The average age of the sample was 36.4 years, with 55.2% being male. Scalds accounted for 3 in five burn injuries (59.1%). Most burn injuries were superficial (79.4%), with 9.7% recorded as full thickness. Nine in ten cases presented with TBSA of less than 30% (91.3%). The average delay in seeking treatment was 0.6 days, while average length of stay in hospital was 7.5 days. Alcohol or drugs were mostly absent (84.4%), and concomitant presence recorded in only 3.3% of cases. A mortality outcome was recorded for 3.8% of cases. Further differentiation of the key analysis variables by category of alcohol/drug use is provided (see Table 1).

### 3.2. Logistic regression analysis

Logistic regression modelling was performed in a sequential manner, generating and testing four models with new explanatory variables entered at each stage of progression.

Given the sequential nature of the logistic regression analysis, the four models tested are reviewed as a single set of results. The first model will be overlooked as it contains the control variables. Model 2, which introduces three burn injury variables, is statistically significant ($\chi^2 = 36.9$, $p = 0.00$). The nature of the burn injury (i.e. flame burn or scalds) does not significantly differentiate risk for mortality, while both burn injury clinical characteristics are significant. Mortality risk is four times greater for full thickness burn degree when compared to superficial burns (OR = 4.01, CI: 1.20–13.54), with no difference across superficial and partial thickness burns. Persons suffering burn injuries greater than 30% of TBSA are six times more likely to suffer mortality outcomes (OR = 6.58, CI: 2.23–19.39).

Model 3, which introduces the treatment delay and length of stay (LOS) variables, is also statistically significant ($\chi^2 = 49.6$, $p = 0.00$). Of these, only LOS is significant (OR = 0.89, CI: 0.81–0.99), indicating that patients remaining longer in hospital have an approximately 10% lower risk for mortality (Table 2).

The final model, incorporating alcohol and drugs, is shown to be significant ($\chi^2 = 63.1$, $p = 0.00$). When the effect for alcohol and drugs is controlled for, the risk for mortality increases for both full thickness (OR = 7.67, CI: 1.98–29.66) and partial thickness burn degree (OR = 4.15, CI: 1.19–14.50) in comparison to superficial burns, and for TBSA of 30% of greater (OR = 4.56, CI: 1.37–15.17). Secondly, LOS is associated with diminished mortality outcomes by 10%. Thirdly, and most importantly, when the injury clinical characteristics and treatment variables are accounted for, patients for whom both alcohol and drugs are indicated are ten times more likely to suffer mortality outcomes as compared to those for whom neither alcohol nor drugs is present (OR: 10.60, CI: 3.50–32.11), while the presence of either is not significant.

Taken together, the model testing indicates that burn victims with (1) full thickness or partial thickness burn degree (as compared to superficial), (2) burn injury over more than 30% of the total body surface area rather than less, and (3), where alcohol and drugs are both indicated rather than entirely absent, are at a substantially higher overall risk for mortality outcomes as compared to all other burn victims.

## 4. Discussion

The overall objective of this study was to assess several key clinical and treatment risk factors for differentiating risk of

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**Table 1 – Sample descriptive characteristics.**

| | No alcohol or drugs 776 (84.5%) | | Either alcohol or drugs 112 (12.2%) | | Both alcohol and drugs 30 (3.3%) | |
|---|---|---|---|---|---|---|
| | n | % | n | % | n | % |
| Gender | | | | | | |
| Females | 363 | 46.8 | 36 | 32.1 | 12 | 40.0 |
| Males | 413 | 53.2 | 76 | 67.8 | 18 | 60.0 |
| Mean age (SD) | 36.77 (15.1) | | 34.98 (11.9) | | 32.4 (7.5) | |
| Age | | | | | | |
| 18–29 years | 307 | 39.6 | 43 | 38.4 | 12 | 60.0 |
| 30–54 years | 375 | 48.3 | 61 | 54.6 | 18 | 40.0 |
| 55 + years | 94 | 12.1 | 7 | 7.1 | – | – |
| Burn injury type | | | | | | |
| Flame burns | 311 | 40.1 | 49 | 43.8 | 13 | 43.3 |
| Scalds | 465 | 59.9 | 63 | 56.3 | 17 | 56.7 |
| Burn degree | | | | | | |
| Full Thickness | 76 | 9.8 | 11 | 9.8 | 2 | 6.7 |
| Partial Thickness | 76 | 9.8 | 18 | 16.1 | 2 | 6.7 |
| Superficial layer | 624 | 80.4 | 83 | 74.1 | 26 | 86.7 |
| Total body surface area | | | | | | |
| >30% | 63 | 8.4 | 11 | 9.8 | 3 | 10.0 |
| <30% | 687 | 88.5 | 99 | 88.4 | 26 | 86.7 |
| Mean length of stay (SD) | 6.75 (16.5) | | 13.64 (27.1) | | 5.08 (18.2) | |
| Mean treatment delay (SD) | 0.42 (1.1) | | 0.46 (1.1) | | 0.16 (0.6) | |
| Outcome | | | | | | |
| Morbidity | 750 | 96.6 | 109 | 97.3 | 24 | 80.0 |
| Mortality | 26 | 3.4 | 3 | 2.7 | 6 | 20.0 |

mortality versus morbidity outcomes in an adult burn population. The current findings show that with respect to burn injury characteristics, the severity and extent of the burn injury are more important explanatory factors in mortality than the type of burn injury (i.e. flame or scalds). Consistent with established literature, risk for mortality increases concomitantly with greater severity (or burn degree) and larger extent (or TBSA) of burn [22,24].

In terms of treatment variables, it was observed that LOS has a significant effect on differentiating mortality from morbidity. Generally, length of stay in hospital is strongly positively associated with improved survival. This is due to improved prospects for survival based on care received, but also because patients with better chances of survival tend to stay longer in hospital. This is consistent with available literature [21]. Ideally, LOS should be primarily dependent on clinical factors; however, optimal length of hospital stay is often impacted by non-clinical factors. Facility constraints (absence of specialised burn units, limited bed capacity and lack of skilled personnel) in under- or unevenly resourced countries such as South Africa [30] may disproportionately increase the impact of non-clinical factors in determining LOS, and generally to the detriment of the patient. As a result, in some instances public hospitals may to resort to early discharge of hospitalised burn patients but for reasons of resource constraints rather than improved burn treatment. Additionally, in other instances, patients with small burns may have prolonged hospital stay and delayed grafting due to lack of such resources [31]. Hence the effect for LOS on mortality as observed in this study may arguably be much lower than it should be.

Results from this study have demonstrated the combined presence of alcohol and drugs as a major mortality risk factor following burn injury. Individuals presenting with both alcohol and drugs were over ten times more likely to die as a result of their burn injuries when compared to individuals for whom neither alcohol or drug use was reported. Though limited, research has demonstrated the adverse effect of both alcohol and drugs on burn outcomes [14–19]. A larger body of evidence exists for research focusing on either alcohol or drugs alone, and not on the concomitant use.

In contrast to existing evidence, either alcohol or drugs alone was not found to be a key contributing factor to burn mortality However, the combined effect for both alcohol and drugs is quite pronounced. In the field of general infectious diseases, alcohol and drug use have been shown to have a strong association to immunosuppression, leading to increased vulnerability to infections [32], which in the case of burn injury may contribute towards mortality risk.

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**Table 2 – Logistic regression analyses assessing mortality vs morbidity risk.**

| | Model 1: demographic variables | | Model 2: model 1 + burn injury Variables | | Model 3: model 2 + treatment variables | | Model 4: model 3 + alcohol/ drugs | |
|---|---|---|---|---|---|---|---|---|
| | $\chi^2 = 2{\cdot}4$, p = 0·49 | | $\chi^2 = 36{\cdot}9$, p = 0·00 | | $\chi^2 = 49{\cdot}6$, p = 0·00 | | $\chi^2 = 63{\cdot}1$, p = 0·00 | |
| | n = 918 | | n = 889 | | n = 883 | | n = 883 | |
| Mortality risk | O.R. | 95% C.I. | O.R. | 95% C.I. | O.R. | 95% C.I. | O.R. | 95% C.I. |
| Female | 1·65 | 0·83–3·30 | 1·82 | 0·88–3·73 | 1·79 | 0·86–3·27 | 1·85 | 0·87–3·93 |
| Male | – | | | | | | | |
| 55 years and older | 1·26 | 0·4 –3·64 | 0·59 | 0·2 –2·33 | 0·72 | 0·22–2·38 | 0·83 | 0·24–2·83 |
| 30–54 years | 1·07 | 0·51–2·28 | 0·98 | 0·47–2·17 | 1·02 | 0·47–2·23 | 0·99 | 0·45–2·22 |
| 18–29 years | – | – | | | | | | |
| Flame Burns | | | 0·41 | 0·15–1·10 | 0·44 | 0·16–1·22 | 0·40 | 0·14–1·13 |
| Scalds | | | | | | | | |
| Burn degree: full thickness | | | **4·01*** | 1·20–13·54 | **5·88**** | 1·58–21·91 | **7·67**** | 1·98–29·66 |
| Burn degree: partial thickness | | | 2·26 | 0·75–6·80 | **3·49*** | 1·03–11·84 | **4·15*** | 1·19–14·50 |
| Burn degree: superficial | | | | | | | | |
| More than 30% TBSA | | | **6·58**** | 2·23–19·39 | **4·68**** | 1·46–14·99 | **4·56*** | 1·37–15·17 |
| Less than 30% TBSA | | | | | | | | |
| Treatment delay | | | | | 1·01 | 0·99–1·02 | 0·99 | 0·99–1·01 |
| Length of Stay in hospital | | | | | 0·89* | 0·81–0·99 | **0·90*** | 0·81–0·99 |
| Both alcohol and drugs | | | | | | | **10·60**** | 3·50–32·11 |
| Either alcohol or drugs | | | | | | | 0·81 | 0·22–3·00 |
| Neither alcohol nor drugs | | | | | | | | |

The reference category is: morbidity.
* $p \leq 0.05$.
** $p \leq 0.05$.

The results for the combined presence of alcohol and drugs in burn victims have specific relevance to South Africa. Alcohol and drug prevalence are high [33] and underpinned by socially sanctioned risky or binge drinking reported by a quarter of the male population [34]. The country also records high rates of abuse of over the counter medication, with nearly 20% of the population reporting problematic codeine use [33]. There is furthermore the widespread use of open flames for the everyday cooking of food, using flammable hydrocarbons or biomass [35]. While most households in South Africa use electricity for everyday cooking, an estimated 34% use either paraffin or wood [35]. This is supplemented by outdoor open flame cooking practices, such as barbecues, which are common and often the centre of recreational and social interactions across socio-economic strata in the country [36]. The risks associated with greater use of open flames are compounded by the use of propellants or accelerants to start and maintain fires [36]. When alcohol and substance abuse are accounted for, this is likely to heighten the exposure of adult South Africans to severe burn trauma [33].

Finally, there are institutional factors which have relevance. Despite considerable policy reform and institutional transformation in the post-1994 democratic era, the national public health infrastructure and system remains beset by considerable constraints and challenges. Approximately 23% of the population report affordability constraints for medical care, with about 73% of that proportion being due to travel costs [37]. Given this scenario, poor burn victims located on the margins of big cities or rural areas have difficulties accessing prompt and specialised treatment. The high (20%) in-hospital mortality in South Africa's burn centres is not only a factor of severity and pre-existing conditions [38] but also influenced by the quality of healthcare services [37], with public health facilities significantly under resourced compared to the private health system. Consequently, for most burn victims there exists the reality of limited specialized burn treatment capacity, the high demand on trauma facilities, and the absence of specific screening for high blood alcohol and substance markers, all of which constrain the prospects of successful burn injury recovery, especially in severe cases.

## 5. Strengths and limitations

This study benefits from the large sample data which is rare, costly and complex to collect on this subject matter. The data covers eight of the nine provinces in the country, providing good national coverage though with a bias towards facilities situated close to major urban and metropolitan centres. There

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is variance across the facilities in terms of level of specialised care provided, which would impact risk of mortality based on duration of hospital stay. The final sample chosen for analysis was impacted by incomplete data (in some instances due to incomplete interviews and/or patient administrative records) which may reflect variable resources which correlate with differential risk outcomes. The presence of alcohol and/or drugs was based on reporting and/or observation at time of admissions and did not include information on prior history of use/abuse or related biomarker testing at admission or during hospitalisation. This indicates lack of data on amount of alcohol and drugs ingested over time or at admission, which relate to level of toxicity which may impact mortality risk. The approach could also have led to under- or over-recording of alcohol and drug cases. The set of burn admissions involving both alcohol and drugs may represent a distinct high-risk sub-population and hence findings are not always generalisable to the general population. However, the presence of such a high-risk category in the general population is important as it has considerable implications for the burden to the health system.

## 6. Recommendations

This study motivates several key recommendations regarding the risk for burn exposure and mortality risk following burn injury. Firstly, in terms of prevention, there is a need for improved focus by targeting of messages in the presence of specific contextual risk factors for burn exposure. In South Africa this would relate jointly to the high prevalence of alcohol and drug use, the greater use of open flames for routine and recreational purposes, and the combustion fuels and accelerants used for these purposes. This recommendation would extend to other similar contexts in LMICs subject to their specific conditions. In terms of treatment, the study highlights the need for improved screening for alcohol and drugs at admission for burn injury, to ensure that patients at greatest risk are triaged into higher levels of burn care as soon as possible, thereby improving overall prognosis and diminishing mortality risk. In contexts such as South Africa, this could potentially diminish the burden imposed on the under-resourced publicly funded health system by ensuring that scarce burn facilities are able to accommodate greater patient admission and discharges.

## Author contributions

Rajen Govender: conceptualisation, data analysis design, data analysis, write-up, review, final approval.

David Kimemia: conceptualisation, write-up, review, final approval.

Nancy Hornsby: data preparation, data analysis, write-up, review, final approval.

Ashley Van Niekerk: conceptualisation, write-up, review, final approval.

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## Declaration of interests

The authors have no conflict of interests to declare.

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