INTRODUCTION
The construction industry is one of the more hazardous industrial sectors, with high rates of injuries and fatalities.\(^1\)\(^,\)\(^2\) For example, in 2012, the construction industry was sixth (6.3\%) among the top 10 sectors with work-related injuries in Ireland.\(^3\) The other sectors were health and social work (19.8\%), manufacturing (16.8\%), wholesale and retail trade (11.6\%), public administration and defence (12.5\%), and transportation and storage (12.3\%). Fatalities and injuries on construction sites are attributed to several causes worldwide, the most common being falls from a high level, struck by a falling object or equipment, electric shock, and caught in-between equipment or fixed objects.\(^4\)\(^-\)\(^6\)

The number of reported fatal cases in the construction industry in different countries varies. For example, in the USA in 2013, construction industry fatalities accounted for 18.1\% of all work-related fatalities.\(^7\) In France, from 2002 to 2004, fatalities from the construction industry constituted 21\% of all accidents.\(^8\) In the Arkhangelsk region of Northwest Russia, from 1996 and 2007, 0.02\% of injuries were fatal.\(^9\) In Japan in 2010, the construction industry contributed 30.5\% of fatalities and 28.0\% of all work-related accidents\(^2\) – probably due to a more effective reporting system than other countries. The risk of fatal injuries among construction workers is higher in less developed countries compared to developed countries.\(^7\)\(^,\)\(^9\) For example, in the years 1996 to 2007, workers in the Arkhangelsk region were twice as likely to be involved in fatal accidents than workers in the USA.\(^7\)\(^,\)\(^9\)

The Construction Industry Development Board (CIDB) of South Africa reported that, in 2010, 0.02\% of workers in the construction industry in sub-Saharan Africa had been fatally injured and 16.01\% of all workers had experienced an injury.\(^10\) Somewhat different findings were reported from Uganda in 2008: 3.8\% of all workers in the construction industry had been injured and 0.01\% were fatally injured.\(^11\)

Tanzania, with a population of about 45 million people\(^12\) has 16 million people working in different economic sectors, including agriculture, hunting and forestry, fishing, mining and quarrying, manufacturing, electricity, and construction.\(^13\) The Integrated Labour Force Survey report of 2006 showed that 1.1\% of all workers worked in the construction sector, Tanzania: a comparison of risk factors between the construction and non-construction sectors, 1980 - 2009
industry and 31.6% of all construction workers worked in the Dar-es-Salaam Region. The same report showed that 2.2% of construction workers in the Dar-es-Salaam region were female. The Employment and Earning Survey conducted in 2012 indicated that the proportion of workers in the construction industry had increased to 2.9%.

In Tanzania, reports on fatalities and injuries are collected and summarised in an Accident and Diseases Register maintained in the Labour Commissioner’s Office in the Ministry of Labour and Employment. This has been compiled since 1949 for compensation purposes, after the enactment of the Workmen’s Compensation Ordinance Cap 263. Four years later, notification of accidents and occupational diseases was required under the Notification of Accidents and Occupational Diseases Ordinance of 1953 Cap 330.

The Accident and Diseases Register does not contain accident information for employees in the informal and agricultural sectors because they are not eligible for compensation. The variables contained in the Register include socio-demographic details such as age, sex and education level, as well as injury details, such as severity of injury and outcome (recovery or death). The information in the Register is obtained from accident notification forms that are submitted by employers, and medical reports from the attending medical doctor who treated the injured worker. The injuries entered in the Register are grouped into three main categories, namely “work-related fatality”, “severe work-related injury” (an occupational injury that leads to the hospital admission of a worker for more than three days), and “over three days off-duty” (an occupational injury that results in a worker being off duty – not hospitalised – for more than three days). Minor injuries that need first aid treatment and do not require time off work are not recorded. This is probably due to the fact that such injuries are not compensable, or their rates of compensation are very low, and hence they are not reported.

Despite the existence of the Accident and Diseases Register, the frequencies of fatalities and severe work-related injuries in the construction industry have not been analysed to determine trends. The analysis presented in this paper focused particularly on the Dar-es-Salaam region, in which the biggest business city is located (Dar-es-Salaam), where 2.6 million people live. It also contains most of the national government offices and is the hub of the country’s business sector. The data of injuries from other regions could not be analysed due to financial constraints.

We hypothesised that the risk for severe injury was greater among construction workers than among those of other industries. The aim of the study was to analyse the frequencies of fatalities and severe injuries, and to determine the risk factors for these injuries and fatalities within the construction sector, in comparison with the non-construction sectors in

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the Dar-es-Salaam region of Tanzania, in the context of the regulatory frameworks.

METHODS

Review of the Accidents and Diseases Register

The records of construction and non-construction workers in the Register were reviewed for the period January 1980 to December 2009. Trained research assistants extracted information from the Register. The transcription process from medical report to register was validated in a subsample of 213 cases.

DATA ANALYSIS

Frequencies of categorical variables, such as gender, level of education, age group, category of job, and work experience were calculated, as well as the causes of injury or fatalities. The outcome variables, work-related fatalities, severe injuries and “over three days off duty” injuries were described by cause of injury, such as falls from heights, hit by moving or flying objects, and slips and falls on the same level.

Absence of denominator data (numbers of workers employed in the construction or other industries) prevented the calculation of prevalence rates. However, comparison with the other sectors allowed for an understanding of the magnitude of effect in the construction sector. Chi-square tests were used to compare accidents and fatalities in the construction and non-construction industries. Odds ratios were derived from logistic regression models for fatal cases and reported injuries. Models were run for all cases, and additional models compared cases in the construction and non-construction industries. In each of these analyses, demographic factors, such as age group, education level, sex, and work experience were additional independent variables.

The study was approved by the University of KwaZulu-Natal Biomedical Research Ethics Committee (BREC) (ref. no. EXP003/06) and the National Institute for Medical Research (NIMR) in Tanzania. The Labour Commissioner’s Office provided permission for access to their records. Each fatality or injury was assigned a case number that was used to identify all information related to that participant. No individual identification data were extracted from the records.

RESULTS

A total of 36,004 fatal and non-fatal incidents were recorded in the Accidents and Diseases Register from January 1980 to December 2009. Of these, 3,815 (10.6%) were reported by the construction industry and the remainder (32,189; 89.4%) were reported by other industries. Overall, fatal cases accounted for 1.4% (n = 497) of all reported cases, of which 96 (0.3%) were from the construction industry. Females comprised less than 1% of the reported construction industry cases, and 8.7% of cases in the other industries (Table 1).

<table>
<thead>
<tr>
<th>Category</th>
<th>All cases</th>
<th>Fatal cases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 3,815</td>
<td>n = 96</td>
</tr>
<tr>
<td>Gender</td>
<td>n = 3,815</td>
<td>n = 96</td>
</tr>
<tr>
<td>male</td>
<td>3,783</td>
<td>96</td>
</tr>
<tr>
<td>female</td>
<td>32</td>
<td>0</td>
</tr>
<tr>
<td>Age group (years)</td>
<td>n = 3,815</td>
<td>n = 96</td>
</tr>
<tr>
<td>15-25</td>
<td>751</td>
<td>20</td>
</tr>
<tr>
<td>26-35</td>
<td>1,998</td>
<td>52</td>
</tr>
<tr>
<td>36-45</td>
<td>735</td>
<td>15</td>
</tr>
<tr>
<td>&gt;45</td>
<td>331</td>
<td>9</td>
</tr>
<tr>
<td>Work experience (years)</td>
<td>n = 3,815</td>
<td>n = 96</td>
</tr>
<tr>
<td>&lt;1</td>
<td>278</td>
<td>5</td>
</tr>
<tr>
<td>1-5</td>
<td>2,957</td>
<td>81</td>
</tr>
<tr>
<td>&gt;5 y</td>
<td>580</td>
<td>10</td>
</tr>
<tr>
<td>Education</td>
<td>n = 3,815</td>
<td>n = 96</td>
</tr>
<tr>
<td>never went to school</td>
<td>73</td>
<td>1</td>
</tr>
<tr>
<td>primary education</td>
<td>2,514</td>
<td>59</td>
</tr>
<tr>
<td>secondary education</td>
<td>882</td>
<td>29</td>
</tr>
<tr>
<td>tertiary education</td>
<td>289</td>
<td>4</td>
</tr>
</tbody>
</table>

*p value < 0.05, comparing each sub-category of the demographic factor with the remaining sub-categories
Table 2. Reported cases by cause of injuries or fatality in the construction and non-construction industries

<table>
<thead>
<tr>
<th>Cause of injury or fatality</th>
<th>Fatality</th>
<th>Severe Injury*</th>
<th>&gt; 3 days off duty**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cons n</td>
<td>Non-C n</td>
<td>Cons n</td>
</tr>
<tr>
<td>Fell from a height</td>
<td>31 32.3</td>
<td>6 1.5</td>
<td>268 8.5</td>
</tr>
<tr>
<td>Hit by moving or flying object</td>
<td>30 31.3</td>
<td>5 1.2</td>
<td>851 27.1</td>
</tr>
<tr>
<td>Hit by moving vehicle</td>
<td>13 13.5</td>
<td>12 2.9</td>
<td>373 11.9</td>
</tr>
<tr>
<td>Moving machinery or material being machined</td>
<td>8 8.3</td>
<td>6 1.5</td>
<td>65 11.2</td>
</tr>
<tr>
<td>Injured by animal</td>
<td>5 5.2</td>
<td>0 0.0</td>
<td>116 10.1</td>
</tr>
<tr>
<td>Exposed to or in contact with harmful substance</td>
<td>3 3.1</td>
<td>1 0.2</td>
<td>129 4.1</td>
</tr>
<tr>
<td>Electrical or an electrical discharge</td>
<td>2 2.1</td>
<td>5 1.2</td>
<td>48 1.5</td>
</tr>
<tr>
<td>Slipped, tripped or fell on the same level</td>
<td>0 0.0</td>
<td>1 0.2</td>
<td>414 13.2</td>
</tr>
<tr>
<td>Physical assault by person</td>
<td>0 0.0</td>
<td>0 0.0</td>
<td>147 4.7</td>
</tr>
<tr>
<td>Injured while handling</td>
<td>0 0.0</td>
<td>0 0.0</td>
<td>101 3.2</td>
</tr>
<tr>
<td>Exposed to fire</td>
<td>0 0.0</td>
<td>7 1.7</td>
<td>4 0.1</td>
</tr>
<tr>
<td>Hit or struck by object or something fixed or stationery</td>
<td>0 0.0</td>
<td>3 0.7</td>
<td>3 0.1</td>
</tr>
<tr>
<td>Trapped by collapsing structure</td>
<td>0 0.0</td>
<td>0 0.0</td>
<td>2 0.1</td>
</tr>
<tr>
<td>Injured by sharp edges, pinch point, nail</td>
<td>0 0.0</td>
<td>2 0.5</td>
<td>2 0.1</td>
</tr>
<tr>
<td>Asphyxiated</td>
<td>0 0.0</td>
<td>7 1.7</td>
<td>0 0.0</td>
</tr>
<tr>
<td>Exposed to explosion</td>
<td>0 0.0</td>
<td>1 0.2</td>
<td>0 0.0</td>
</tr>
<tr>
<td>Data not available</td>
<td>4 4.2</td>
<td>352 86.3</td>
<td>131 4.2</td>
</tr>
</tbody>
</table>

* Occupational injury which leads to admission of a worker to the hospital for more than three days
** Occupational injury which results in a worker being off duty (not hospitalised) for more than three days
Cons: Cases that were reported from construction industry
Non-C: Cases that were reported from non-construction industries
Among all severe and fatal injuries, there were significant differences in the proportions of cases between industry type (construction vs non-construction) and the various demographic categories, except for those workers in the 36–45 year age group and the 1–5 years of work experience category. When only fatal cases were analysed, the differences were not significant (Table 1).

The cause of injury or death was not stated for 159 (4.2%) and 6 911 (21.1%) cases from the construction and non-construction industries, respectively. Hit by a moving or flying object was the most common cause (26.7%) of all injuries, while falling from heights and hit by moving or flying objects were the main causes of fatalities among construction workers. These two categories accounted for 63.5% of fatalities among the construction workers. In the non-construction industries, the cause of a substantial number of fatalities (86.3%) was not mentioned, while the main causes of severe injuries were by sharp edges, pinch points or nails (24.9%) (Table 2).

The distribution of reported cases by job category in the construction industry showed that most accidents resulted in severe injuries (66.7–87.3%). For all job categories, the reported accident was most likely to result in a severe injury, rather than a fatality or days off work without hospitalisation (Table 3). Electricians were most likely to be fatally injured (9.1%), if they experienced an injury (Table 3).

Regression analysis results indicated a statistically significant increased risk for being either a fatality case or an injury case from the construction industry among the intermediate age groups (26–35 and 36–45 years). An increased risk was seen among those with some form of education compared to those without. Increased work experience was protective against being a case in the construction industry (Table 4).

The risk of being fatally injured in the construction industry was similarly increased across all demographic variables, but none reached statistical significance (Table 4). However, when adjusting for the various demographic variables, the risk of having a fatal injury was twice as high among those from the construction industry, than among those from other industries (OR 2.0; 95% CI: 1.6–2.5) (Table 5).

**DISCUSSION**

In terms of the cases reported in the Accidents and Diseases Register in Dar-es-Salaam in the study period, construction workers have a two-fold greater risk of experiencing a fatal injury, compared to their non-construction industry counterparts.

The percentage of construction sector fatal injuries among all fatal injuries reported was 19.3% while, within the sector itself, fatal injuries accounted for a modest 2.5% of all injuries reported. These data are at variance with those reported in other countries. For instance, in the construction industry in sub-Saharan Africa in 2010, 0.02% of workers were fatally injured and 16.01% experienced some injury.10 The analysis of occupational injuries conducted in Korea from 1997 to 2004 showed that the fatalities in the construction industry constituted 42.2% of total fatal occupational injuries, and the one-year mortality was higher in the construction industry (23.7/100 000 persons) compared to non-construction industries (10.4/100 000 persons).19 In 2014 in Britain, fatal injuries in the construction industry contributed 31% of all fatal injuries despite the fact that...
the construction industry employs approximately 5% of employees in that country. In 2009, a similar situation prevailed in Mexico where the fatalities were marginally higher in the construction industry (7.9% of all industries) compared to other sectors, such as the metallic products sector (7.4%), and the manufacture of rubber and plastic products (3.5%).

Limited research comparing fatal injuries in the construction industry and other industries has been conducted worldwide. A study on fatal and non-fatal occupational injuries among immigrant and non-migrant workers in Korea in 2007 showed that the risk of fatal cases for migrant workers compared to non-migrant workers was higher in the construction industry than in other industries (RR 23.9, 95% CI 16.6–34.3 for the construction industry; RR 1.7, CI 1.1–2.5 for the manufacturing industry, and for other industries RR 0.7, 95% CI 0.3–1.3).22

The possibility of being injured in the construction sector was increased for males in the 26–45 year age group with some formal education (49.7%–54.2%). This age group has been shown to be at high risk in other studies, where proportions of injuries range from 17.9% to 60.0%. Counter-intuitively, those workers who had some formal education were twice as likely to be injured in the construction sector compared to those with no education. The finding is contrary to previous reports. A study conducted in central China showed that the prevalence of work-related injuries among workers with six or fewer years of formal education was higher (17.7%) than that in workers with more years of formal education (for those with 7–9 years of education, prevalence was 13.9%; for those with more than nine years of education, prevalence was 14.5%).

It is possible that those with higher levels of education perform more skilled tasks which have greater risks compared to the purely manual and less risky types of work conducted by those without formal educations. Unfortunately, we did not have the necessary data to test this hypothesis.

Almost 11% of all reported cases were from the construction sector. This is similar to the findings from a previous study in Dar-es-Salaam in 1990, which showed that 10% of accidents was contributed by the construction sector. The findings of this latter study concurred with other reports that the causes of injuries are due to falls from heights (7.0%–52.7%), motor vehicle accidents (3.0%–23.4%), and electrocutions (5.0%–9.6%). This may suggest a lack of adequate safety measures with regard to manual handling and the movement of equipment, machinery, objects or vehicles on construction sites.

The 1990 report indicated that 9.6% of fatalities were in the construction industry, a substantially lower estimate. The 1990 report indicated that 9.6% of fatalities were in the construction industry, a substantially lower estimate.
than our findings of almost 20%. This is probably an indication of the increase in construction work in Dar-es-Salaam over the last decade, with projects of a much larger scale which are, consequently, more hazardous.27

“... our findings of almost 20% (of fatalities) ... is probably an indication of the increase in construction work in Dar-es-Salaam over the last decade.”

While, in the majority of cases, the causes of injuries are similar to those reported elsewhere, some factors seem to be unique, such as that of being injured by an animal (10% of injuries in the construction sector). This may be as a result of working in more rural areas within the region and being exposed to wild animals; or, in the semi-urban areas, large domesticated animals. This also implies inadequate securing of working environments, allowing for entry of animals into workspaces. Thus, in addition to focusing on hazard controls for the traditional causes of injury (slips, falls and moving objects), the industry in places such as the Dar-es-Salaam region must ensure appropriate access controls on worksites.

A major limitation of this study was the absence of data on the total numbers of workers employed in the various industrial sectors. This made it difficult to compare the prevalence of outcomes across the sectors. However, it was possible to show the trends across the various demographic variables, and using “all reported cases” as a denominator. It was also possible to compare construction and the other sectors’ differences across the most extreme of outcomes, namely fatalities.

These findings provide evidence for the need for further investigation into factors that increase the risk of severe injuries and fatalities in the construction sector. A concerted effort needs to be made to identify risk factors in the construction industry, and interventions need to be implemented. Training, improved health and safety standards, enforcement of legislation, and improved supervision, are some of the considerations. Training programmes for those workers entering the industry should be developed to foster a health and safety culture and to increase the level of awareness and knowledge among workers. In addition, proper supervision of workers by competent persons who have a sound knowledge of health and safety is required as part of the industry standards.
Over the last couple of decades, Tanzania has addressed the legislative and regulatory framework for occupational health. These have included the establishment of a regulatory authority, the Tanzania Occupational Safety and Health Authority; promulgation of regulation, and the development of advanced education and training programmes. Despite these developments, our findings argue for a comprehensive accident and occupational diseases reporting and notification system to be established that will record not only severe injuries, but also near-miss and property damage data. The system should include informal sector and self-employed persons, and could include incentives for reporting and disincentives for not reporting.

LESSONS LEARNED

- Construction workers have a two-fold greater risk of being involved in a fatal injury, compared to non-construction industry workers
- Practitioners need to be aware that more highly educated workers could have a greater risk for injury
- Falls from heights, hit by moving or flying objects and hit by moving vehicles are the leading causes of fatal and other injuries in the construction industry and require particular control in the working environment

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

REFERENCES