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How safe are industries in India? Ascertaining industrial injuries in Dadra and Nagar Haveli, India by capture-recapture method

Sajjan S Yadav

Secretary Health, Daman and Diu and Dadra and Nagar Haveli, Moti Daman, Daman and Diu, India

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Correspondence Address:

Dr. Sajjan S Yadav

Secretary Health, Daman and Diu and Dadra and Nagar Haveli, Secretariat, Moti Daman, Daman and Diu - 396220 India

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Abstract

Context: Every year, more than 4 million people die from injuries worldwide. India reported 413,457 deaths due to unintentional injuries in 2015. Manufacturing industry is a major contributor to injury morbidity and mortality. **Aims:** This study aims to estimate the burden of industrial injuries in Dadra and Nagar Haveli, India. **Settings and Design:** Dadra and Nagar Haveli is a small territory spread over 491 sq. km, having a population of 343,709 as per 2011 population census. **Methods and Materials:** The two-sample capture-recapture method was used for ascertainment of fatal and non-fatal injuries reported from 1st January to 31st December 2017. The first capture was data of injuries extracted from First Information Reports registered by the police. The recapture was data of injuries reported by the government health facilities. **Statistical Analysis Used:** Chapman estimator was used to derive total fatal and non-fatal injuries. An analysis was done using Microsoft Excel software. **Results:** According to police records, there were nine fatal and eight non-fatal injuries during the study period. Health facilities reported 21 fatal and 113 non-fatal injuries. Six cases of fatal and 3 cases of non-fatal injuries were found in both the data sources. The capture-recapture analysis estimated 30 fatal (95% CI: 20 to 40) and 225 non-fatal injuries (95% CI: 90 to 420). **Conclusions:** Both records of police and government health facilities underestimate fatal and non-fatal injuries with under-reporting more pronounced in police records.

Keywords: Capture-recapture, Dadra and Nagar Haveli, DALYs, industrial injuries, NCRB, SRS

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Introduction

Background/rationale

Injuries contribute significantly to the global burden of morbidity and mortality. The worldwide rate of unintentional injuries has been estimated to be 61 per 1,000 populations with 90% occurring in low and middle-income countries (WDR, 1993). More than 4 million people die from injuries, whereas 138 million Disability Adjusted Life Years (DALYs) are lost every year (ibid). The younger population is more prone to fatal and non-fatal injuries and DALYs. In India too, injuries are emerging as a major public health problem. National Crime Records Bureau (NCRB) has reported 413,457 deaths due to unintentional injuries in India in 2015, an increase of 40.5% compared to 2005 (NCRB, 2015).^[1] Sample Registration Survey (SRS) informs that injuries contributed 10.7% to total deaths in India in 2010–2013 (SRS 2010–13, 2014).^[2] Age stratification of injuries reveals that people in 15–29 years age group are affected the most with 44.6% deaths due to injuries followed by the 30–44 year's cohort with 25.7% deaths (SRS 2010–13, 2014). Gender segregation of SRS data informs that injuries are the cause of 12.4% deaths in male and 8.4% deaths in females.^[2]

After road traffic collisions, workplace accidents are the next major cause of injuries in India (CGHR, 2015).^[3] The International Labour Organization (ILO) has estimated that there were 47,000 fatal and 44.1 million non-fatal work-related accidents in India in 2003 (ILO, 2008).^[4] ILO has also informed that workplace injuries are vastly under-reported in India (Takala, 2005).^[5] Industrial accidents are important contributors to workplace injuries and preventable death and disability. There were 361,994 registered factories in India in 2014, which had employed 200,34,859 workers (OHS Profile India, 2017).^[6] In the same year, 1,141 fatal and 25,173 non-fatal injuries were reported in these factories (DGFASLI, Standard note, 2014).^[7] However, with only the formal sector, comprising just 3% of total industries, required to report injuries, high under-reporting and many states not compiling and reporting injury data, this number is believed to be a gross underestimation (Parachute, 2015).^[8]

Injuries put an enormous financial burden on the poor industrial workers. Aside from hospitalization and treatment expenses, injuries also lead to a decline in earnings and rehabilitation cost. Moderate and severe grade injuries may lead to poor quality of life and have long-term psychosocial impacts. Although there are laws like the Employees' State Insurance Act, 1948 and the Workmen Compensation Act, 1923 to compensate injured workers and families of the deceased, they cover only a small segment of workers. The amount of settlement is inadequate too.^[9]

This study is nested in Dadra and Nagar Haveli, a small territory of India having an area of 491 sq. km and a population of 343,709 as per 2011 population census (Districts.nic.in, 2018).^[10] It is in the western part of the country and is administered directly by the federal government (Dnh.nic.in, 2018).^[11] The territory was declared as an industrially backward area by the Government of India in the year 1971, and several incentives were announced to attract industries to the territory (Dcmsme.gov.in, 2018).^[12] This led to an influx of investors who have set up 3,175 industrial units employing 95,000 workers. The top three industrial sectors are textiles (36%), basic metals (15%), and rubber and plastic (10%) (Industrial Policy, 2015).^[13]

Aims and objectives

This study aimed to estimate the burden of fatal and non-fatal industrial injuries in Dadra and Nagar Haveli, India. Effectively highlighting this emerging public health problem may lead to the development of policies and programs to reduce the burden and provide a strong social security net to the victims.

Material and Methods

Study design

This study has deployed capture-recapture method for ascertainment of injuries. Originally developed in wildlife biology and demography, capture-recapture methods have also been successfully applied in epidemiology to enumerate difficult-to-count populations using multiple, overlapping but incomplete data sources (Hook and Regal, 1995).^[14] For this study, a case was defined as any injury, fatal or non-fatal, occurring in the territory of Dadra and Nagar Haveli from 1st January to 31st December 2017 due to an accident in any of its 3,175 industrial units.

This is a two-sample capture-recapture study. The first capture is data of accidents extracted from the First Information Reports (FIRs) registered by the police. The recapture is data of such injuries, as per WHO's International Classification of Diseases, version 10 (ICD10) reported in government health facilities, both in Outpatient department (OPD) and casualty. Records of government health facilities are expected to capture a large proportion of injuries because it is a remote part of the country where quality private health facilities are not available. Moreover, private health facilities are usually reluctant to entertain such cases which involve administrative procedures and police enquiries. Gumber (2012)^[15] reports that about three quarters of all injuries involving hospitalization and one-quarter of non-hospital based injuries were treated by public health facilities.

Matching procedure

For each of the two sources, a computerized database in Microsoft Excel was created containing the variables: name of the victim, father's name, age, sex, date of occurrence, and place of occurrence. Police data also contained name of police station while health facility data also included the date of treatment or admission. Thereafter, in each of the two databases, the list was arranged in alphabetical order of names of victims. The data in each list was cleaned, and the duplicates in each list were removed. Thereafter, an additional field, "data-source" was added and was appropriately populated with "police" or "health" as the case may be. Finally, the two lists were merged in an excel sheet, and information was again arranged in alphabetical order of names of victims. Matching of cases in the two lists was conducted using the variables name, father/husband's name, age, sex, and date of occurrence to identify unique individuals in the two databases. Where all the variables did not match, relaxing matching was used. In cases where father's name was not available, a case was considered as matched if name, age, sex, and date of occurrence matched. After completing the matching exercise, the names were replaced by codes for data security and ethical reasons.

Statistical methods

Total fatal and non-fatal injuries among the factory workers in Dadra and Nagar Haveli were derived using the Chapman estimator in a two-sample capture-recapture model (Wittes and Sidel, 1968; McCarty *et al.*, 1993).^{[16];[17]} Completeness of police and hospital data sources was also estimated. The total number of non-fatal injuries was estimated using the following formula:

$$\text{Total injuries } (N_i) = \frac{(H_i + 1)(P_i + 1) - 1}{m + 1}$$

Where, H_i is the number of non-fatal injuries to industrial workers as per records of health facilities. P_i is the number of people injured as per records of the police. m is the number of people identified in both the databases (i.e. matches). The variance was estimated using the following formula:

$$\text{Variance} = \frac{(H_i + 1)(P_i + 1)(H_i - m)(P_i - m)}{(m + 1)^2(m + 2)}$$

An approximate 95% confidence interval (CI) for the estimate of n was estimated using the following formula:

$$95\% \text{ CI} = \sqrt{n \pm 1.96 \text{Variance}}$$

Similarly, the total number of fatal injuries because of industrial accidents was estimated by using the following formula:

$$\text{Total fatal injuries } (N_d) = \frac{(H_d + 1) (P_d + 1) - 1}{m + 1}$$

Where, H_d is the number of people died in accidents in factories as per records of health facilities.

P_d is the number of people died in accidents in factories as per records of the police. m is the number of people identified in both the databases (i.e. matches).

The variance was calculated using the following formula:

$$\text{Variance} = \frac{(H_d + 1)(P_d + 1)(H_d - m)(P_d - m)}{(m + 1)^2 (m + 2)}$$

An approximate 95% CI) for the estimate of n was calculated using the following formula:

$$95\% \text{ CI} = \sqrt{n \pm 1.96 \text{Variance}}$$

Injury prevalence rate per thousand industrial workers (R_i) was calculated by dividing the total number of non-fatal injuries N_i as the numerator by the total number of workers (W) as the denominator and multiplied by 1,000 as shown below:

$$R_i = N_i / W * 1000$$

The death rate due to industrial accidents per thousand industrial workers (R_d) was calculated by dividing the total number of fatal injuries N_d as the numerator by the total number of workers (W) as the denominator and multiplied by 1,000 as shown below:

$$R_d = N_d / W * 1000$$

Ethical approval

This study is approved by the Research Ethics Committee of Vinoba Bhawe Civil Hospital, Dadra and Nagar Haveli.

Results



Fatal injuries

According to the police records extracted from the FIRs, there were nine fatal injuries due to accidents in the industries in Dadra and Nagar Haveli in the year 2017. All the deceased were male. According to Health facility data, there were 21 deaths of industrial workers in 2017.^[5] Of these, 50% were brought dead to the hospital, whereas the rest expired after admission. There was one female and 21 male workers among the dead.

There were six unique cases that appeared in both the databases. Thus, using the Chapman estimator, the total estimated number of fatal injuries is calculated as under:

$$\text{Total fatal injuries } (N_d) = \frac{(21 + 1)(9 + 1) - 1}{(6 + 1)}$$

$$= 30.42$$

As the answer must be truncated and not rounded, the estimated number of fatal injuries is 30.

$$\text{Variance} = \frac{(21 + 1)(9 + 1)(21 - 6)(9 - 6)}{(6 + 1)^2(6 + 2)}$$

$$= 25.25$$

$$95\% \text{ CI} = \sqrt{n \pm 1.96 \text{Variance}}$$

$$= 30 \pm 1.96 (5.025)$$

$$= 30 \pm 9.85$$

Thus, the 95% CI for the estimated number of fatal injuries is from 20 to 40 per year.

Non-fatal injuries

As per police records, there were eight non-fatal injuries at the workplace during the year 2017.^[5] All the victims were male. In only one case, two persons were injured, whereas in the remaining cases,

there was one victim per accident. However, as per the records of Health facilities, there were 113 non-fatal injuries suffered by workers in the industrial units during the study period. Out of them, 106 victims were male, whereas seven victims were females. Matching the details of victims between police and Health department records revealed that three victims are common to both the lists.

By applying Chapman estimator, total non-fatal injuries estimated from police and health facility records are

$$\text{Total non - fatal injuries } (N_i) = \frac{(113+1) (8+1)-1}{3+1}$$

= 255

$$\text{Variance} = \frac{(H_i+1)(P_i+1)(H_i-m)(P_i-m)}{(m+1)^2(m+2)}$$

$$= \frac{(113+1)(8+1)(113-3)(8-3)}{(3+1)^2(3+2)}$$

= 7.053

$$95\% \text{ CI} = \sqrt{n \pm 1.96 \text{Variance}}$$

= 255 ± 5.21

Thus, at 95% CI, the estimated number of non-fatal injuries ranges between 250 and 260 per year.

Further analysis of the health department data revealed that only 20 victims required hospitalization, whereas the remaining 93 were treated in OPD. Details of body part injured are shown in [Table 1] below.

Body Part	Number of Cases	Percentage
Head	8	7.08%
Hand including fingers	41	36.28%
Back	4	3.54%
Foot	11	9.73%
Leg	11	9.73%
Abdomen	3	2.65%
Face	2	1.77%
Eye	3	2.65%
Chest	1	0.88%
Shoulder	4	3.54%
Multiple body parts	1	0.88%
Details not available	24	21.24%

Table 1: Body Parts Injured in Industrial Accidents

[Click here to view](#)

As discerned from the table above, hands including fingers are the most vulnerable to injuries accounting for 36.28% of total injuries followed by leg and foot which in total accounted for 19.46%. Head injuries contributed 7.7%, whereas back injuries accounted for 3.54%. In 21.24% cases, the information regarding body part injured was not available.

Prevalence rate

On the basis of study, the estimate of fatal and non-fatal injuries using the capture-recapture method, the injury prevalence and death rate were estimated. The estimated number of industrial workers in Dadra and Nagar Haveli is 95,000. Thus, injury prevalence is estimated as 2.63 to 2.74 per thousand workers at 95% CI. The death rate because of industrial accidents in Dadra and Nagar Haveli is estimated as 0.21 to 0.42 per thousand workers at 95% CI.

Discussion



Key results

The analysis of data shows that the rate of ascertainment of fatal and non-fatal injuries in Dadra and Nagar Haveli, India both by police records and health facility records was incomplete. Police records have surprisingly captured only 30% of the deaths while health facilities captured 70% of the estimated deaths. This is surprising as every death case must be reported to the police and must get converted into an FIR. This requires in-depth investigation as to why so many death cases are being concealed from the police.

In case of non-fatal injuries, police records captured only 3.1% of the estimated non-fatal injuries. Performance of health facilities, which captured 44% of the estimated cases, is better. However, this still indicates that a large number of injured workers are availing treatment outside government health facilities which is expensive as well as there are concerns regarding the quality of treatment available outside public health facilities in this remote part of the country. There also appears to be either large-scale concealment of injuries by industrial workers from the government agencies, reasons for which also need to be investigated.

The injury rate of 2.63 to 2.74 per 1,000 workers in Dadra and Nagar Haveli ascertained in this study is much higher compared to pan-India injury rates arrived at from government documents. Records of the federal Ministry of Labor inform that there are 20,034,859 industrial workers in the country among which 25,173 non-fatal injuries were reported. This leads to an injury prevalence rate of 1.26 per 1000 workers. Similarly, death rate of 0.21 to 0.4 per 1000 workers ascertained in this study for the workers of Dadra and Nagar Haveli is higher than the all India death rate of 0.056 per 1,000 workers arrived at based on Labour Ministry's data.^[18] On the face of it, this could be taken as an indicator that the industrial units in Dadra and Nagar Haveli are less safe. However, it could well be because of a better estimation of injury prevalence in Dadra and Nagar Haveli by capture-recapture method.

Although there are 20% females in the industrial workforce, the females accounted for just 3.33% of total fatalities. This could be because of the deployment of males on machines and in dangerous operations. Similarly, in case of non-fatal injuries, females accounted for just 6.2% which is also not proportional to the participation of women in the industrial workforce in Dadra and Nagar Haveli.

Age stratification analysis of victims was also done. After combining police and health department records, 118 unique victims of non-fatal injuries could be identified. Out of them, the maximum number of 55 (46.6%) persons belonged to 21 to 30 years age group followed by 26 (22%) persons in 15 to 20 years bracket. This resonates with the data of SRS^[19] which informs that the people in 15–29 years age group are affected the most with 44.6% deaths due to injuries. This study finds that more than two-third of the injured are 30-year-old or younger. Any disability or injury to them in the prime of their productive life could have long-term consequences on their family income and quality of life. Further analysis reveals that 21 injured persons (17.8%) fell in 31–40 years bracket, 10%, i.e. 12 in 41–50 years group and four victims (3.4%) fell in 51–60 years cohort. In case of females, the injured

were of 16 to 49 years of age.

In case of fatal injuries, the age of 22 victims was available in the records. The analysis of data shows that the maximum 40.9% victims belonged to 31–40 years bracket followed by 27% each in 21–30 years and 41–50 years age group. Only 4.5% of the dead were 20 years old or younger. The analysis reveals that the older cohort is more prone to fatal injuries.

Injury type is not being meticulously recorded. In case of non-fatal injuries, records of 29 victims say that it was an accidental injury without identifying the agent responsible for the injury. In 7 cases, the victims received burn injuries. Five cases were classified as crush injury, whereas 8 cases were of cut injury. Electric shock and fall from height were responsible for one case each, while remaining 23 cases were recorded because of machine injury. In remaining cases, the cause of injury was not recorded. In case of fatal injuries, injury by the molding, crushing, and binding machine on which the worker was working is responsible for 62.5% of total deaths. The machines included molding machine, grinding machine, rolling machine, and binding machine. Other causes are fall from height, hit by crane, and injury by chemicals, which claimed one victim each.

The emergency severity index (ESI) provides clinically relevant stratification of patients from acuity and resource needs (Ahrq.gov, 2018).^[20] It is a five-level triage algorithm from 1 (most urgent) to 5 (least urgent). The ESI was recorded in health facilities for many of those who sought treatment there. In 53 cases, the ESI was 5, in 7 cases, it was 4, in 6 cases, it is 3, in 4 cases, it was 2, and in 3 cases, it was 1. In the remaining 7 cases, which are from police records, the ESI was not determined. Thus, in majority of cases, the injuries suffered were low on severity index.

Although it is a legal requirement to report all industrial accidents resulting in injuries, it has been observed that only a small proportion of cases get reported under the Labor laws. Victims or their families filed an application with the competent authority in the Department of Labour and Employment of Dadra and Nagar Haveli, only in 8% of the cases for claiming compensation. The reasons for the same need to be probed more deeply in a separate study.

Limitations

Four major assumptions must be satisfied for the capture-recapture methodology to produce reliable results (Razzak, 1998, Kiakalayeh, 2011).^{[21],[22]} The first assumption is that all the members of the population should have the same probability of being captured. In our study, this assumption is satisfied because it covers an entire population of factory workers of Dadra and Nagar Haveli. Accidents occurring anywhere in the territory would get reported to health department who also has an extensive network of emergency medical transport. People prefer to take victims to a government health facility because of medico-legal requirements. In addition, because of the requirement of police reports to process compensation cases, the accidents also get reported to the police. The second assumption is that the capture sources should be independent. This is a difficult assumption to fulfil. Fatal and non-fatal injury cases get reported to the police either by the doctor or in-charge of a health facility. Hence, there is some positive dependence between the two sources. A positive dependence between capture sources will lead to an overestimate of the number of matches, and thus, an underestimate of the total number of injuries and vice versa.

The third assumption for applying capture-recapture is that the population should be closed. This assumption ensures that there are no major changes in the total population between the time periods between the two captures. In this study, the capture-recapture took place at the same time, and hence, there are very low chances of a change in workers' population who are permanent or at least semi-permanent. Thus, the study population can be treated as a closed population. The final assumption is that the cases must be matched confidently and accurately between sources. Use of four unique data variables gives confidence that the cases in this study were matched accurately and confidently between sources.

Although capture-recapture methods are being increasingly used to improve surveillance for several diseases, they have been criticized too. Major criticism revolves around for a lack of compliance with several important assumptions and model selection strategies. There are multiple limitations in applying the method that include source dependence, imperfect data linkage, and heterogeneity of the population. Deaths also mean that the individual has effectively left the population, and hence, the

closed population is no longer closed.^[14]

Another possible limitation in the study is that it does not include data of private health facilities to which the injured worker may be taken for treatment to avoid legal hassles and avoid payment of compensation.

Interpretation/Conclusion



Industrial accidents and consequent deaths and injuries are preventable. However, accurate epidemiological information on injuries suffered by industrial workers is not available in India. Hence, the capture-recapture method to estimate death and injury rate can be successfully used. An accurate estimate is vital to understand the magnitude of the problem and devising effective prevention programs. There is no doubt that the prevention efforts would lead to large gains.

Injuries need to be recognized as a major public health problem in India. However, there is a lack of a systems approach to understand causality and development of interventions regarding broader system-related factors. Presently, there is no national policy on injury prevention and control. Even the National Health Mission, the biggest public health program in the world lacks a budget line aimed at injury prevention. Although there are huge national public health programs for other health problems including HIV/AIDS, vector borne diseases, tuberculosis, leprosy, non-communicable diseases and so on, such a program and a collective effort to surmount the challenge posed by injury morbidity and mortality are conspicuously absent. A surveillance system to track this growing epidemic and a specialized agency, both in the center and in the states to coordinate the range of activities aimed at reducing injuries are lacking too.

Quality and representative information is a must to understand a health problem and its determinants. A lack of credible data in India is also hampering efforts to improve workplace safety in the industries. There is a need to set-up a surveillance system and a trauma registry to systematically and regularly collect injury data from health, police, Labor department, and other related sectors. The information should then be analyzed and disseminated to policymakers and key stakeholders and should also be put in public domain. This will help in developing an evidence-based understanding of the problem and devising cost-effective solutions. It will also help in effective and informed decision-making in designing sustainable policies and programs to mitigate the problem.

The Indian government may also consider setting up of an independent agency with sufficient human and financial resources, on the lines of Occupational Safety and Health Administration of United States.^[23] The agency should be mandated to effectively develop, implement, evaluate, coordinate, monitor, and guide activities injury prevention programs to make the shop-floor a very safe place. The agency should also investigate all accidents instead of the present system of setting up ad hoc committees that are more like firefighting arrangements rather than intended to bring about systemic change.

India is moving on a fast trajectory of growth, development, and economic prosperity. This is likely to push the injury morbidity and mortality rates and burden upward. Successful implementation of injury prevention policies and programs will lead to multiple benefits including reduction in fatal and non-fatal accidents, reduction in the number and severity of disabilities caused by injuries, an increase in the number of productive working years, a decrease in the costs associated with treatment and rehabilitation of trauma victims. There is a need to wake up to the rising trend of injuries as serious contributors to morbidity and mortality.

Generalizability

The results of this study can be used to estimate the burden of injuries on industrial workers in other parts of India as well because the working conditions of industrial workers and safety environment are largely similar. The capture-recapture method used in this study may also be applied to ascertain the burden of injuries because of the other causes such as road traffic injuries, unintentional injuries at home, and unintentional injuries among other class of workers like building and other construction workers.

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Conflicts of interest

There are no conflicts of interest.

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Table 1: Body Parts Injured in Industrial Accidents

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Head	8	7.08%
Hand including fingers	41	36.28%
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Abdomen	3	2.65%
Face	2	1.77%
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Shoulder	4	3.54%
Multiple body parts	1	0.88%
Details not available	24	21.24%