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Non-fatal Occupational Injury Among Male Workers in India: A Systematic Review

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Abstract:
It is well-known that non-fatal occupational injuries occur more often than fatal injuries. It is estimated that 17% of world's total non-fatal injuries occurred in India. In most cases, male workers are more likely to be exposed to non-fatal occupational injuries than women. This systematic review aims to synthesize evidence from previous studies on the prevalence and associated risk factors for non-fatal occupational injuries among male workers in India. Articles were searched in PubMed, Scopus, Cochrane CENTRAL, ScienceDirect, and Google Scholar databases. Included studies were appraised for methodological quality rated as Good, moderate, and low. The pooled prevalence of injury was computed using MedCalc statistical software. Forty-eight studies retrieved from four databases met our inclusion criteria. Of the 48 articles, 14 were rated as good quality 31 were rated as moderate quality, and 3 were rated as low quality. The pooled prevalence of non-fatal occupational injuries among male workers was 34.58% (95% CI: 24.67, 45.22). Factors such as age, work experience, substance use, sleep disturbance, nature of work, long working hours, working at night, less availability

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and low or no usage of Personal Protective Equipment (PPE) and lack of Occupational safety and health (OSH) knowledge and awareness are strong risk factors for injuries. Falling from a height/same level and hit by falling object are the most common mode of injury at workplace. Concerning type of injuries, wounds/cuts/bleeding (n=17), followed by burn/acid burn (n=17), fracture and dislocation (n=15), and sprain and strain (n=14) were found to be the most cited types of injuries. It demonstrates that prevalence of injuries among male workers are varies by industry type and job characteristics. This review found that combined risk factors increase the occurrence of injuries. Special attention is required for workers who are associated with construction and manufacturing industry.

Keywords: Occupational injuries, non-fatal, male workers, systematic review, India

1.0 Introduction

Occupational injury is a major public health problem all around the globe [1]. The importance of this issue reflects that employed workers spend at least 8 hours a day at their workplaces, which strongly affects their health and well-being and may lead to fatal and non-fatal injuries [2–4]. In general, non-fatal occupational injury is defined as any physical injury that workers temporarily or permanently unable to perform their job efficiently, resulting in lost working hours, i.e., absence from work is considered a non-fatal occupational injury [1,5,6]. Each year, an estimated globally 374 million workers suffer non-fatal workplace injuries [7]. It is also estimated that 17% of world’s total non-fatal occupational injuries occurred in India, causing severe injuries and absences from work [8]. Further, over 92% of the workforce in India is employed in the informal sector, and most of them are forced to work in high-risk jobs, consequently making them more vulnerable to workplace injuries [4]. Despite its magnitude and seriousness, occupational injury remains a neglected public health concern in India. For example, in the year 2021, only 2803 cases of non-fatal injuries were recorded in the registered factories as the reality of injuries is much worse than the official government records [9].

From a gender perspective, male-dominated industries such as construction, mining, manufacturing, metal, and welding industries have significantly higher incidences of non-fatal injuries in India [10]. Consequently, men are more prone to work-related injuries than women [11,12]. In most cases, male workers are engaged in higher-risk jobs that compromise their safety, making them more prone to injury at the workplace. Moreover, male workers are more likely to be exposed to excessive working hours [12–15], more physically demanding work [16–18], work overload [12,17,19] high occupational stress [19–21], and regular substance use [12,14,17,19,20,22,23]. These occupational and behavioural risk factors make them more exposed to non-fatal injuries. Additionally, personal (e.g., demographic, education, work experience) and occupational factors (e.g., physical work environment, work culture) are among the leading aspects of non-fatal occupational injuries [24,25] among male workers. However, no clear picture has emerged from the previous studies of which factors were more contributing to non-fatal injury.

Additionally, Indian government or any non-government agencies does not report or publish statistics on occupational accident and injuries [11,23]. Due to the poor availability of robust occupational injury data, there is a lack of clarity on the actual prevalence of non-fatal occupational injuries across different industries in India. To address this gap, we systematically reviewed non-fatal occupational injuries among male workers in India. It is well-known that non-fatal occupational injuries occur more often than fatal injuries and have a significant impact on disability, productivity, cost of treatment, and rehabilitation of workers. Therefore, an improved understanding of non-fatal injuries can pave the way for more effective preventive strategies on occupational injury. Moreover, most of the existing studies exclusively address non-fatal injury. Studies that focus on both fatal and non-fatal injuries by occupational accidents or injuries are extremely rare. Because there is insufficient information on fatal injuries, the current study excludes the fatal injury. Therefore, current study solely focuses on non-fatal injury.

To the best of our knowledge, till date, there is no systematic review that focuses on non-fatal occupational injuries among male workers in India. The review was guided by a research question: "What is the pooled prevalence and key risk factors leading to non-fatal occupational injury among male workers in India?". To answer this question, this systematic review aims to synthesize evidence from previous studies on the prevalence and associated risk factors for non-fatal occupational injuries among male workers in India.

2.0 Methods and Materials

2.1 Search strategy and eligibility criteria

An extensive search was performed from 1st April 2023 to 30th June 2023 for peer-reviewed articles using four primary electronic databases: PubMed, Scopus, Cochrane CENTRAL, ScienceDirect, and Google Scholar. We also used secondary sources to identify additional relevant articles. To connect, MeSH terms "AND" and "OR" were used. The search strategies included all possible combinations of keywords along with their synonyms and closely related words. The search approach involved a combination of keywords which are: ("occupational injury"), OR ("occupational accident"), OR ("Non-fatal injury"), OR ("Non-fatal accident") OR ("Workplace injury") OR ("Work-related injury") OR ("Occupational hazards") combine with the AND ("Male workers"), ("Workers"), and ("India"). Boolean operators "AND" and "OR" were used as connectors. No study design restrictions were applied to the search. The references in all relevant papers were manually searched in order to identify any further relevant articles. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocol (PRISMA) guideline was used to confirm the scientific accuracy.

2.2 Inclusion and exclusion criteria

The modified PICO (Population, Intervention [or exposure], Comparison, and Outcome) framework was used to study selection [26].

Table 1. Description of inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Population	Indian male workers (Group or cohort) are associated with current or previous workplace settings.	Female workers are not included. Additionally, those studies that contained information about occupational injuries but did not segregate the participants by their sex (male and female workers) were also excluded from the study.
Intervention/ Exposure	Articles that examines various risk factors related to occupational/work-related non-fatal injury	Non-occupational exposures
Comparison	Results presented only for men	NA
Outcome	• Accidents occurred during work at the workplace. • Articles that segregated data by fatal and non-fatal injuries, in this case, data on non-fatal injuries were only included.	Any studies that were not fully accessed/ difficult for data extraction/ did not report occupational injuries were excluded. • Fatal occupational injury • Non-occupational injury
Relevance	Only peer-reviewed articles published in the English language	Commentaries, grey literature, working papers, and review articles
Time	Journal articles published between January 2000 and June 2023 are included	Article published before January 2000 or after June 2023.
Setting/Location	Any specific industry located in India, /Indian states/cities/ Multiple industrial sites	Any study conducted outside of India.
Study types and designs	Quantitative study design	Qualitative study

2.3 Literature screening

Three steps are involved in selecting the related articles: identification, screening of title and abstract, and eligibility. In the first step, the relevant studies were identified by advanced search in each database through the subject area's keywords, following the inclusion and exclusion criteria. The inclusion and exclusion criteria for this review are provided in Table 1. The next step was the screening phase. All the relevant studies were imported into Covidence, a web-based systematic review software to remove duplicates and screen titles and abstracts. After removal of duplicates, in the third step, shortlisted articles were retrieved for an independent full-text article review and were assessed for the eligibility criteria by both authors. Full-text articles were extracted and assessed against the inclusion and exclusion criteria. The articles that met all inclusion criteria were included in final systematic review. Any disagreement between the reviewers was handled by discussion and consensus to minimize bias. Selected full-text articles were re-evaluated for data extraction and assessed for quality.

2.4 Data extraction

Author (RR) independently extracted all necessary data using a standardized form. The following data were extracted from each study: (i) Author (s) and year, (ii) type of industry, (iii) study location, (iv) study design, (v) sample size, (vi) number of injured population (vii) prevalence (viii) contributing factors to injury. Additionally, tables and graphs were created to illustrate the study characteristics.

2.5 Quality assessment and risk of bias

Study quality was appraised using the "Quality Assessment tools" developed by 'National Heart, Lung, and Blood Institute'[27]. We used separate methods for cohort and cross-sectional, case, and case-control studies. In each checklist, 9-12 questions are assessed based on types of study design. Each question was marked as 'Yes' (Score:1), 'No' (Score:0), and 'Unclear' (No

Score). For example, cohort, cross-sectional, and case-control studies, 12 questions assess the quality. Quality was rated as Poor (score 0–4 out of 12 questions), Moderate (score 5–8 out of 12 questions), and Good (score 9–12 out of 12 questions). For case studies, a total of nine questions evaluates the quality. Quality was rated as Good (score 7–9 out of 9 questions), Moderate (score 4–6 out of 9 questions), and Poor (score 0–3 out of 9 questions). Further details on the quality appraisal can be found in Appendix Table 1.

The author appraised the risk of bias of all included studies, and for the cross-checked and validation the author hired an independent reviewer. To validate the risk of bias assessment, an independent reviewer rechecked the extracted data. Disagreements in data extraction were resolved through discussion between author and independent reviewer until a consensus was gained.

To examine the risk of bias in cross-sectional and cohort studies, a total of 12 questions were assessed. The following items were included for risk of bias assessment: (1) Questions clearly describe research question (2) clearly described study population, (3) participation rate, (4) inclusion and exclusion criteria, (5) sample size justification, (6) exposure assessed prior to outcome measurement, (7) different levels of the exposure of interest, (8) exposure measures and assessment, (9) repeated exposure assessment, (10) outcome measures, (11) blinding of outcome assessors, (12) Statistical analyses.

Similarly, to assess the risk of bias of the case-control study, a total of 12 questions were assessed. The following items were included for risk of bias assessment: (1) clearly described research (2) population is clearly and fully described, (3) Sample size justification, (4) were controls selected from a similar population, (5) inclusion and exclusion criteria, (6) cases clearly defined and differentiated from controls, (7) cases and/or controls randomly selected, (8) concurrent controls, (9) investigators able to confirm that the exposure, (10) exposure measures, and assessment, (11) blinding of exposure assessors (12) statistical analysis.

For the case study, a total of 9 questions were assessed. The following items were included for risk of bias assessment: (1) clearly described research question (2) population clearly and fully described (3) cases consecutive (4) subjects comparable (5) intervention clearly described (6) outcome measures clearly defined, (7) valid, reliable, and implemented consistently (8) length of follow-up adequate (9) statistical methods well-described.

The scoring ranges of all included scales from 0 to 1, with a higher score indicating no risk of bias (0 = High Risk of Bias; 1 = No Risk of Bias, Unclear No marks). Studies that scored less than 30% were considered at high risk of bias; the author was not included in the study. The result of risk of bias is presented in Figures 3.1, 3.2, and 3.3. 2.6.

2.6 Data analysis

The pooled prevalence of non-fatal occupational injury among male workers was estimated using a random-effects model. MedCalc (MedCalc, Software, Ostend Belgium) software was used for meta-analysis. We used the forest plot to visualize the presence of heterogeneity. I2 values of 0–25%, 25–50%, and >50% were taken as indicative of low, moderate, and high heterogeneity, respectively (Ades et al. 2005). Potential publication bias was also assessed by using Egger's and Begg's test at 95% significant level with a p-value of less than 0.05 as a cutoff point to declare the presence of publication bias.

2.7 Selection of articles

A total of 1273 studies were initially identified through a search performed on [primary search (n=1256), secondary search (n=17)] using different keywords. Out of them, 722 duplicate studies were removed. After screening the articles by their abstract, 386 records were found based on title and abstract screening. The remaining 148 potentially relevant studies were identified. For these, a total of 84 full-text articles were retrieved [primary search (n=105), secondary search (n=8)] after the exclusion of 117 studies. Out of 105 full-text articles reviewed, 36 were excluded based on multiple reasons such as outcome of interest not reported (n=20), gender of the participant not clear (n=10), and not fit in quality assessment (n=6). Finally, 48 articles [primary search (n= 40), secondary search (n= 8)] matched the inclusion criteria and were included in this systematic review, and out of that, 32 studies were included in meta-analysis.

3. Results

3.1 Description of study characteristics

A total of 31,810 male workers were included from 48 studies. About 73.5% (n=33) studies were cross-sectional studies, followed by 12.2% (n=7) case study, 10.2% (n=5) case-control study, and only 4.1% (n=2) described cohort study/longitudinal study. The majority of the studies were published between 2015 and 2016 (12.5%, n=6), 2017-2018 (12.5%, n=6), 2019-2020 (14.3%, n=11) and 2021-2023 (up to 30th June, 2023) (12.5%, n=6). The sample size of the individual studies ranged under the <50 to more than 1000 participants. A total of 33.3% (n=16) studies had their sample size under 201-500 participants, and only 12.5% (n=6) studies had a sample of more than 1000 participants. The lowest number of participants was observed in a study conducted on iron and steel industry workers (n=23) [28], and the largest sample study was conducted on Brickfield construction workers (n=1293) [14]. Regarding the number of injured workers, 22.92% of studies (n=11) reported that their injured workers were less than 50. Only 4 studies reported injured workers more than 500 out of total sample [29–32]. The detailed study characteristics for the included articles are shown in Table 2.

Figure 1. The PRISMA flow diagram showing process of study selection for inclusion in our meta-analyses

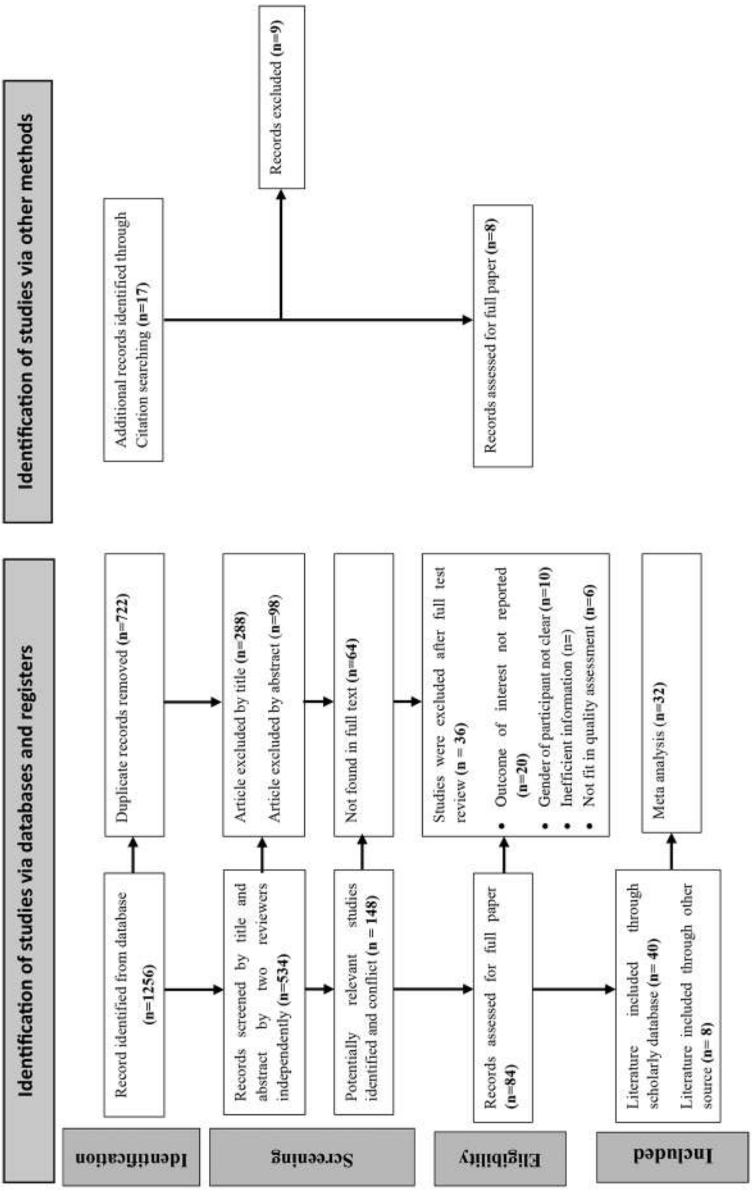
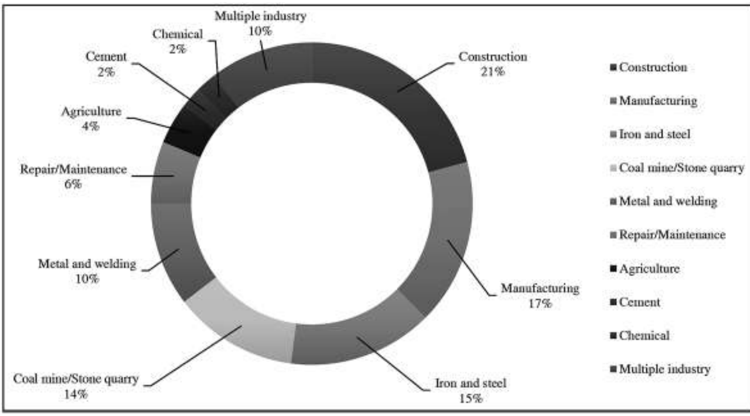


Table 2 characteristics of included studies (n=48)

General characteristics of studies	N (%)	Study Reference
Study methods		
Cross-sectional	35 (72.9)	[3,6,11–17,19–23,28–48]
Case study	6 (12.5)	[49–54]
Case-control study	5 (10.4)	[2,18,55–57]
Cohort study/Longitudinal study	2 (4.2)	[11,58]
Year of publication		
2001-2002	1 (2.1)	[49]
2003-2004	1 (2.1)	[56]
2005-2006	4 (8.3)	[28,50,55,58]
2007-2008	5 (10.4)	[29,30,51,52,57]
2009-2010	2 (4.2)	[31,32]
2011-2012	3 (6.3)	[2,33,37]
2013-2014	4 (8.3)	[16,34,36,59]
2015-2016	6 (12.5)	[3,21,22,38,39,53]
2017-2018	6 (12.5)	[6,40–43,60]
2019-2020	10 (20.8)	[11,13–15,18,20,44–47]
2021-2023 (upto 30th June, 2023)	6 (12.5)	[12,17,19,23,48,54]
Sample size		
< 50	3 (6.3)	[38,43,58]
50 -100	4 (8.3)	[15,30,42,53]
101 – 200	9 (18.8)	[6,13,19,22,36,40,45,47,55]
201 -500	16 (33.3)	[3,12,16,18,21–23,31–34,41,56, 59–61]
501 - 1000	10 (20.8)	[2,14,17,28,37,39,46,50,52,54]
More than 1000	6 (12.5)	[6,11,20,29,48,49]
Number of injured populations		
< 50	11 (22.9)	[16,23,30,33,34,38,40,43,45,50,58]
50 -100	12 (25.0)	[12–15,21,31,39,41,42,47,53,61]
101 – 200	10 (20.8)	[3,6,11,17,18,22,36,37,41,55]
201 -500	11 (25.93)	[14,28,32,37,44,46,49,56,57,59,60]
501 - 1000	3 (5.56)	[48,54,61]
More than 1000	1 (1.85)	[29]

A total of 9 different industries were included in this systematic review. The highest contribution was from the construction industry (n=21%), followed by manufacturing industry (17%), iron and steel industry (15%), coal mine/stone quarry industry (14%), metal welding (10%), and a combination of multiple industry (10%) (Figure 2).

Figure 2. Characteristics of selected study by type of industry



3.2 Assessment of study quality

After the critical appraisal of the included studies, the risk of bias graphs of cross-sectional study, case study, and case-control study were presented in figure number 3.1, 3.2, and 3.3. Cross-sectional and cohort study/longitudinal study (n= 37) had low to moderate risk of bias for most of the items, except three items, i.e., inclusion and exclusion criteria, exposure assessed prior to outcome measurement, and repeated exposure assessment variables (Figure 3.1). Similarly, in case study (n=6), we observed a low risk of bias except two items, i.e., cases consecutive and subject comparable and unclear about clearly described (Figure 3.2). At last, case-control study (n=5) also had low risk of bias as most of the items except two items cases, and/or controls were randomly selected and concurrent controls (Figure 3.3). Overall, of the 48 articles, 14 were rated as good quality, 31 were rated as moderate quality, and 3 were rated as low quality. The risk of bias in the included studies was overall moderate.

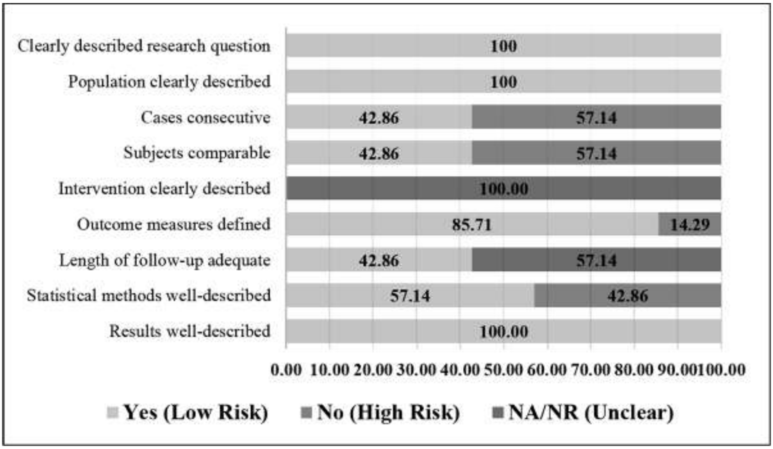


Figure 3.1 Risk of bias graph: percentages across all included cross-sectional and cohort studies

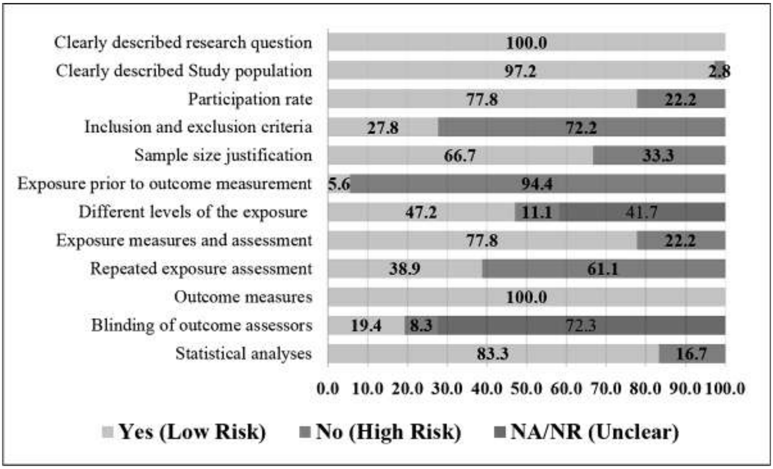


Figure 3.2 Risk of bias graph: percentages across all included case studies

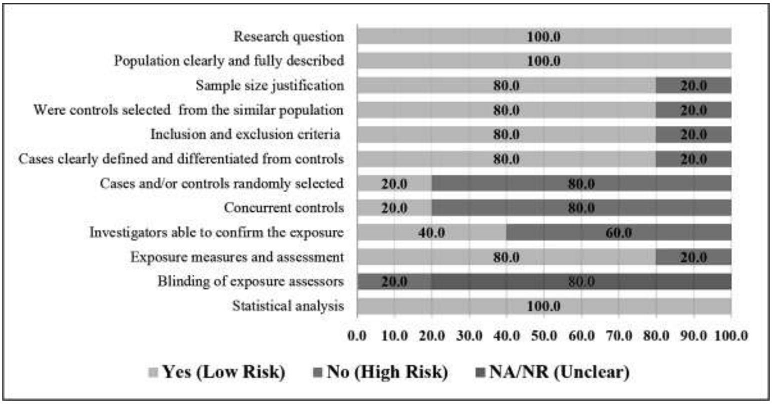


Figure 3.3 Risk of bias graph: percentages across all included case- control studies

3.3 The prevalence of occupational injuries

A total of 21,257 male workers from the 32 studies were used to calculate the pool prevalence of occupational injury among male workers in India. The findings of meta-analysis showed that pooled prevalence of non-fatal occupational injury among Male workers in India by using the random-effect model was 34.58% (95% CI: 24.67, 45.22). This meta-analysis, showed that the highest prevalence was 85.07% (95% CI: 81.97, 87.82), as reported in a study conducted in Tamil Nadu, India [54], whereas the lowest prevalence was 3.55% (95% CI: 2.94, 4.26) in Dadra and Nagar Haveli, India [11].

Table 3. Summary of 32 studies included in the meta-analysis of non-fatal occupational injuries among male workers in India

Sr. No.	Author (publication year)	Sample size	Prevalence with 95%	Random (Weight (%)
1	Maiti and Bhattacherjee, 2001 [49]	6281	7.30 (6.67, 7.97)	3.15
2	Brahmapurkar et al.2006 [28]	526	67.49 (63.30, 71.48)	3.14
3	Calvin and Joseph, 2006 [50]	570	4.91 (3.28, 7.02)	3.14
4	Saha et al. 2007a [61]	220	30.00 (24.02, 36.52)	3.12
5	Pandit and Tiwari, 2008 [30]	100	14.00 (7.87, 22.37)	3.08
6	Kumar et al. 2010 [31]	355	18.31 (14.42, 22.73)	3.13

Sr. No.	Author (publication year)	Sample size	Prevalence with 95%	Random (Weight (%)
7	Singh.2010 [32]	500	80.00 (76.22, 83.42)	3.14
8	Manjunatha et al. 2011 [33]	245	5.30 (2.85, 8.90)	3.12
9	Jaiswal, 2012a [2]	640	48.43 (44.50, 52.38)	3.14
10	Jaiswal, 2012b [37]	588	17.68 (14.68, 21.01)	3.14
11	Rani and Jyothi, 2013 [16]	360	7.22 (4.77, 10.40)	3.13
12	Jayakrishnan et al. 2013 [34]	387	12.14 (9.06, 15.82)	3.13
13	Bhumika et al. 2014 [36]	160	80.00 (72.95, 85.90)	3.11
14	Jain et al. 2015 [22]	200	61.50 (54.37, 68.27)	3.12
15	Ujwala et al. 2015 [21]	306	21.56 (17.09, 26.60)	3.13
16	Jasani et al. 2016 [3]	231	46.32 (39.75, 52.97)	3.12
17	Jaiswal et al. 2016 [39]	184	51.63 (44.16, 59.04)	3.11
18	Sashidharan et al. 2017 [41]	302	44.37 (38.68, 50.17)	3.13
19	Joseph et al. 2017 [40]	155	24.51 (17.97, 32.06)	3.10
20	Kaur et al. 2019 [45]	90	25.55 (16.94, 35.83)	3.07
21	Prasad et al. 2019 [44]	292	82.53 (77.68, 86.71)	3.13
22	Yadav, 2019 [11]	3175	3.55 (2.94, 4.26)	3.15
23	Rajasekar et al. 2020 [47]	143	49.65 (41.18, 58.12)	3.1
24	Debbarma et al. 2020 [15]	90	68.88 (58.26, 78.23)	3.07
25	Das, 2020 (a) [20]	1293	18.71 (16.62, 20.95)	3.15
26	Das, 2020 (b) [14]	742	13.20 (10.85, 15.85)	3.14
27	Bharti et al. 2020 [13]	129	60.46 (51.48, 68.95)	3.09
28	Kashyap et al. 2021 [23]	284	10.56 (7.24, 14.73)	3.13
29	Rajak et al. 2021 [17]	505	28.11 (24.23, 32.25)	3.14
30	Ragavi et al. 2021 [54]	603	85.07 (81.97, 87.82)	3.14
31	Edwards et al. 2022 [48]	1217	59.90 (57.0, 62.66)	3.15
32	Sarkar et al. 2023 [12]	384	23.43 (19.28 ,28.00)	3.13
	Total (random effects)	**21257**	**34.58 (24.67, 45.22)**	**100**

3.4 Forest plot

The forest plot showed a high level of heterogeneity between studies indicated by 99.58%, P < 0.0001, demanding further analysis to find out causes of heterogeneity. The forest plot showed a high heterogeneity level between studies, indicated by 99.58%, P < 0.0001, demanding further analysis to find out the causes of heterogeneity (Figure 4).

3.5 Publication bias

The funnel plot for assessing publication bias is shown in Figure. 5. Funnel plot, in which the vertical line indicates the effect size, whereas the diagonal line indicates the precision of individual studies with 95% confidence limit. The results of both Begg's and Egger's tests indicated possible publication bias at p-value = 0.012 and 0.061, respectively.

Figure 4. Forest plot showing the pooled prevalence of non-fatal occupational injuries

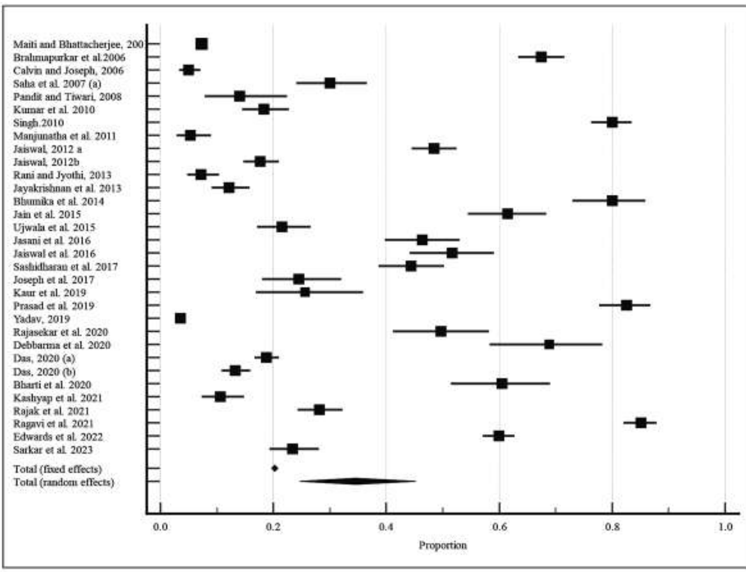
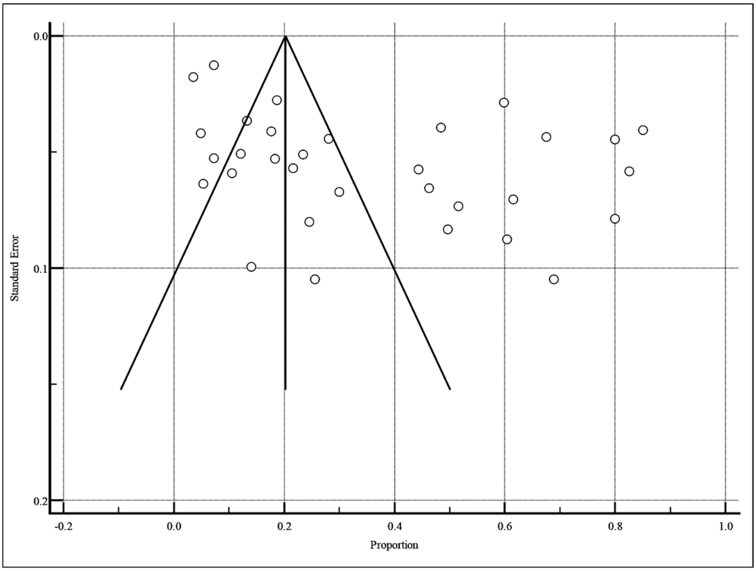


Figure 5. Funnel plots for publication bias of prevalence of non-fatal occupational injuries in India



3.6 Socio-demographic factors of non-fatal occupational injuries

In socio-demographic factors, age, work experience, education, and awareness are the most investigated factors of non-fatal occupational injuries [6,13,14,17–21,42,46,51,53,57,59,60]. In this regard, twenty-one studies reported that young workers with lower educational attainment had a consistently elevated risk of occupational injury [6,11–13,15,17–21,23,31,37,41,42,46,50,53, 54,59,61].

Regarding work experience, thirteen studies reported that workers with less work experience are at significantly high risk of being injured than workers with high experience [12,15,18, 19,28,29,32,44,46,51,52,57]. In contrast, eleven studies found that high work experienced workers are more exposed to non-fatal occupational injury than less experienced workers [17,19, 21,23,28,32,38,48,49,55,60]. In addition, other factors such as big family size (5 or more family members) [18,57], mistakes by oneself/co-workers/seniors [17], lack of media exposure [23], insufficient income [12,13,17,20,35] were also strong risk factors for non-fatal occupational injuries.

3.7 Behavioral and Psychological Work Environment

From behavioural determinants, sixteen studies [12,14,17,19,21–23,34,37,41,45,46,51,57,59,61] found that regular consumption of alcohol, smoking and chewing tobacco was significantly associated with occupational injury. Other important determinants such as sleep disturbance, insufficient sleep, and insomnia had a significant [2,17,20,37,46] associated with occupational injury. For instance, Jaiswal et al. (2012) found that workers who complained of sleeping disturbance during work were about two times more likely to report occupational injury than workers who did not face any problem with sleeping disturbance [AOR: 1.99,95% CI: 1.30.3.04] [37]. In case of psychological factors, emotional instability [56] job dissatisfaction [12,20,21,37,39,46,55], conflict regarding organization/authority/family [19] contributed to an increase in non-fatal occupational injury. In this context, few studies reported that work injury significantly decreased workers who are highly satisfied with the existing working condition and supervisors/co-worker’s support [39,55,56]. A study conducted on workers in steel plant at Visakhapatnam, Indian state of Andhra Pradesh, found that workers with severe job stress were more likely to experience occupational injuries than moderate or no stress workers ($\chi 2 = 9.11$, $p = 0.003$, OR = 2.32) [21].

3.8 Work organization and work behaviour factors

The location and nature of work are the major predictors of non-fatal occupational injury. Eleven studies observed a statistically significant difference ($p<0.05$) between the injury rate by the skilled workers compared to the unskilled workers [3,12,29,41]. Additionally, risk-taking behaviour [17,43,55–57] and unsafe acts [16,17,43] during the work is another important risk factor for injury. Poor management and supervision [56] are other work organization factors for non-fatal occupational injury. Six studies [17,20,23,46,51,52] reported that temporary nature of employment is more responsible for a high incidence of accidents in comparison to permanent workers. It may have happened due to temporary workers employed in more dangerous operations or due to a lack of sufficient training in relation to safety matters [52]. Also, many times temporary workers often did not benefit from occupational health and safety services to avoid accidents and injuries at work. Also, occupational injuries are significantly associated with various biomechanical factors such as manual machine handling [18,20,34], repetitiveness of work [14,19], awkward postures performing work [14,19]. Rajak et al. (2021) found that workers who were directly exposed to workplace were 2.85 times (95% CI [1.62, 5.03]) higher in risk of injury than those intermittently exposed group [17]. Civil workers had a high risk of injury (6.6% vs. 17.2%. P = 0.001), and most of them were mechanical injuries, which may be due to a high rate of manual work using sharp tools and falls [34].

3.9 Occupational related factors

Nine studies identified long working hours [3,13,15,20,30,36,46, 50,61] significant occupational factor to non-fatal occupational injury. Seven studies found that night shift workers were more likely chances of injuries than daytime workers [14,20,37,46,58,59,61]. In this regard, Ujwala et al. (2005) found that around 54.55% of the accidents in steel plant occurred during at night [21]. Thermal stress/heat stress at workplace [17,19,22], poor work environment (poor light arrangement and poor ventilation) [43,56,58] in the workplace were other major cause of injury. Therefore, it can be hypothesized that all the above four occupational-related factors are significantly related to the occurrences of non-fatal injury at workplace.

3.10 Workplace safety environment

Eighteen studies found that less availability and low or no usage of PPE were high risks for non-fatal occupational injuries [12,14–17,20,22,36,37,43,46,50,60]. However, ignorance and inconvenience to wear to PPE are the major reported reasons for irregular use of PPE [19,40,50]. It is also reported that proper safety training [20,36,55], positive safety behaviour [20], hazard/safety awareness [59] and availability as well as usage of safety equipment's [20] are minimizing the occurrence of accident at workplace [18,36,37,55,56,59]. On their contrary, poor safety environment [37,56], neglect of safety precautions and lack of lack of safety and health training programs significantly associated with injury [14,19,20,37,56,59]. For example, Das et al. (2020a) in his study on brickfield workers, found that 91.5% of workers stated that no safety and health training programs have been provided by the company [20].

The complete explanation of each included study provided in Appendix Table 2. The summary of all contributing factors to non-fatal occupational injuries among male workers is presented in Appendix Table 3.

3.11. Causes of Injuries

Total nineteenth studies reported that fall from height/same level [6,13,15–17,19,19,20,31,41,43,45,46,48,51,54,57] and hit by falling object [6,13,16–19,31,41,43,45,46,48,51,53,57] are the most common mode of accident at workplace. Furthermore, struck by an object [14,18,31,43,45,48,51,53,54], fire/contact with hot metal [14,16,17,31,43,48,53,54], electrical injury [16,17,41,43,46,48,54], and wrong handling of machines [16–18,21,31,48,51,53,54] are another most cited causes of non-fatal injuries (Figure 6).

Table 4. Proportion of injuries by body parts

Body part	Body part involved	Number of studies	Reference
Head	Upper head	12	[6,11,17,20–22,31,45,46,51,54,58]
	Eye	12	[11,17,18,22,29,36,41,42,46,53,57,59]
	Ear	1	[17]
	Nose	2	[6,46]
	Neck	9	(6,14,17,19–21,35,48,49)
	Face	4	[21,29,36,54]
Trunk	Back	5	[6,17,19,20,46]
	Chest	5	[11,17,46,51,57]
Upper limb	Forearm	5	[19,21,31,36,58]
	Arm/shoulder	8	[11,14,17–19,54,56,61]
	Elbow	3	[18,19,22]
	Wrist	5	[6,14,17,19,20]
Hand	Finger	13	[6,11,14,17,18,20,22,29,45,56–58,62]
	Wrist	6	[14,17,20,29,58]
Lower limb	Pelvis	2	[46,56]
	Hips/thigh/buttocks	1	[19]
	Leg	15	[6,11,14,17,19,21,29,31,36,45,57,61]
	Ankle	8	[6,14,19,20,54,56,57]
	Knee	4	[6,17,19,31]
	Toes	2	[6,20]
	Feet	8	[11,14,17–20,22]

Note: Workers can have injuries to several body parts

Figure 6. Number of studies describing causes of non-fatal occupational injury

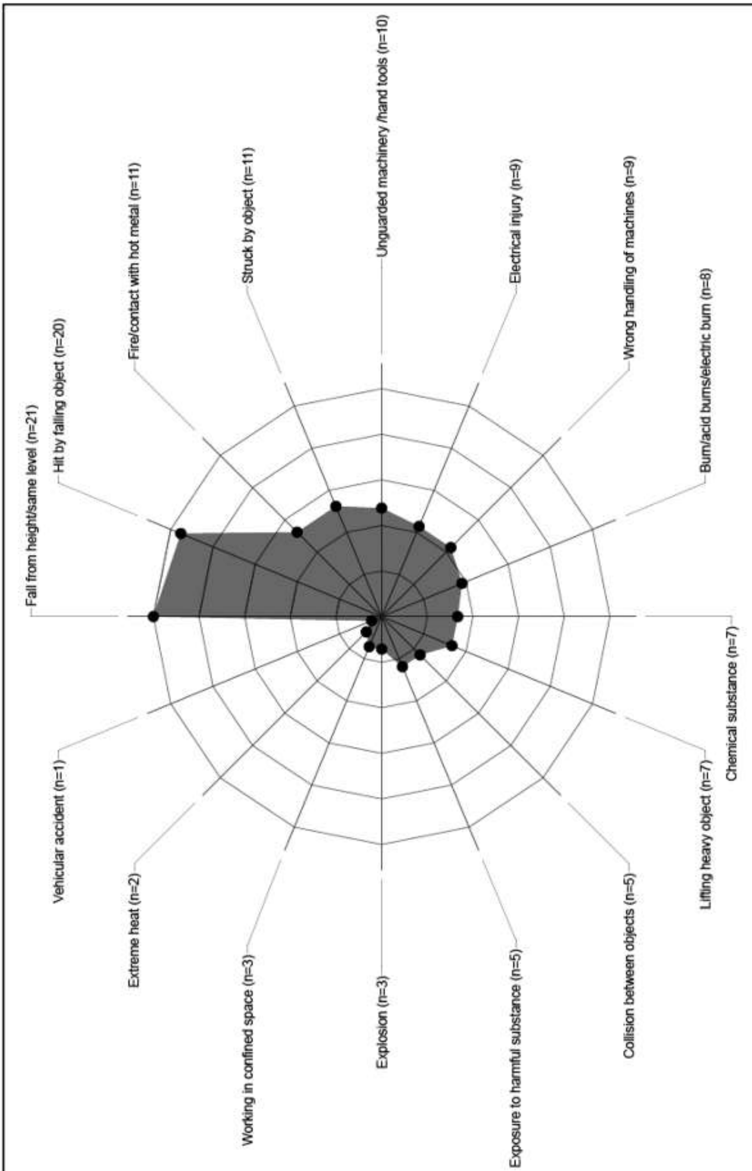
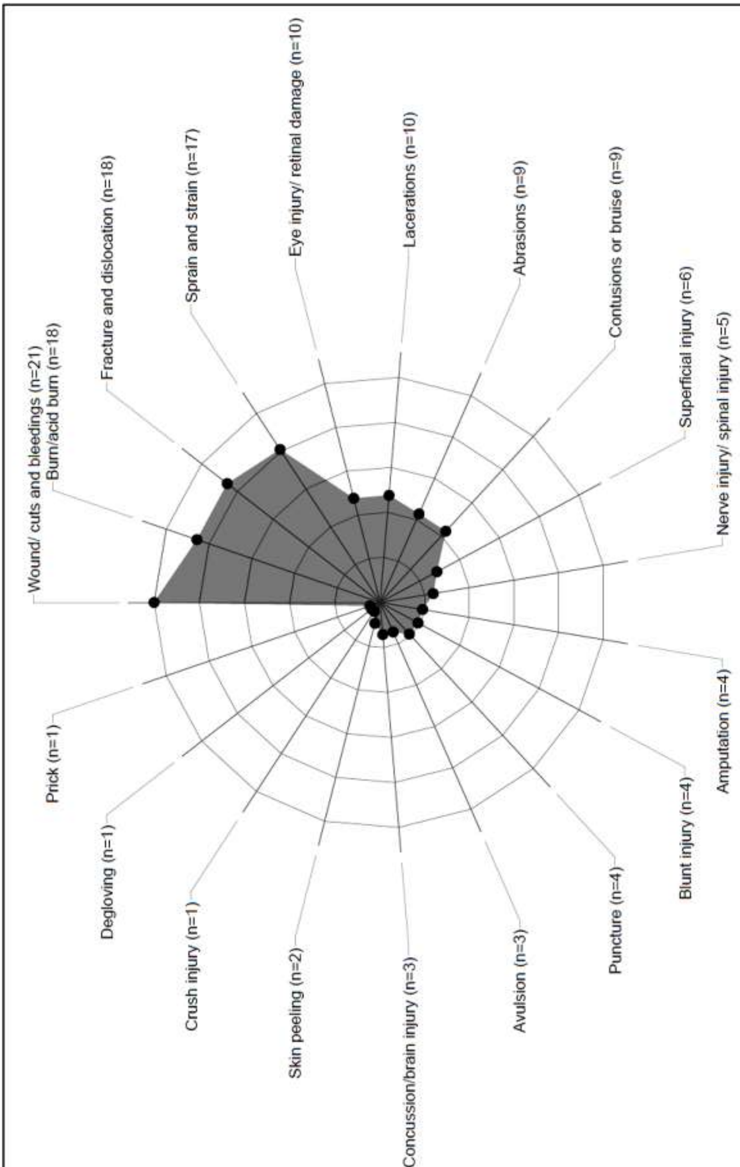


Figure 7. Number of studies describing type of non-fatal occupational injury



3.12 Type of injury

With regard to type of injuries, wounds/cut/bleeding (n=17), followed by burn/acid burn (n=17), fracture and dislocation (n=15), and sprain and strain (n=14) are found to be the most cited types of injuries (Figure 7).

3.13 Body parts involved in the injuries

In this review we found that eye is the most affected portion of the body [11,17,18,22,29,36,41,42,46,53,57,59], followed by the upped head [11,17,20–22,31,45,46,52], leg [6,11,14,17,19, 21,29,31,36,45,57], hand finger [6,11,14,17,19,21,29,36,52,57] whereas ear [17], nose [6,46], pelvis [46] and hips/thigh/buttocks [20] very less observed (Table 6).

4. Discussion

This systematic review examined the prevalence and associated risk factors of non-fatal occupational injuries among male workers from the study published between January 2000 and June 2023. We found that the prevalence of occupational injuries significantly varied across industries, ranging from 3.5% to 85.0%. The findings reported that pooled prevalence of non-fatal occupational injuries among male workers was 34.58% (95% CI: 24.67, 45.22). However, our finding was lower than the study done in Ethiopia 40.39% and 46.78% [1,63] and Africa, 57% [64]. A high prevalence of injuries was reported in the workers engaged in manual labour such as coal mines/stone query (p:82.53%) [44], cement industry (p: 80.0%) [32], and metal and welding industry (p: 80.0%) [36] whereas relatively low prevalence was observed in the small size manufacturing industry such as garment manufacturing (p:4.60%) [50] and leather manufacturing (p:10.56%) [23] industry. The possible justifications for the variation in prevalence could be due to the scale (size) of the industry and the nature of work in the industry. The other possible reason for the differences in the prevalence across the industry is the differences in knowledge and practices of occupational and safety equipment. By understanding the causes of injuries occurring, fall from height/same level and hit by falling object as the major cause of accidents. and the most frequent type of injuries was wound/cut/bleeding, burn/acid burn, followed by fracture and dislocation, sprain and strain, and contusions/ bruise. Also, most studies reported that the head injury (upper head and eye injury) were the most injured body parts. The synthesis of the findings clearly explained that numerous individual and occupational factors were associated with occupational injuries. However, age and work experience are the most investigated factors for occupational injury. We found that young male workers (under 25 years of age) are particularly vulnerable compared to the older age group. This finding is consistent with a previous meta-analysis explaining that young workers are at higher risk of non-fatal injury than old workers [65]. Younger workers were inexperienced, had less safety awareness, and engaged in risky work compared to older workers [6,11,17,46,48,57,59] and hence exposed to more injuries. However, we found mixed findings on the relationship between age, work experience, and non-fatal injury. A few studies reported that older workers with high experience have a higher chance of injuries than younger workers [32,56]. In contrast, some studies claim that younger workers with less experience have high rates of injuries [11,13,18,37,46,50,53]. The contradictory results between the studies may be due to different statistical approaches, study designs, or the effect of other confounding factors. However, there is a need for further study to get clarity on the results. The relationship between the educational status of workers and occupational injury was also consistent across studies. For instance, workers with higher education or technical education degrees had less chance of injury than workers without formal education. This finding aligns with an earlier systematic review, which identified that the level of education increases, and simultaneously, the occurrence of injury decreases [25,66].

This review also found consistent evidence that substance use consumption of alcohol, smoking cigarettes, and chewing tobacco) as a major behavioural risk factor for occupational injury [12,17,19,20,20–22,22,23,41,45,46]. Moreover, potentially contributing psychological factors such as emotional instability, occupational stress, and sleep problems strongly correlate with occupational injuries. The findings related to sleep problems align with previous systematic reviews, and meta-analysis found that workers with sleep problems had a 1.62 times higher risk of injury than workers without sleep problems [67]. Our review also showed that workers who are highly satisfied with the existing working conditions and supervisors/co-workers' support have significantly decreased chances of workplace injuries [39,55,56]. A similar observation was also found in the recent systematic review on industrial workers, which mentioned that supervisors' and co-workers' support minimizes the prevalence of injury [25]. However, very few studies reported that conflict in organizations or families increases the chances of injury [19,20]. This study also revealed that workers most exposed to work-related injuries are those engaged in precarious employment (temporary, casual, or part-time workers), i.e., in informal employment, those working in small and medium-sized enterprises (SMEs). This study also revealed that unskilled workers had a higher risk of injuries than skilled workers. A previous study from Pakistan found similar findings, revealing that skilled workers were at the least risk of injury, while craft and related trade workers were at the greater risk [68]. Moreover, temporary workers have a higher risk of occupational injuries than permanent workers. In most cases, temporary employment often does not benefit from occupational health and safety services, and there are elevated rates of occupational injuries. To support this finding, Debala et al. (2022) found in their systematic review that workers with temporary employment and those not receiving safety training had 2.13 times higher chances of incurring occupational injuries [64].

It is also important to note that long working hours were prominent factors associated with non-fatal occupational injuries. A large number of studies reported that workers who were engaged in working more than eight hours per day were at higher risk of being injured than those who were engaged for less than or equal to eight hours per day [12,13,15,17,23]. To support this findings, WHO/ILO Joint Estimates of the Work-related Burden of Disease and Injury, 2000-2016: Global Monitoring Report (2021) also explained that long working hours (≥ 55 hours per week) was major risk factor for the largest number of attributable (744 924 deaths; 95% UR: 705 519–784 329) deaths in the workplace [69].

The physical work environment is an additional crucial factor directly associated with non-fatal injury. The poor physical environment in the workplace (poor lighting, limited space, high temperature) was also considered to be necessary, particularly in the mining and iron and steel industry [17,18,21,22,29]. Interestingly, it has been seen that compared with other occupational factors, the physical work environment was a less focused factor. Availability and usage of PPE was another risk factor associated with non-fatal occupational injury. Most of studies statistically proved that non-fatal occupational injury was significantly lower among workers using PPE compared to their counterparts [17,18,22,53,55,60]. This finding was also in line with findings of a previous systematic review conducted in Ethiopia by Ashuro et al. (2021), which identified that workers who use PPE were 2.32 times less likely to have a work-related injury than workers who did not use PPE [63]. Almost every study recommended safety training, safety awareness, and a safe work environment to reduce accidents and injuries in the workplace. However, significantly fewer studies examined the status of safety management practices and training of workers in different industries.

5. Conclusions

This systematic review and meta-analysis summarized the all-relevant studies in recent twenty-two years reported the non-fatal occupational injuries among male workers and their risk factors in India. It demonstrates that the prevalence of injuries among male workers varies by industry type and job characteristics. It also identified important contributing risk factors for non-fatal occupational injury, such as young age, lack of work experience, substance use, sleep disturbance, nature of work, long working hours, working at night, less availability, and low or no usage of PPE and lack of OHS knowledge and awareness.

Furthermore, our finding shows that young workers are high-risk groups, which calls for prioritization of these segments of workers. Therefore, comprehensive occupational health strategies are needed to protect young workers. Other risk factors, such as substance use, cause a significant number of non-fatal occupational injuries. It is observed that due to continuous substance use, few workers may avoid work-related safety precautions and take greater work-related risks. However, the proportion of non-fatal injuries caused by substance use is relatively small. The findings emphasize a need to develop strategies to make workers aware of the harmful effects of substance use. Moreover, our findings highlight that occupational stress increases the chances of injuries in the workplace. Therefore, assessing job stress at the workplace and counselling workers at regular intervals is very important for reducing occupational stress at the workplace. Special attention is required for workers associated with the construction and manufacturing industry as the number of injuries at these sites was high compared to other working sites. Workers engaged in manual tasks and contractual or temporary work were also high-risk groups. Lastly, improving occupational safety, regularly using PPE, and health management in every working site are needed to improve safety practices in the workplace.

In conclusion, multiple risk factors increased the occurrence of non-fatal injuries. To minimize this prevalence of non-fatal occupational injuries, the concerned authorities must give special attention to all the identified factors.

6. Strengths and limitations

The review research has comprehensive search strategies and an in-depth methodological quality make this study more reliable. Also, the current study estimates the pooled prevalence rate of non-fatal injury among male workers, which was previously unavailable in any studies conducted in India. This review has several limitations. First, although this review focused on synthesizing medium to high quality observational studies, it is also possible that some of the estimates were inflated because of measurement biases in the assessment of risk factors and outcomes. Second, the majority of the studies included in this review were cross-sectional in nature as a result, the prevalence of injury might be affected by other confounding variables, which was not measured in the reported risk factors. Also, we did not report findings on long-term outcomes of occupational injury, such as work disability, working days lost, and economical loss, as only a few studies presented this information. Third, few relevant studies were excluded from the study because of not provided the gender distribution of injury and we were unable to identified the actual prevenances of injury among male workers, hence we excluded this type of study.

7. Implications and future directions

The findings from this systematic review recommend that future research must be conducted on association between work characteristics and occupational injury to provide a more complete picture of the epidemiology of occupational injury among workers. Moreover, most studies included in the present review were cross-sectional; there is a great need for cohort or intervention studies, which would also allow establishing the causal link with higher confidence. Future studies are needed to confirm whether social climate of the workplace will have a potential to improve occupational injury prevalence. There is a need to further explore the preventative measurement for non-fatal injury within and across the industry. Gender analysis in occupational injury is very less explored.

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Appendix Table 1 Critical appraisal of observational cohort and cross-sectional studies

Sr. No	Author, Year	Clearly described research question	Clearly described Study population	Participation rate	Inclusion and exclusion criteria	Sample size justification	Exposure assessed prior to outcome measurement	Different levels of the exposure of interest	Exposure measures and assessment	Repeated exposure assessment	Outcome measures	Blinding of outcome assessors	Statistical analyses	Total score	Quality
1	Brahmapurkar et al. 2006 (33)	Yes	Yes	Yes	No	No	No	NA	Yes	Yes	Yes	NA	Yes	7	Moderate
2	Gangopadhyay et al. 2007 (32)	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	NA	Yes	8	Moderate
3	Pandit and Tiwari, 2008 (34)	Yes	Yes	Yes	No	No	No	NA	Yes	No	Yes	NA	No	5	Moderate
4	Kumar et al. 2010 (35)	Yes	Yes	Yes	No	No	Yes	NA	Yes	No	Yes	NA	Yes	7	Moderate
5	Singh, 2010 (36)	Yes	No	Yes	No	No	No	NA	Yes	No	Yes	NA	No	4	Poor
6	Manjunatha et al. 2011 (37)	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	NA	No	7	Moderate
7	Jaiswal, 2012 (b) (41)	Yes	Yes	Yes	No	No	No	Yes	Yes	No	Yes	NA	Yes	7	Moderate
8	Rani and Jyothi, 2013 (16)	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	NA	Yes	8	Moderate
9	Jayakrishnan et al. 2013 (38)	Yes	Yes	Yes	No	Yes	No	NA	Yes	Yes	Yes	No	Yes	8	Moderate
10	Bhumika et al. 2014 (40)	Yes	Yes	No	No	Yes	No	Yes	No	No	Yes	Yes	Yes	8	Moderate
11	Kumar and Dharanipriya, 2014 (59)	Yes	Yes	Yes	No	Yes	No	NA	No	No	Yes	Yes	Yes	7	Moderate
12	Akanksha et al. 2015 (22)	Yes	Yes	Yes	No	Yes	No	NA	No	No	Yes	Yes	Yes	7	Moderate
13	Ujwala et al. 2015 (21)	Yes	Yes	Yes	No	No	No	NA	No	No	Yes	NA	Yes	5	Moderate
14	Jasani et al. 2016 (3)	Yes	Yes	Yes	No	Yes	No	NA	Yes	Yes	Yes	NA	No	7	Moderate
15	Jaiswal et al. 2016 (43)	Yes	Yes	No	No	No	No	Yes	No	No	Yes	No	Yes	5	Moderate
16	Bensal et al. 2016 (42)	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	NA	No	7	Moderate
17	Sashidharan et al. 2017 (45)	Yes	Yes	Yes	Yes	Yes	No	NA	Yes	Yes	Yes	NA	Yes	6	Moderate
18	Patel et al. 2017 (6)	Yes	Yes	Yes	No	Yes	No	NA	Yes	No	Yes	NA	Yes	6	Moderate
19	Joseph et al. 2017 (44)	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	NA	Yes	7	Moderate
20	Ali and Shukla, 2018 (28)	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	NA	Yes	9	Good

Appendix Table 1 Critical appraisal of observational cohort and cross-sectional studies

Sr. No	Author, Year	Clearly described research question	Clearly described Study population	Participation rate	inclusion and exclusion criteria	Sample size justification	Exposure assessed prior to outcome measurement	Different levels of the exposure of interest	Exposure measures and assessment	Repeated exposure assessment	Outcome measures	Blinding of outcome assessors	Statistical analyses	Total score	Quality
21	Chand and Chauhan, 2018 (46)	Yes	Yes	No	No	No	No	NA	Yes	No	Yes	NA	Yes	4	Poor
22	Kaur et al. 2019 (48)	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	NA	Yes	8	Moderate
23	Prasad et al. 2019 (47)	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes	NA	Yes	9	Good
24	Yadav, 2019 (11)	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes	10	Good
25	Rajasekar et al. 2020 (50)	Yes	Yes	No	No	Yes	No	NA	No	No	Yes	NA	No	4	Poor
26	Debbarma et al. 2020 (15)	Yes	Yes	No	No	No	No	Yes	Yes	Yes	Yes	NA	Yes	7	Moderate
27	Serrao et al. 2020 (49)	Yes	Yes	No	No	Yes	No	Yes	Yes	No	Yes	NA	Yes	6	Moderate
28	Das, 2020 (a) (20)	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	11	Good
29	Das, 2020 (b)(14)	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	Yes	Yes	10	Good
30	Bharti et al. 2020 (13)	Yes	Yes	No	No	Yes	No	Yes	Yes	Yes	Yes	NA	Yes	8	Moderate
31	Das, 2021 (19)	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes	10	Good
32	Kashyap et al. 2021 (23)	Yes	Yes	Yes	No	Yes	No	NA	Yes	No	Yes	NA	Yes	9	Good
33	Rajak et al. 2021 (17)	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	10	Good
34	Edwards et al. 2022 (31)	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	10	Good
35	Sarkar et al. 2023 (12)	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	Yes	Yes	10	Good

Note: Quality was rated as poor (score 0–4 out of 12 questions), moderate (score 5–8 out of 12 questions), good (score 9–12 out of 12 questions); NA: not applicable, NR: not reported.

Category	Yes	No	CD/NA/NR
Score	1	0	-
Colour coded			

Appendix Table 1. Critical appraisal of Case study

Sr. No	Author, Year	Clearly described research question	Population clearly and fully described	Cases consecutive	Subjects comparable	Intervention clearly described	Outcome measures clearly defined, valid, reliable, and implemented consistently	Length of follow-up adequate	Statistical methods well-described	Results well-described	Total score	Quality
1	Maiti and Bhattacherjee, 2001(51)	Yes	Yes	No	Yes	N/A	Yes	N/A	Yes	Yes	6	Moderate
2	Calvin and Joseph, 2006 (52)	Yes	Yes	No	No	N/A	Yes	N/A	No	Yes	4	Fair
3	Shah et al. 2007(a) (53)	Yes	Yes	Yes	Yes	N/A	Yes	Yes	Yes	Yes	8	Good
4	Shah et al. 2007(b) (29)	Yes	Yes	Yes	No	N/A	Yes	Yes	Yes	Yes	7	Good
5	Mavli and Sisodiya, 2016 (54)	Yes	Yes	No	No	N/A	No	N/A	No	Yes	4	Moderate
6	Ragavi et al. 2021 (30)	Yes	Yes	No	No	N/A	Yes	N/A	No	Yes	4	Moderate

Category	Yes	No	CD/NA/NR
Score	1	0	-
Colour coded			

Note: Quality was rated as good (score 7– 9out of 9 questions); moderate (score 4–6 out of 9 questions), poor (score 0–3 out of 9 questions). NA = not applicable

Appendix Table 1. Critical appraisal of Case-control study

Sr. No	Author, Year	Research question	Population clearly and fully described	Sample size justification	Were controls selected from the similar population	Inclusion and exclusion criteria	Cases clearly defined and differentiated from controls	Cases and/or controls randomly selected	Concurrent controls	Investigators able to confirm that the exposure	Exposure measures and assessment	Blinding of exposure assessors	Statistical analysis	Total score	Quality
1	Ghosh et al. 2004 (56)	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	NA	Yes	9	Good
2	Paul et al. 2005 (55)	Yes	Yes	No	Yes	Yes	Yes	No	No	No	Yes	No	Yes	7	Moderate
3	Kunar et al. 2008 (57)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	NA	Yes	9	Good
4	Senapati et al. 2019 (18)	Yes	Yes	Yes	Yes	No	Yes	No	No	No	Yes	NA	Yes	7	Moderate
5	Jaiswal, 2012 (a) (2)	Yes	No	Yes	Yes	Yes	No	No	No	Yes	No	NA	Yes	7	Moderate

Category	Yes	No	CD/NA/NR
Score	1	0	-
Colour coded			

Note: Quality was rated as poor (score 0–4 out of 12 questions), moderate (score 5–8 out of 12 questions), good (score 9–12 out of 12 questions); NA: not applicable, NR: not reported.

Appendix Table 2. Descriptive data of included studies

Author (s), Year	Type of industry	Study location	Study design	Sample size	Number of injured populations	Prevalence	Contributing factors to injury	Quality appraisal, Certainty
Maiti and Bhattacherjee, (2001) [49]	Coal mine	West Bengal	Case Study	6281	459	7.31	Old aged workers (50–60 years) fairly high injury rate as compared to the younger workers.	Moderate (6/12)
Ghosh et al. (2004) [56]	Coal mine	West Bengal	Case-Control	Case group (n=202), Control group (n=202)	202	Not provided	Poor perception of working condition:1.61 (95% CI: 1.00-3.18), job stress: 1.83 (95% CI: 1.00-3.46), poor safety performance: 3.10 (95% CI: 1.45-6.63) were significantly associated with injury at workplace.	Good (9/12)
Paul et al. (2005) [55]	Coal mine	West Bengal	Case-Control	Case group (n=150), Control group (n=150)	150	Not provided	Older age group workers (> 46 years) are 3.48 times and most experienced workers are 5.5 times more injurious than the youngest age group (<29 years of age) and least experienced workers.	Moderate (7/12)
Singh et al. (2005) [58]	Agriculture	Haryana	Cohort study	45	45	Not provided	Poor light arrangements, alcohol abuse, fatigue, and lack of orientation to work were the contributory factor for injury.	Moderate (6/12)
Brahmapurkar et al. (2006) [28]	Glassware manufacturing	Nagpur	Cross-Sectional	526	355	67.49	Less than 5 years length of exposure 83.7% had the injury and in 5-10 had 100% injury. The injuries were more in the furnace section (100%) followed by manufacturing section (98.0%).	Fair (7/12)
Calvin and Joseph, (2006) [50]	Garment manufacturing	Bangalore	Case Study	570	28	4.90	Neglected wearing protective device, frequent change of the type or machine and to unsafe condition of the machine were major reason for accident at workplace.	Moderate (4/9)
Saha et al. (2007) (a) [61]	Metal industry	Gujarat	Case Study	220	66	30.00	Workers having lesser experience (OR, 2.39: 95% CI, 1.25-4.56) were high risk of accident occurrence.	Good (8/9)
Shah et al. (2007) (b) [52]	Chemical industry	Eastern India	Case study	726	726	Not provided	Temporary nature of employment was at greater risk (OR, 2.51: 95% CI, 1.42–3.77) in comparison to permanent workers.	Good (7/9)

Appendix Table 2.

Author (s), Year	Type of industry	Study location	Study design	Sample size	Number of injured population	Prevalence	Contributing factors to injury	Quality appraisal, Certainty
Gangopadhyay et al. (2007) [29]	Metal industry	West Bengal	Cross-Sectional	3023	3023	Not provided	A statistically significant difference was observed between the injury rate by the skilled (21.1 per 1000 workers) and unskilled workers (23.9 per 1000 workers). Also, with the increase in work experience, there is a gradual decrease in the number of incidents.	Moderate (8/12)
Kunar et al. (2008) [57]	Coal mine	South part of India	Case-Control	Cases (n=245), Control= (n=330)	245	Not provided	Workers with no formal education, regular consumption of alcohol, presence of disease, risk taking behavior, and big family size were significantly associated with occupational injury.	Moderate (6/12)
Pandit and Tiwari, (2008) [30]	Steel pipe manufacture	Gujarat	Cross-Sectional	100	14	14.00	Type of work also major affect the workplace injury. Out of total injuries, 42.9% workers belong to loading and transport department and 57.1% from press machine department.	Moderate (5/12)
Kumar et al. (2010) [31]	Tile Manufacturing factory	Karnataka	Cross-Sectional	355	65	18.30	Workers having lesser experience (OR 5 2.62: 95% CI, 1.37-5.01) were at an increased risk of accident occurrence	Moderate (7/12)
Singh. (2010) [32]	Cement industry	Jharkhand	Cross-Sectional	500	400	80.00	Less work experienced workers (1-5 years) the percentage of injury was (32%) than that of high experienced workers (97.14%).	Poor (4/12)
Manjunatha et al. (2011) [33]	Iron and steel industry	Karnataka	Cross-Sectional	245	13	10.2	Blue collar workers and shift works experienced more injury than their counterpart (P<0.05)	Moderate (7/12)
Jaiswal, (2012 a) [37]	Carpet manufacturing	Uttar Pradesh	Case-Control	640	310	48.43	Young age (<30 years) [AOR 1.90, 95% CI 1.22, 2.94], health and safety training [AOR 1.85, 95% CI 1.17, 2.91], sleeping disturbance [AOR 1.99, 95% CI 1.30, 3.04] and were significant predictors of occupation injury.	Moderate (7/12)

Appendix Table 2.

Author (s), Year	Type of industry	Study location	Study design	Sample size	Number of injured populations	Prevalence	Contributing factors to injury	Quality appraisal, Certainty
Jaiswal, (2012b) [2]	Manufacturing	Uttar Pradesh	Cross-Sectional	588	104	39.4	Sleep insufficiency (OR 1.3, 95% CI 1.1–1.7), and insomnia symptoms (OR 1.5, 95% CI 1.1–1.9) had a significantly higher prevalence for injury after adjusting for multiple confounders.	Moderate (7/12)
Rani and Jyothi, (2013) [16]	Iron and Steel Industry	Visakhapatnam	Cross-Sectional	360	26	7.2	Unsafe acts and unsafe conditions are the major causes of accidents.	Moderate (8/12)
Jayakrishnan et al. (2013) [34]	Construction industry	Kerala	Cross-Sectional	387	47	12.10	Civil workers had high risk of injury (6.6% vs. 17.2%. P = 0.001) and most of them were mechanical injury, which may be due to high rate of manual works using sharp tools and falls.	Moderate (8/12)
Bhumika et al. (2014) [36]	Welding workers	Karnataka	Cross-Sectional	160	128	80.00	Not using of PPE and workers working hours more than 8 hours/day was higher chances of accident at workplace.	Moderate (8/12)
Kumar and Dharanipriya, (2014) [59]	Welding workers	Puducherry	Cross-Sectional	209	209	Not provided	Age less than 30 years (OR = 5.19), tobacco use (OR = 2.56), alcohol use (OR = 3.96) and institutional training (OR = 0.10) were independently associated with more than 10 injuries	Moderate (7/12)
Jain et al. (2015) [22]	Iron and Steel Industry	Maharashtra	Cross-Sectional	200	123	61.5	The association between history of heat exposure and history of injury was significant (x^2=33.97, df=1, p value <.0001).	Moderate (7/12)
Ujwala et al. (2015) [21]	Iron and Steel Industry	Visakhapatnam	Cross-Sectional	306	66	21.56	The factors such as age<30 years (OR=1.99), <5 years' job duration (OR=2.33) and stress at work (OR=2.32) were associated with a significantly higher risk of occupational injuries.	Moderate (4/9)
Mavli and Sisodiya, (2016) [53]	Multiple industry	Gujarat	Case study	68	68	Not provided	Most of the injuries were in the age group of 21-30 years. Lack of awareness and the usage of protective gear was major reason for injury.	Moderate (4/12)

Appendix Table 2.

Author (s), Year	Type of industry	Study location	Study design	Sample size	Number of injured populations	Prevalence	Contributing factors to injury	Quality appraisal, Certainty
Jasani et al. (2016) [3]	Construction workers	Gujarat	Cross-Sectional	231	107	46.32	Unskilled workers observed most of the injuries (77%). Also, injuries were common in labor work (62.62%) like carry sand/cement/brick/concrete etc.	Moderate (7/12)
Jaiswal et al. (2016) [39]	Manufacturing	Uttar Pradesh	Cross-Sectional	184	95	20.65	High job strain (specifically, high job demand), and co-worker support are important factors affecting work injury.	Moderate (5/12)
Bensal et al. (2016) [38]	Maintenance workers	Himachal Pradesh	Cross-Sectional	25	25	Not provided	The prevalence of accident increases by work experience. For example: 3-4 years of work experience had 46% of total injury.	Moderate (7/12)
Sashidharan et al. (2017) [41]	Construction workers	Tamil Nadu	Cross-Sectional	302	134	44.37	Workers who are prone to alcohol habit (53.2%) are at high risk i.e., 2.7 times more prone to external injury than those who do not drink (29.5%) (x1 2 =16, p<0.001).	Moderate (6/12)
Joseph et al. (2017) [40]	Welding workers	Karnataka	Cross-Sectional	155	38	24.51	Non-usage of protective gears of face and eyes and unaware of occupational hazards are major causes of accident and injury at workplace.	Moderate (9/12)
Patel et al. (2018) [6]	Agriculture worker	Arunachal Pradesh	Cross-Sectional	12562	174	Not provided	The root causes of accidents are the use of traditional tools and equipment in various agricultural activities.	Moderate (6/12)
Ali and Shukla, (2018) [43]	Iron and Steel Industry	Madhya Pradesh	Cross-Sectional	23	23	Not provided	Unsafe working condition, working in unsafe posture or position for long period, no use of PPE, Lack of skills and knowledge are major causes of injury.	Good (9/12)
Chand and Chauhan, (2018) [42]	Multiple industry	Rajasthan	Cross-Sectional	52	52	Not provided	Not using PPE were major cause of injury. Maximum number of patients with ocular injury came from steel industry (32.69%), followed by handicraft industry (30.76%), and stone mining (21.15%).	Poor (4/12)
Gupta et al. (2018) [60]	Repair/ Maintenance worker	Uttar Pradesh	Cross-Sectional	288	288	Not provided	Age group, education level, and utilization of safety measures were significantly associated with pattern of occupational injuries in univariate analysis ($P < 0.05$).	Moderate (8/12)

Appendix Table 2.

Author (s), Year	Type of industry	Study location	Study design	Sample size	Number of injured populations	Prevalence	Contributing factors to injury	Quality appraisal, Certainty
Kaur et al. (2019) [45]	Construction worker	Maharashtra	Cross-Sectional	90	23	25.56	Factors like not using PPE (68.57%), smoking (47.86%), and lack of sleep (61.43%) were associated with occupational injury.	Moderate (8/12)
Prasad et al. (2019) [44]	Stone Quarry workers	Maharashtra	Cross-Sectional	292	241	82.53	Age group, education level, and utilization of safety measures were significantly associated with pattern of occupational injuries in univariate analysis ($P < 0.05$).	Good (9/12)
Senapati et al. (2019) [18]	Coal Mine	Chhattisgarh	Case-Control	Case group: (n=135), Control group: (n=270)	135	Not provided	Big family size ($\geq$5 dependents) (61.5%), no formal education (58.5%), less job experience (35.6%), presence of diseases (37.0%), and poor safety perception (60.0%) were major causes of injury.	Moderate (7/12)
Yadav, (2019) [11]	Multiple industry	Dadra and Nagar Haveli	Cross-Sectional	3175	113	3.55	Out of total accidents, 46.6% belonged to 21 to 30 years age group. Electric shock and fall from height were responsible for major reason for injury.	Good (10/12)
Rajasekar et al. (2020) [47]	Iron and Steel Industry	Tamil Nadu	Cross-Sectional	143	71	49.65	Workers who not using PPE were higher risk of injuries. Nature of work such (Pressing and cutting, powdering and polishing, packing and beading) another major causes of injuries.	Poor (4/12)
Debbarma et al. (2020) [15]	Multiple industry	Kanpur	Cross-Sectional	90	62	69.11	Majority of accident (73.3%) were in the 20-40 years' age group. No institutional training (81%), and less work experience (61%) positively associated with occupational injury.	Moderate (7/12)
Serrao et al. (2020) [46]	Building Construction workers	Mangalore	Cross-Sectional	101	37	36.63	Age group of <30 years are more likely to injure than those who are >30 years (COR: 3.69 [CI]: 2.554 –5.219).	Moderate (6/12)
Das, 2020 (a) [20]	Brickfield Construction	West Bengal	Cross-Sectional	1293	242	18.71	Manual material handling (21.8%), overcrowded work (59.5%), and poor income (92.0%) were major factor for workplace injury.	Good (11/12)
Das, 2020 (b) [14]	Railway track maintenance worker	West Bengal	Cross-Sectional	742	98	13.2	Long working hours (42.9%), thermal stress (39.8%), Repetitiveness of work (18.4%) and neglect of safety precautions are the main reason for injury	Good (10/12)

Appendix Table 2.

Author (s), Year	Type of industry	Study location	Study design	Sample size	Number of injured populations	Prevalence	Contributing factors to injury	Quality appraisal, Certainty
Bharti et al. (2020) [13]	Construction industry	New Delhi	Cross-Sectional	129	78	60.46	Number of working hours, falling of objects were significantly associated with frequent injuries ($p<0.01$).	Moderate (8/12)
Das, (2021) [19]	Brickfield Construction	West Bengal	Cross-Sectional	159	159	Not provided	Work fatigue (87.3%), lack of rotation at task (27.0%), lack of personal protective device (35.8%), and sleep disturbance (21.5%) were major factors for workplace injury.	Moderate (10/12)
Kashyap et al. (2021) [23]	Leather Manufacturing	Kanpur	Cross-Sectional	284	30	10.56	Workers involved in loading and unloading of raw hides manually were 2.0 ($p<0.1$) times likely to experience a work-related injury.	Good (9/12)
Rajak et al. (2021) [17]	Iron and Steel Industry	West Bengal	Cross-Sectional	505	142	28.12	Workers who had a non-technical education degree were 2.52 times (95% CI [1.09, 5.86]), and daily alcohol consumers were 2.47 times (95% CI [0.93, 6.52]) higher in risk of accident and injury.	Good (10/12)
Ragavi et al. (2021) [54]	Multiple industries	Tamil Nadu	Case study	603	513	85.0	Patients working in wood-related industries (AOR [OR]: 1.74 (1.04–2.93); $P = 0.001$) and those sustaining a sharp object injury (AOR OR: 1.45 (0.95– 2.19); $P = 0.082$) had a higher odd of sustaining severe injury.	Moderate (4/9)
Edwards et al. (2022) [48]	Construction workers	Delhi	Cross-Sectional	1217	729	59.90	Higher age group (>64) higher chances of accident: OR 1.33 (0.24–7.52). Unskilled workers (55.0%) have high chance of injuries than skilled workers.	Good (10/12)
Sarkar et al. (2023) [12]	Construction workers	West Bengal	Cross-Sectional	384	90	23.4	Age less than equal to 40 years and lesser work experience were statistically significant [2.9 (1.7 - 4.1) and 2.2 (1.5 - 3.9), respectively].	Good (10/12)

Appendix Table 3. Summary of contributing factors of occupational injuries

Contributing factors	Number of studies	Reference
Socio demographic factor		
Young age group (Under 25 years of age)	23	[6,6,11,12,15,17,18,18,21,23,29–31,35,43,45,46,46,49,52–54,59]
Less work experience	13	[12,15,18,19,21,32,33,35,36,47,49,61,70]
High work experience	11	[17,19,21,23,31,33,36,42,51,55,60]
Poor economic condition	8	[12,13,13,14,14,17,59]
Lack of education/No formal education	4	[6,18,21,57]
Old age group	2	[36,56]
Big family size (5 or more family members)	2	[18,57]
Mistakes by oneself/co-workers/seniors	1	[17]
Lack of media exposure	1	[23]
Behavioural and psychological factors		
Substance use (Smoking cigarettes, bidi, drinking alcohol)	19	[2,12,14,17,19–23,28,38,45,48,49,53,57,59,61]
Sleep disturbance	12	[2,17–20,23,48,49,58]
Job dissatisfaction	9	[12,20,21,23,43,49,55,56]
Emotional instability	7	[12,14,21,41,43,49,55]
Occupational stress	6	[19–21,43,55,56]
Conflict regarding organization/authority/family	2	[14,20]
Organizational and work behaviour factors		
Nature of work (skilled/unskilled)	11	[17,18,22,31,32,38,44–46,58,60]
Biomechanical factors (Manual machine handling, Repetitiveness of work, Awkward postures while performing work)	9	[14,18–20,35,38,52,56,56]
Status of employment (permanent/temporary)	5	[17,20,23,53,61]
Risk taking behavior	5	[17,28,55–57]
Unsafe acts	3	[16,17,28]

Appendix Table 3

Contributing factors	Number of studies	Reference
Organizational and work behaviour factors		
Lack of proper knowledge and skillful activity	3	[17,20,52]
Lack of rotation of task	2	[19,20]
Lack of supervisor and coworker support	2	[43,55]
Job location	1	[22]
Work overload	1	[17]
Occupational related factors		
Long working hours	9	[3,13,15,20,34,40,44,49,53]
Working at night	7	[2,14,20,49,53,58,59]
Poor physical environment (poor light arrangement/ poor ventilation/ inadequate working space/platform)	5	[17,28,35,44,58]
Shift job	3	[21,53,58]
Overcrowding at workplace	1	[44]
Thermal stress/heat stress	1	[14]
Workplace safety environment factor		
Less availability and low or no usage of PPE	18	[15,17–20,22,28,34,40,44,46,48–50,53–55,60]
Lack of OHS knowledge and awareness	13	[14,16,17,20,28,35,38,44,48,54,55,57,59]
Lack of safety and health training programs	13	[2,14,15,17,19,20,28,35,40,44,55,56,59]
Neglect of safety precautions	10	[14,17,20,22,28,41,52,56,59]
Poor safety environment	5	[18,20,23,41,56]

OCCASIONAL PAPERS

1. *Keynes, Kaldor and Development Economics* by Amiya Kumar Bagchi, July 2004.
2 *Epar Ganga Opar Ganga - A creative statement on displacement and violence* by Subhoranjan Dasgupta, July 2004.
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