The pooled effect of Factors Contributing to Occupational Injury among Workers in the Construction, Manufacturing, and Mining Industries in Africa: *A systematic Review and Meta-Analysis*.

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Abstract

Working in the industry is commonly associated with a combination of personal and environmental health and safety risks. However, the finding from African countries on the factors contributing to occupational injury is inconsistent and not inclusive. Therefore, this systematic review and meta-analysis were estimated the pooled effect of factors leading to occupational injury among workers in the industries in Africa.

Published articles found in Scopus, PubMed/Medline, Science Direct, and Cochrane Library databases were systematically searched. Observational studies revealing the factors leading to occupational injury among workers in the industry in Africa were incorporated. The pooled effect size of the studies was computed using STATA version 14 statistical software. The heterogeneity of the study was assessed using Cochrane Q test statistics, the I-squared values test, and the Galbraith plot. Considering within and between studies variability, the random-effect model was used to determine the pooled effect size. Funnel plot and egger's tests were conducted to evaluate publication bias.

Out of 603 accessed studies, 20 studies that fulfilled the eligibility criteria were included to estimate the pooled effect of factors contributing to occupational injury. Accordingly, being temporary employment workers (pooled odds ratio= 2.13 (1.06, 3.21)), not receiving ongoing health and safety training (pooled odds ratio= 1.98 (1.21, 2.76), and the proper and consistent use of personal protective equipment (pooled odds ratio= 0.60 (0.32, 0.88) were factors significantly associated with the odds of experiencing an occupational injury.

Being temporary employment workers and not receiving ongoing health and safety training elevates the odds of sustaining occupational injuries. But, the proper and consistent use of personal protective equipment reduces the odds of experiencing an occupational injury. Hence, the government, industrial managers and industrial hygienists, and other stakeholders should implement rigorous law enforcement to ensure compliance, proper implementation of health and safety measures practices, and safety audits.

Introduction

Any personal injury, illness, or death resulting from an occupational accident is referred to as an occupational injury [1]. Such injuries pose a significant public health issue and lead to severe social and economic implications. Evidence shows workplace injury represent a large portion of the global injury burden, accounting for almost 30% of all medically treated injuries to adults aged 18 to 64 years worldwide [2, 3]. In 2017 alone, workplace injury was responsible for over 2.78 million deaths and 374 million non-fatal injuries worldwide [4, 5]. Besides, it is estimated that the number of non-fatal occupational injuries has significantly increased since 2010. The key reason for this was that previous reports accessed low portion of the incidents and under-reporting rate of the issue accompany by less consideration by different agents [6]. Also, according to the World Health Organization (WHO), 20 to 50 %

of industrial employees worldwide are exposed to various occupational hazards. In developed and newly industrialized countries, these estimates are likely to be higher [7].

As a result, in low and middle-income countries, where the industries are mostly concentrated where health and safety regulation is not well enforced, the burden of occupational injuries is incredibly high [8, 9]. Occupational injuries are common among construction, manufacturing, and mining workers in Africa than in other developing countries [10, 11]. In African countries , the prevalence of occupational injury was significantly varied ranging from 23.7% to 72.2% in Congo [12, 13], 39.25 to 69% in Nigeria [14, 15], 9.7% to 97.5% in Ethiopia [16, 17], and 19.2% to 98.1% in Kenya [18, 19].

As a result, several studies have been conducted to identify the factors that influence occupational injuries worldwide [20-25]. Accordingly, a service year, undergoing health and safety training, working more than 48 hours per week, and wearing personal protective equipment regularly are all factors that can reduce or increase the risk of an occupational accident and the related economic costs [23, 26-32]. Similarly, performing workplace safety inspections, reducing weekly working hours, using personal protective equipment, employment working conditions (being temporary employment workers), service year, being male, and job category were all found to be independent predictors of occupational injuries in multiple studies [33-42]. Besides, most studies found an association between weekly working hours, health and safety instruction, workplace safety supervision, and occupational injuries and illness. Working in the industry is commonly associated with a combination of personal and environmental health and safety risks [43-46]. However, studies on factors associated with occupational injury from different African countries are inconsistent and not inclusive. To the best of our knowledge, there is no comprehensive study on polled effect of occupational injury factors in Africa. Therefore, understanding the pooled effect size of occupational injury factors is critical for developing practical and feasible occupational injury and illness prevention and control strategies.

Hence, the purpose of this systematic review and meta-analysis was aimed to estimate the pooled effect size of factors that contribute to occupational injury among workers in the construction, manufacturing, and mining industry in Africa countries and to provide the necessary information to the scientific communities and policymakers who intervene in the problem.

Materials And Methods

Setting and study period

This systematic review and meta-analysis was conducted in Africa countries from October 1/2020 to February 10/2021. According to 2021 United Nations projections, Africa's population was estimated to be 1,361,684,609. Africa's population density and total land area are 45 people per square kilometer and 29, 648, 48 square kilometers, respectively. Nigeria is Africa's most populous country, with over 206 million people as of 2020 and followed by Ethiopia [47].

In most developing countries, health workers are concentrated in large cities and towns in Africa. However, many sub-Saharan African regions fall below the WHO guideline of 2.3 health staff per 1000 population for greater accessibility of critical services and reduce the risk of occupational injury resulting from work overload [48].

Africa's business-to-business manufacturing investment is expected to hit $666.3 billion by 2030. The evolution and prospects of manufacturing and industrialization in Africa were addressed in this study. Finally, it gives business leaders an outline of Africa's greatest manufacturing markets by 2030. It gives policymakers some options for attracting private investors, accelerating manufacturing and industrialization, and contributing to growth and poverty alleviation, making the Sustainable Development Goals and the African Union's Agenda 2063 more achievable. Manufacturing and industrial growth will be vital to Africa's ability to achieve its development goals, even if policy solutions vary by region [49].

Searching strategies

First, a search was done on the Cochrane Library, Joanna Briggs Institute (JBI), and PROSPERO databases to check whether a systematic review and meta-analysis studies exist or for the presence of ongoing review projects related to pooled effect sizes of factors contributing to occupational injuries in Africa. Predesigned search strategy was developed to confirm the scientific accuracy and make the review systematic. PRISMA guideline was used to illustrate the process of the searching, accessing, rejecting and including of the papers for systematic review and meta-analysis. Articles were accessed from SCOPUS, PubMed, Science Direct, Cochrane Library databases, Google Scholar (Search engine) and African journals online. Grey literature like surveillance reports, academic dissertations, and conference abstracts was also be examined and included when it fulfills the inclusion criteria.

For this review, relevant articles were identified using the following Mesh terms. PubMed search strategy; (determinant) OR (predictors) OR (risk factors) OR (associated factors) AND (workplace injuries) OR (occupational accident) OR (occupational injury) OR (work-related injury) OR (work-related accidents) AND Africa. The key terms were used in combination using Boolean operators like "OR" or "AND". The review was restricted to full texts, free articles, and English language publications. This search involved articles published from 1 January 2015 to 10 February 2021. Besides, during the advanced PubMed search, it was used all fields and Mesh words. The first reviewer was performing the initial search and completes it on 10/02/2021. The review was then scanning the literature for updates.

Eligibility of the study

Inclusion criteria

All researches performed in African countries were included in this systematic review and meta-analysis. It took into account research that established the factors that contribute to occupational injury and met the following conditions:

Study design; Observational study design.

Time frame: all studies published from 1 January 2015 up to 10 February 2021

Publication type: both published and unpublished studies.

Language: studies done in English language was included.

Study area: studies conducted in Africa, which are methodologically institutional-based.

Outcome: studies that reported the outcome of interest (factors leading to occupational injury).

Exclusion criteria

Those papers not entirely accessed at the time of our search process were omitted after attempted to contact at least twice with the principal investigator via email. After reviewing their full texts, studies that did not report the outcome of interest and with methodological problems were removed. Besides, studies with low quality as pre-settled parameters and review papers were also omitted.

Quality assessment

The database search results were merged and duplicate papers were removed using Endnote (version X8). To assess the methodological qualities of the included articles, a modified version of the Newcastle-Ottawa quality assessment tool scale for cross-sectional studies was adapted and used to assess each study's quality [50]. Three independent reviewers were critically appraising each paper. Disagreements were resolved by discussion among those reviewers. If not, to address contradictions among the three independent reviewers, a third reviewer was involved by taking the three authors' mean score or by involving the third author. The original studies, which scored ≥7 out of 10, were considered high quality and included in the final meta-analysis. The three authors (MB, MA, and AM) were then independently assessing the quality of included research articles using the above tool.

Data extraction

Using a structured data extraction spreadsheet (Microsoft Excel), data was extracted. The regression tables were developed. The primary author of the original research was contacted for additional information or to clarify method details as needed. All the abstracts included during the title and abstract review goes to full-text review and the necessary data were extracted using the prepared spreadsheet. Data was defined and extracted by MB and double-checked by a second reviewer in a pilot excel sheet. Authors were notified if the data for selecting papers are incomplete or ambiguous. Besides, two authors (MB and MA) independently extracted all the required data using Microsoft Excel. The outcome of interest data extraction consists of the first author's name, publication year, study location, the design of the analysis, sample size, main funding's, sub-region of the study, site of injury, scale or size of the industry, variables under specification and response rate.

Outcome of measurement

After identification, the PROSPERO registration number was (CRD42021230787). Variables in this meta-analysis were considered as a predictor because at least two or more studies reported them as a predictor. Besides, the association table was constructed, and correspondingly, for the factors associated, the logarithm of adjusted odds ratio (AOR) and standard error (SE) of the logarithms of OR were computed.

Data analysis

The extracted data was imported into STATA 14 version software for analysis. Meta-analytic integration was carried out using STATA 14 version software and its "Metan" and "galbr" commands and the individual study prevalence estimations. The' Metan' command was explicitly developed for determinant factors meta-analysis and was based on the double arcsine transformation of Freeman-Tukey for stabilizing variances. Using Der Simonian and Laird random-effects models, a systematic review was computed with Metan, a Stata command for pooling effect sizes, and presented in a forest plot with corresponding 95% CIs.

Publication bias was checked by funnel plot using the "metafunnel" command, by Egger's and Begg's test. The symmetrical graph was interpreted based on the graph's shape to indicate the lack of publication bias. In contrast, an asymmetrical graph was interpreted to indicate the presence of publication bias. Both Egger's and Begg's test was used as a cutoff point to declare the existence of publication bias with a p-value of less than 0.05. To visualize the existence of heterogeneity, we were subjectively using the Galbraith plot and Forest plot. Also, objectively (statistical test) using Higgins I-Squared (I2), and Cochran's Q statistic was used. I-square statistics was quantifying the impact of heterogeneity on the meta-analysis across studies, and was a cutoff point of 50% was used to declare significant/considerable heterogeneity.

The prevalence rate, the logarithm of prevalence, and standard error (SE) of the logarithm of prevalence were computed. The pooled effect size of occupational injury with a 95% confidence interval was computed using a random-effects model. To estimate the pooled effect size, a random effect model was used to the account within and between-study variability. Due to the limited number, non-linear logistic regression analysis was used after extending studies into unit record archives. An output in meta-analyses was double-checked for internal consistency by the same person.

Results

Selection and identification of studies

A total of 603 papers were accessed from PubMed databases (n=488), Scopus (n=15), Google scholar (search engine) (n=56), and manual search, including gray literature (n= 40 articles) and science direct (n=4). From the total accessed papers, 326 studies were rejected due to duplication. After reading the title and the abstract, 48 studies were omitted because they were not in line with this review's purpose and methodological deficit. Finally, 60 studies were screened for full-text review, 20 studies (n=10,155 participants) were included for this systematic review and meta-analysis *(Fig 1).*

response rate ranging from 83–100% and almost all the studies had a good response rate having a response rate of above 80%. About 16 of the 20 reviewed studies were published in reputable journals were cross-sectional concerning the research design [46, 51-53]. Concerning the geographical distribution of the studies, 13 studies were obtained from the East Africa countries. Finally, the quality score of the studies ranges from 7–9 out of 10 points ***(Table 1).***

Table 1: *Included studies in the systematic review and meta-analysis among workers in the Construction, Manufacturing, and Mining industry in Africa countries, 2021 (n=20).*

First author/ Year	Country	Study design	Site of injury	Scale of industry	Quality score
Eric et.al 2017	Ghana	Cross-sectional	Construction	Large	7
Chipo et.al 2015	Zimbabwe	Case control	Mining	Large	7
Serole et.al 2016	South Africa	Case control	Construction	Large	7
Daniel et.al 2017	Ethiopia	Cross-sectional	Manufacturing	Large	7
Yitagesu et.al 2015	Ethiopia	Cross-sectional	Manufacturing	Large	8
Gebrekiros et.al 2015	Ethiopia	Cross-sectional	Manufacturing	Large	9
Edward et.al 2015	Rwanda	Cross-sectional	Manufacturing	Large	8
Patrick et.al 2018	Ghana	Cross-sectional	Construction	Medium	8
Nagasa et.al 2019	Ethiopia	Cross-sectional	Manufacturing	Medium	9
Richard,et.al 2013	Zambia	Case control	Manufacturing	Medium	9
Kunar et.al 2010	South Africa	Case control	Mining	Large	8
Eshetie et.al 2020	Ethiopia	Cross-sectional	Manufacturing	Large	8
Hanna et.al 2017	Ethiopia	Cross-sectional	Construction	Medium	9
Getnet et.al 2015	Ethiopia	Cross-sectional	Manufacturing	Medium	7
Getachew et.al 2017	Ethiopia	Cross-sectional	Construction	Large	9
Myriam et.al 2015	Congo	Cross-sectional	Manufacturing	Medium	8
Christophere et.al 2015	Nigeria	Cross-sectional	Construction	Medium	7
Immaculate et.al 2019	Uganda	Cross-sectional	Manufacturing	Medium	7
Michael et.al 2020	Kenya	Cross-	Mining	Medium	7

		sectional			
Arthur et.al 2015	Uganda	Cross-sectional	Manufacturing	Large	8

Publication bias

The existence of publication bias was determined within the included studies. In this systematic review and meta-analysis, the funnel plot was assessed for asymmetry distribution of factors leading to of occupational injury by visual inspection. This shows that all the studies' effect sizes were normally distributed around the center of a funnel plot due to the absence of publication bias. As defined subjectively below in the funnel map, each study's scatter plot is more clustered near zero, suggesting that there was no publication bias (*Fig 2).*

Sensitivity analysis

In this systematic review and meta-analysis, a sensitivity analysis was done to see the effect of individual studies on the pooled effect of factor leading occupational injury using the random-effects model. The result of the sensitivity analysis shows no single study influenced (no outlier studies) the pooled effect of factors. This could be due to none of the single studies being influential. The estimate was not away from each corresponding article either from its corresponding lower confidence interval or an upper confidence interval **(Fig 3).**

Besides, the publication bias was objectively assessed using Begg's and Egger's tests to rule out test of the null hypothesis: no small-study effects. The estimated bias coefficient (intercept) was 0.13 with a standard error of 0.18, giving a p-value of 0.46. Using Egger's regression test with a p-value of 0.46 tests provides strong evidence for the absence of small-study effects (no publication bias). Lastly, as the p-value is > 0.05, was no statistical evidence of publication bias using the Begg's test for estimating the pooled effect sizes of factors leading to of occupational injury among workers in the construction, manufacturing, and mining industry in Africa countries (p = 0.23) and (p = 0.46) respectively *(Fig 4).*

Besides, it was observed that the amount of variation between studies were minimal ***(Fig 5).***

Factors contributing to occupational injury in Africa countries

This systematic review and meta-analysis identified employment conditions (being temporary employment workers), not obtaining health and safety training, and using the proper personal protective equipment factors associated with occupational injury. Five studies were used to look at the links between being temporary employment workers and occupational injuries. Thus, the pooled odds of experiencing an occupational injury were 2.13 times higher for temporary employment workers than permanent employment workers (AOR= 2.13 (1.06, 3.21)) (*Fig 6).*

In addition, the associations between not receiving health and safety training and occupational injuries were investigated using seven studies. Thus, the pooled odds of sustaining occupational injury were 1.98 times higher among employees who have not received any health and safety training than among workers those who may have (AOR= 1.98 (1.21, 2.76) *(Fig 7).*

Incontarst, the association between consistent use of personal protective equipment and occupational injury was explored using ten studies. As a consequence, workers who regularly use personal protective equipment have a 40% lower the odds of being experiencing occupational injury than workers who don't even (AOR= 0.60 (0.32, 0.88)) (*Fig 8*).

Discussion

The availability of robust evidence is more relevant for policymakers, occupational health and safety authorities, and other stakeholders. This systematic review and meta-analysis were aimed to synthesize existing primary studies on the pooled effect of factors that influence occupational injury among workers in the construction, manufacturing, and mining industries in Africa. Thus, being temporary employment workers, not receiving ongoing health and safety training, and the proper and consistent use of personal protective equipment were the contributing factors associated with the odds of sustaining an occupational injury.

Furthermore, employment conditions (being temporary employment workers) play a major role in raising an occupational injury in seven studies. This review found being temporary employment workers elevates the odds of sustaining an occupational injury. This finding is supported by the studies conducted in Italy [54], Norway [55, 56], Finland [56]. This may be because workers in temporary employment jobs couldn't benefit from access to reliable occupational health and safety services as a means of acquiring injuries and preventing workplace accidents. Besides, the possible explanations may be related to temporary employment workers have a higher risk of workplace injury than permanent employment workers due to job insecurity and danger accumulation.

Moreover, consistent with the literature, this review revealed that taking ongoing health and safety training is statistically related to a significant decrease in injury. Six studies have also demonstrated a significant association between receiving health and safety training and occupational injury. Not taking health and safety training significantly increased the odds of occupational injury. This finding in line with the studies conducted in France [57], Iran [58], South Africa [59], Kenya [60], and Ethiopia [61]. This may be because workers who did receive health and safety training had the requisite knowledge and safety precautions in place to reduce the risk of workplace hazards and injury. Besides, Workers who engage in health and safety programs are also more aware of risks and better defend themselves. Taking health and safety training often motivates and increases workers' awareness of, responsibility for, health and safety issues and safety measures, which can be related to lower morbidity and mortality on the job.

Moreover, the association between consistent and proper use of personal protective equipment and occupational injuries was investigated using ten studies. Consequently, workers who properly and consistently use personal protective equipment have lower odds of incurring an occupational injury than workers who don't even. This observation is consistent with the findings from India [62], Saudi Arabia [63] ,Uganda [64], Ethiopia [65]. The possible explanation for the above view is that proper personal protective equipment is just one component of a comprehensive hazard management program that employs several techniques to maintain a secure and healthy environment. Although consistent use of personal protective equipment reduces the odds of sustaining an occupational injury, it does not eliminate the risk and does not provide permanent or complete protection.

On the other hand, eight studies found that working more than 48 hours a week has a slight impact on the likelihood of suffering an occupational injury. This observation contradicts the results of the American study [2], India [62], German [66], Ethiopia [67]. Similarly, the effect of receiving health and safety supervision on odds of experiencing occupational injury was still marginal. This finding is disagreeing with the studies done in Iran [58], japan [68], Brazil [69].

Finally, since the industrial sector encompasses various industries, manufacturing, and construction jobs are mostly labor-intensive. Even with health and safety measures intervention, the chance of the works exposed to various occupational hazards is still high.

Strengths and limitations

One of the strengths of this analysis is that it covers a vast geographic area. Three researchers screened, extracted and reviewed the articles. The inter-rater agreement between reviewers was statistically tested during the selection process. Furthermore, this systematic analysis and meta-analyses on occupational injury in African countries is the first of their kind. The limitations of this study, like those of other systematic reviews and meta-analyses, are numerous. As a result, most of the experiments in this analysis were cross-sectional, and other confounding factors may have affected the dependent variable. It wasn't easy to pool data and produce accurate proof due to the heterogeneity of the studies. Many papers only included a few experiments, which reduced the proof's severity. Finally, we only looked at articles published in English, even though the recognition of articles published in languages other than English was consistent with others.

Conclusion And Recommendation

Occupational injuries among workers in the construction, manufacturing, and mining industry are still imminent health and safety concerns in Africa. Being temporary employment workers and not obtaining ongoing health and safety training were the risk factors elevating the odds of sustaining occupational injuries. However, the proper and consistent use of personal protective equipment reduces the odds of experiencing occupational injury.

Hence, the stakeholders should implement rigorous law enforcement to ensure compliance with health and safety measures practices, and multifaceted methods should be the areas of action, according to our recommendations. Besides, we suggested that incorporating the health and safety management systems tends to eliminate incidents and improve safety in industries as they are integrated into daily business operations.

Declarations

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Ethics approval and consent to participate:

No ethical approval was necessary because data was collected and analyzed for previously reported research in which primary investigators was obtain informed consent.

Consent for publication:

For publication in a peer-reviewed journal, we were preparing a manuscript and present the findings at conferences.

Availability of data and materials:

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no conflict of interest.

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Figures

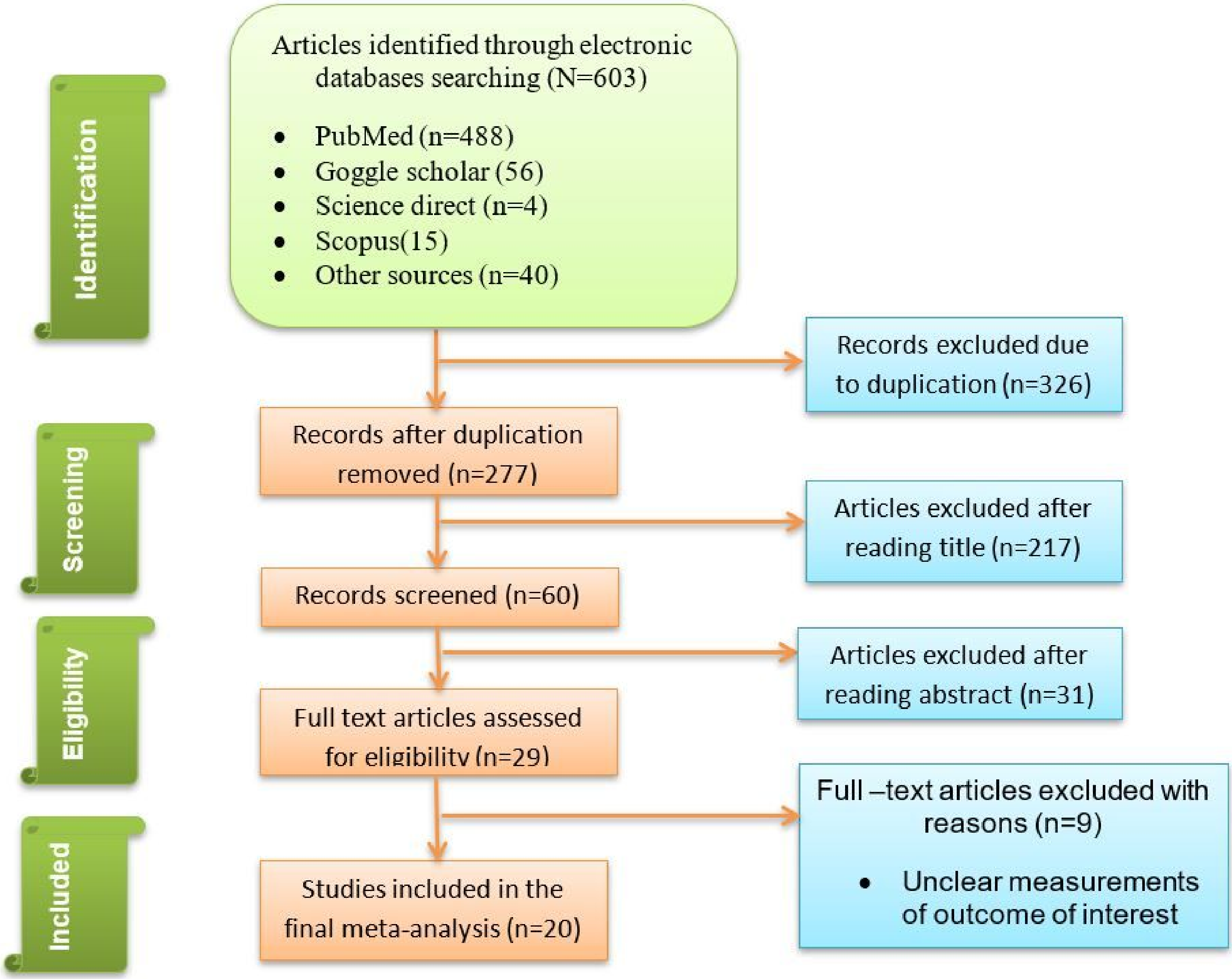

Figure 1

PRISMA flow diagram for study selection for systematic review and meta-analysis of pooled effect sizes of factors leading to occupational injury among workers in industry in Africa, 2021(n=20).

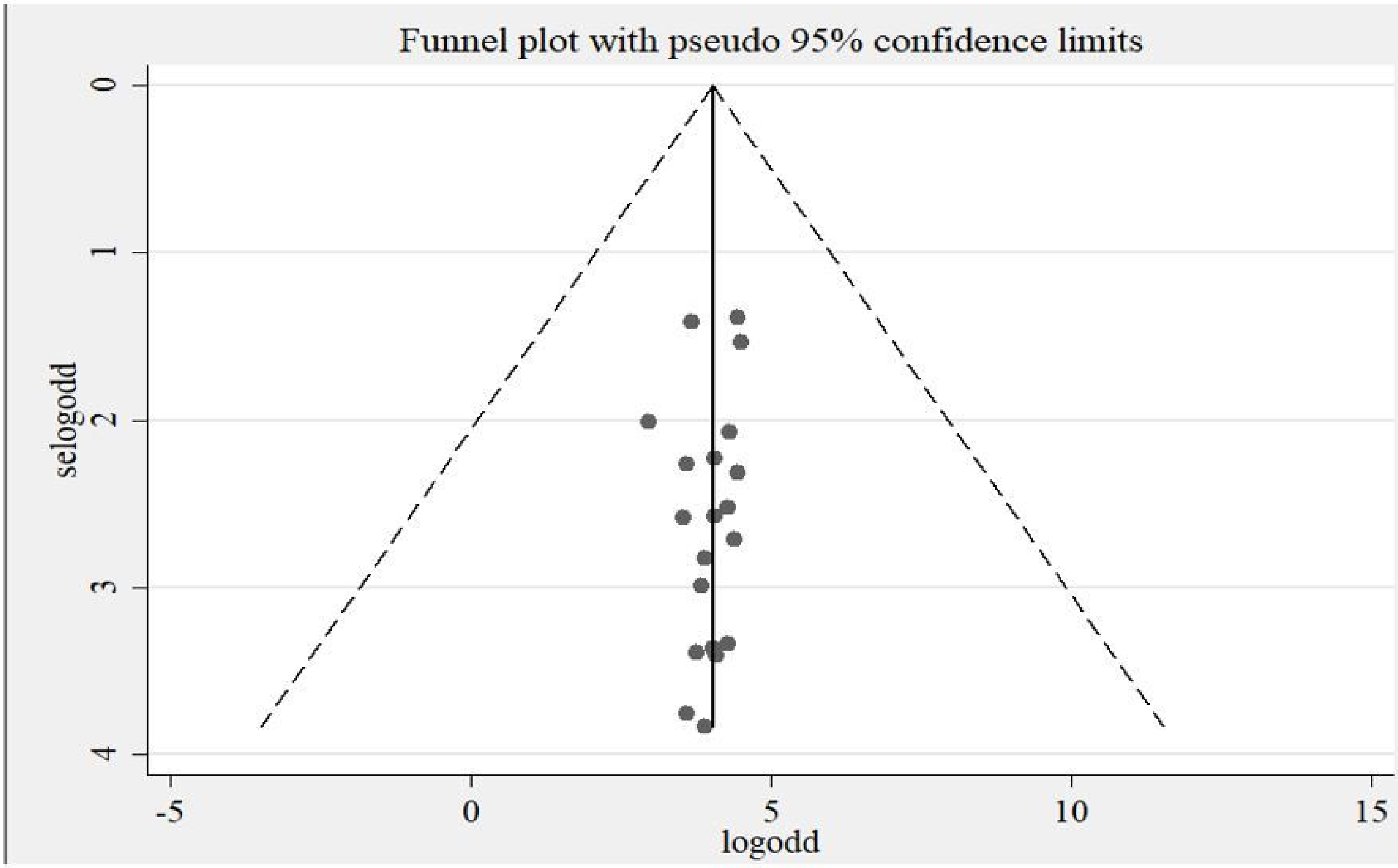

Figure 2

Funnel plot with 95% confidence limits of the pooled effect size of factor leading to occupational injury among workers in construction, manufacturing, and mining industry in Africa, 2021 (n=20).

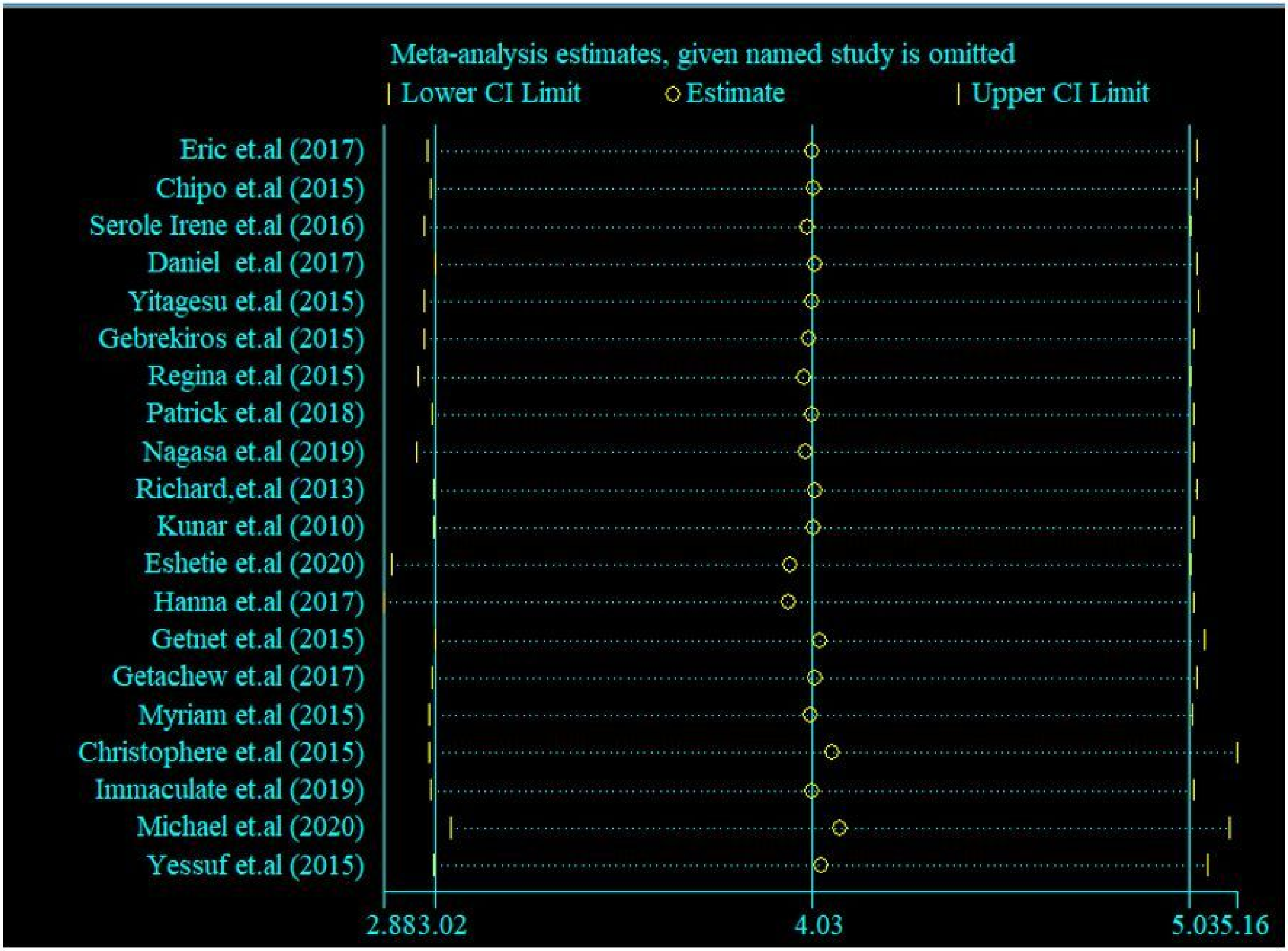

Figure 3

Sensitivity analysis of this systematic review and meta-analysis to estimate the pooled effect size of factors leading to occupational injury among workers industry in Africa, 2021 (n=20).

```
Begg's Test

  adj. Kendall's Score (P-Q) =     -38
          Std. Dev. of Score =   30.82
           Number of Studies =      20
                          z  =   -1.23
                    Pr > |z| =   0.218
                          z  =    1.20 (continuity corrected)
                    Pr > |z| =   0.230 (continuity corrected)
```

Egger's Test

Std_Eff	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
slope	4.324496	.3488954	12.39	0.000	3.591494	5.057499
bias	-.1392823	.1859408	-0.75	0.463	-.5299295	.2513648

Figure 4

Begg's and Egger's test for detection of publication bias for studies included systematic review and meta-analysis in Africa countries, 2021 (n=20).

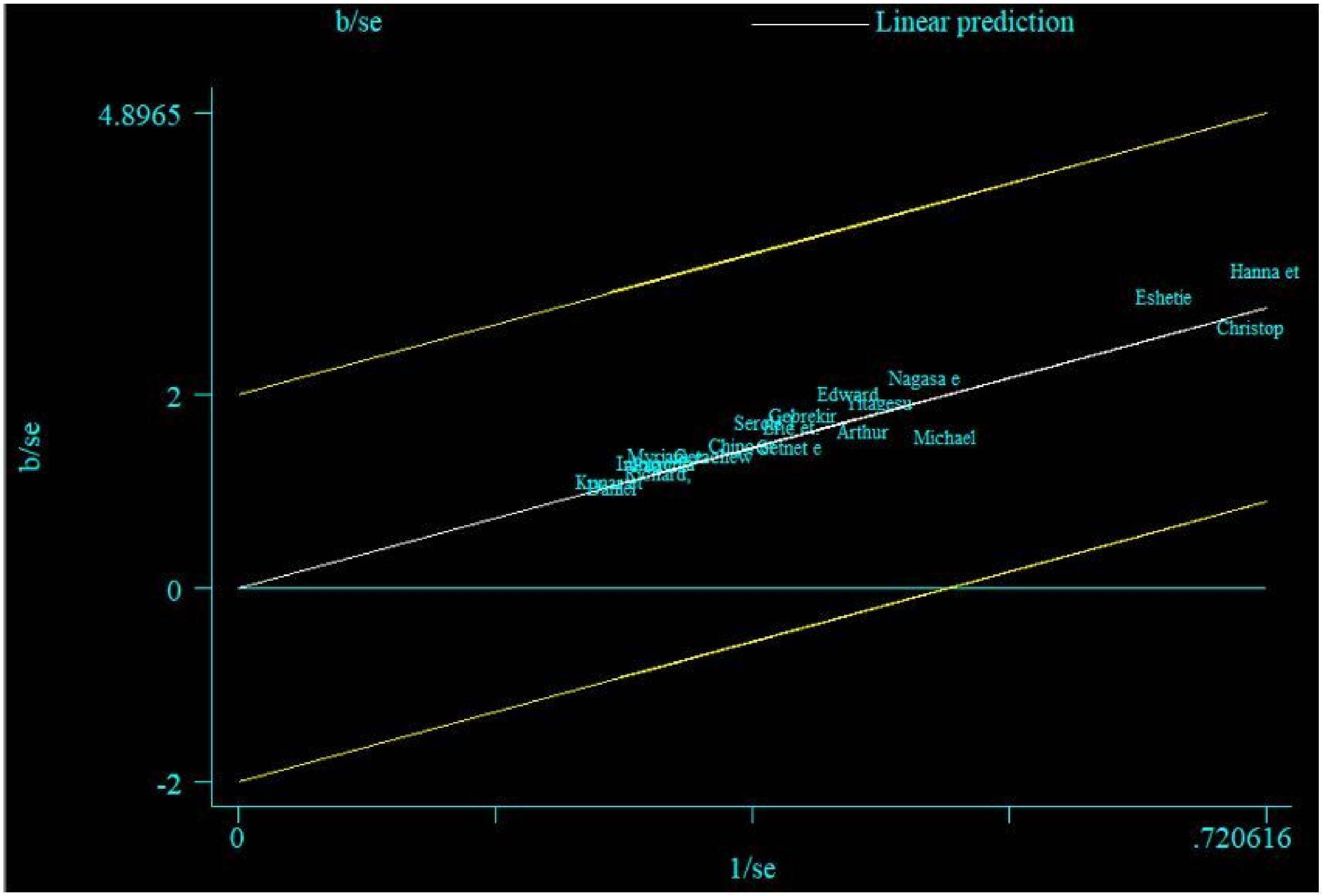

Figure 5

Galbraith plot to ruleout the amount of heterogeneity from a meta-analysis.

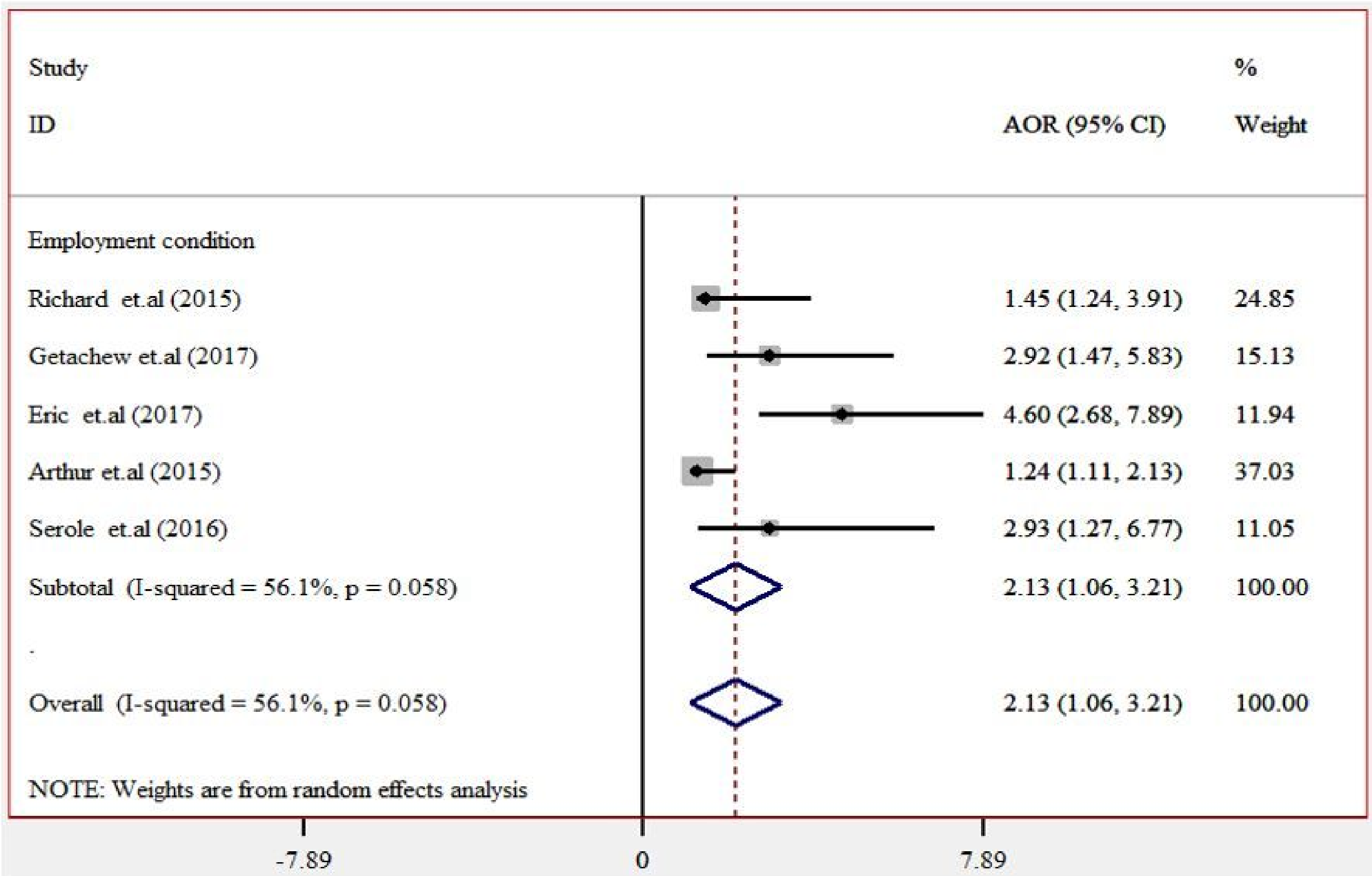

Figure 6

Forest plots which describe the association between employment conditions and occupational injury among workers industry in Africa countries, 2021 (n=5).

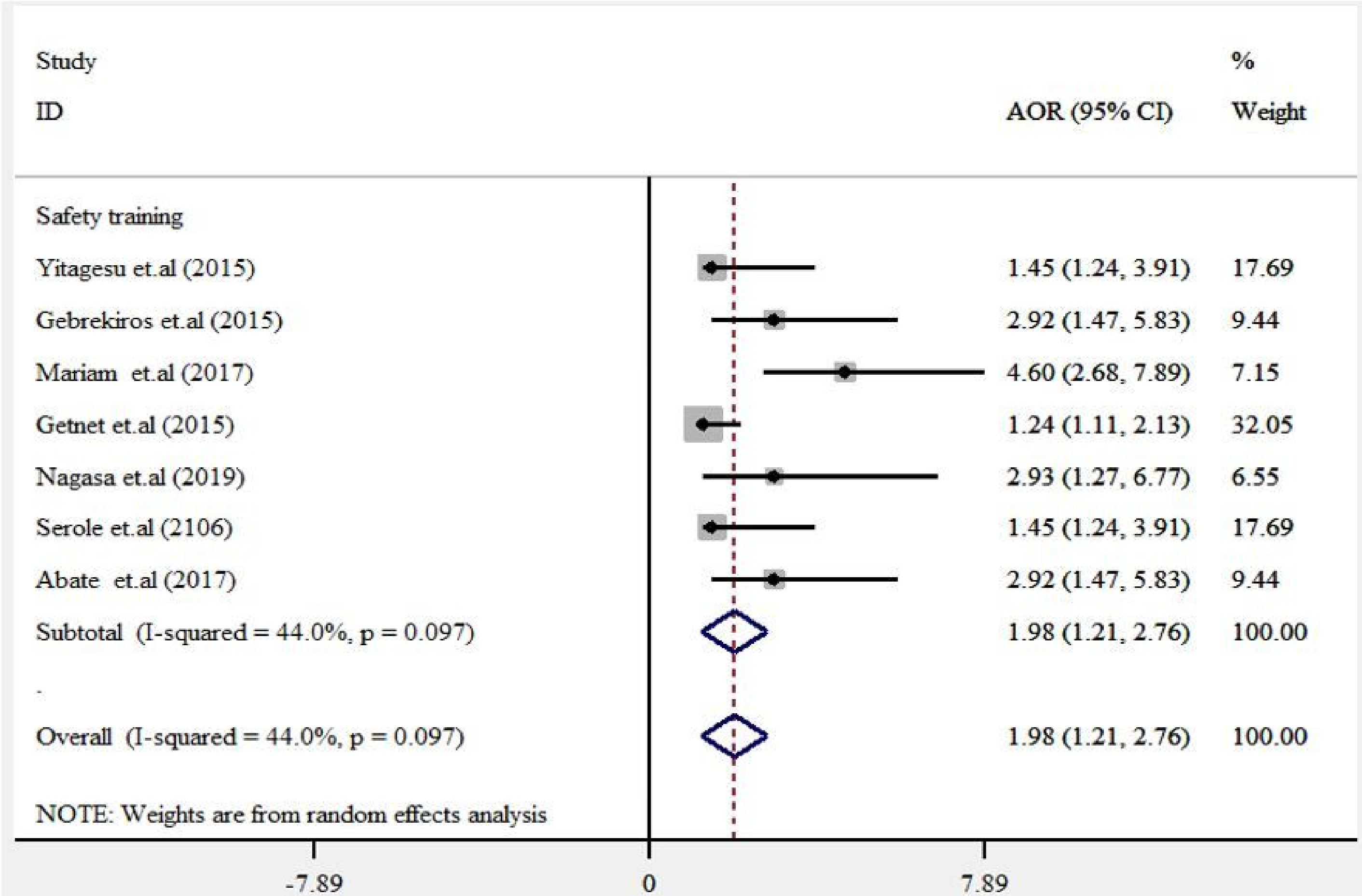

Figure 7

Forest plots describe the association between having health and safety training and occupational injury among workers in industry in Africa, 2021 (n=7).

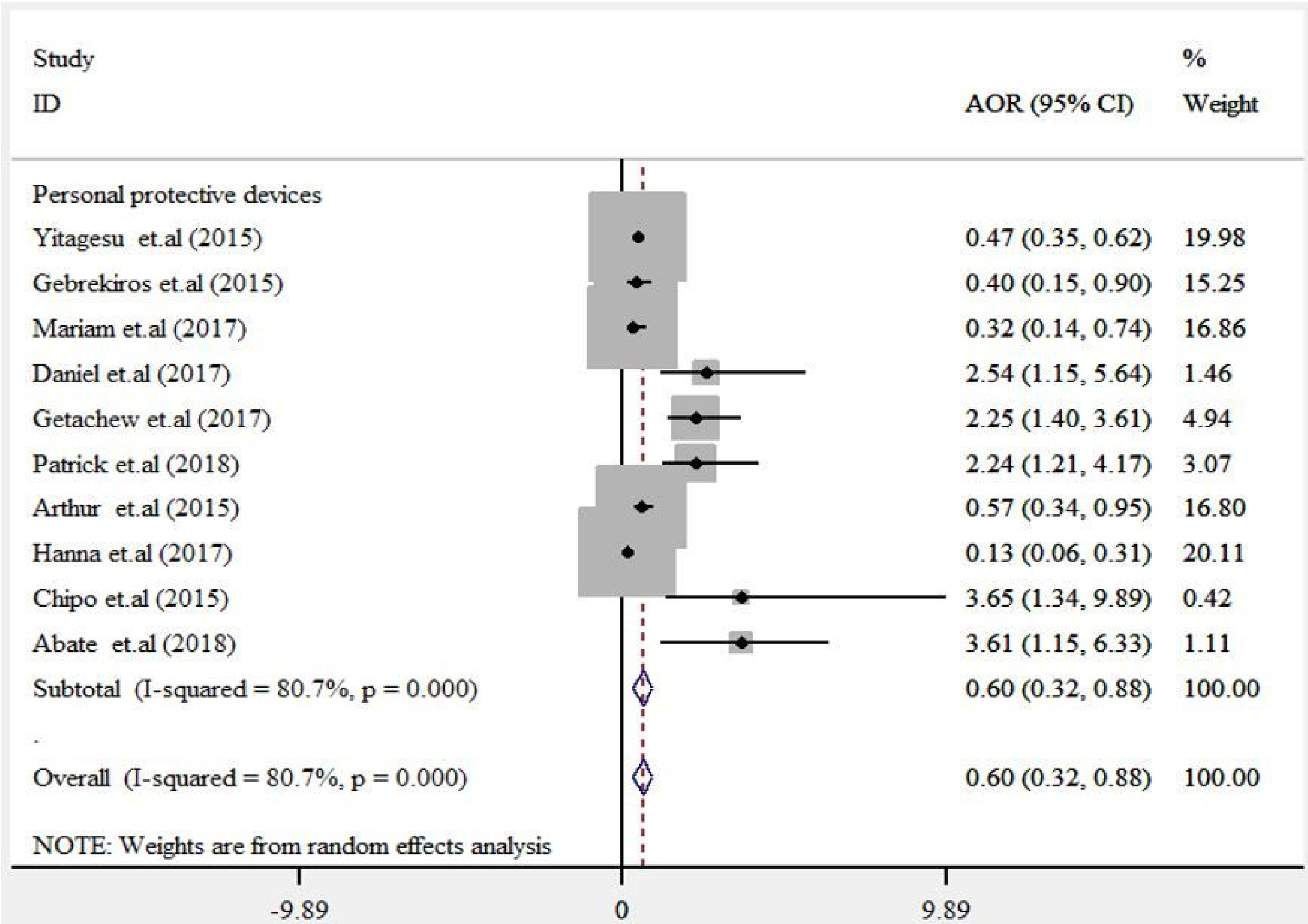

Figure 8

Forest plots describe the association between Personal protective use and occupational injury among workers in industry in Africa, 2021 (n=10).