

# Prevalence and causes of needlestick injuries among dental care providers: A systematic review and meta-analysis

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## Research article

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# Abstract

**Background** The objective of this systematic review and meta-analysis was to identify the prevalence and causes of NeedleStick Injuries (NSI) among dental care providers.

**Methods** Data collection was carried out through searching the following key words: needlestick injuries, percutaneous injuries, epidemiology, prevalence, occurrence, etiology, risk factors. The following databases were searched: Google Scholar, PubMed, Scopus, MagIran, Iranian Scientific Information Database (SID) and IranMedex. Moreover, some relevant journals and websites were searched manually and the reference lists of the selected articles were checked. In the final stage of the literature review, we searched the gray literature and contacted the experts whenever needed.

**Results** From 765 articles reviewed, 31 cases were included in the study. In total, the needlestick injury history of 6,737 people (4,402 dentists, 1,000 Dental Health Care Workers (DHCWs) and 1,335 students) had been reported. The overall prevalence of NSI was 48% at an average of 11.1 months. About 69% of NSI cases were not reported. About 79% of the different groups of DHCWs had been vaccinated for the hepatitis B virus (HBV). The most important factors affecting the occurrence of NSI were categorized into two groups of individual factors (lapse in concentration, stress, lack of adequate trainings, and not using safety precautions) and patient-related factors (unexpected patient movements, anxious and uncooperative patients). The occurrence of NSI during treatment procedure (40.1 mean proportion), doing injections (34.2 mean proportion) and recapping (30 mean proportion) were the most important procedures causing NSI among dentists.

**Conclusion** Results of the study show that prevalence of NSI among DHCWs is high, incidence report of NSI is low and vaccination rate for prevention of bloodborne diseases is inadequate. In this regard it's recommended to design and implement comprehensive preventive measures to reduction of NSI prevalence, increase reporting of NSI and vaccination rate

## Background

The injury caused by needlestick and sharp objects while working in health care environments is one of the major health threats among the health care providers. This means that NSI and injuries caused by sharp objects such as blood-contaminated syringes and needles infected by patients' body fluids can seriously threaten the health of health care workers [1-3]. The most important complications caused by these injuries are HIV, hepatitis B and hepatitis C virus infection [4-6]. According to the results of a study in the US, a total of 894 people suffered from these kinds of injuries in a 6-year period among which 30 cases had been infected with hepatitis C virus, 6 cases with hepatitis B virus and 3 cases with HIV [7]. Needless to say, these injuries dramatically increase health care costs [8, 9].

In the conducted studies, the prevalence of NSI has been reported very differently [10-18]. In England's National Health Service (NHS), the injuries caused by needlestick (with 17%) are considered to be the second most harmful medical events [19]. Negligence and carelessness of the personnel, not using safety precautions and lack of sufficient information and knowledge on the principles of prevention and protection against these types of injuries were also reported as the most important factors of needlestick incidence [20-25].

Dentists are a group of health care providers who are at a high risk for NSI [26-28], in a way that every dentist experience needlestick at least once during his/her professional career [29]. Several studies have shown a high NSI prevalence among dentists [30-32].

Despite many studies have been conducted so far on the prevalence and causes of needlestick among dentists in different parts of the world, there is a need to summarize the results of these studies and provide a clear view for planning, decision making and effective interventions. Also there is some systematic review studies in this topic [33-35], but these review studies not provide a comprehensive view about different aspects in this area such as incidence report of NSI or vaccination rate. This systematic review and meta-analysis aims at evaluating the prevalence of NSI in different countries and investigating related factors among dentists.

## Methods

This systematic review and meta-analysis was conducted in accordance with the systematic review approach adopted from the book entitled "A Systematic Review to Support Evidence-Based Medicine" in 2017 [36]. The study was in accordance with the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement (PRISMA) (Supplementary 1) [37].

### Inclusion/exclusion criteria

Eligibility criteria consisted of: first, cross-sectional studies on the prevalence and causes of needlestick among DHCWs, and second, the articles published in Persian and English languages. All the articles published before 1st January 2000, conference presentations, case reports, Interventional and qualitative studies were excluded from the study.

## Information Sources

The required data were collected through the keywords related to the search strategy as follows: needlestick injuries, percutaneous injuries, epidemiology, prevalence, occurrence, etiology, risk factors. 6 databases were screened: Google Scholar, PubMed, Scopus, MagIran, Iranian Scientific Information Database (SID) and IranMedex. Moreover, some relevant journals and websites were searched manually and the reference lists of the selected articles were checked. In the final stage of the literature review, we searched the gray literature and contacted the experts whenever needed.

## Review Process

In the first phase of the review process, an extraction table was designed. The table included the following items: first author's name, publication year, country, sample size, participants, NSI prevalence percentage, time period (month), unreported NSI, vaccination percentage for Hepatitis B virus (HBV), the NSI causes, and the most important factors causing NSI. Validity of the tabulated data was evaluated by experts, and a pilot study (with 5 articles) was conducted for further improvement of the data extraction. Two experienced and knowledgeable authors were responsible for extracting the data independently.

In first phase of article selection, articles with non-relevant titles were excluded. In the second phase, the abstracts and full texts of the retrieved articles were reviewed to include those articles matching the inclusion criteria. Reference management (Endnote X5) software was used for organizing and assessing the titles and abstracts, as well as for identifying the duplicates. Microsoft Excel 2010 software was used to draw the graphs.

## Quality Assessment

Two reviewers evaluated the articles according to the checklist of Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) [38]. Controversial cases were referred to a third author.

## Data Analysis

To estimate the overall NSI prevalence, the Comprehensive Meta-Analysis (CMA: 2) (Englewood, NJ, USA) software was used. In order to report the results, forest plot was employed. In the forest plot the size of each square shows the sample size and the lines on each side of the square show the Confidence Interval (CI). NSI prevalence was calculated using fixed effects model with 95% confidence interval. To measure the heterogeneity of studies, Q and  $I^2$  indicators were used.  $I^2$  index higher than 50% was suggested as indicative of substantial articles heterogeneity.

## Results

Out of 765 articles retrieved from databases and other sources, 345 cases were removed due to duplicates. In title and abstract screening, 372 other papers were excluded from the study. In the full-text review, 17 cases were also excluded, and 31 articles were finally included (Figure 1).

The characteristics of the articles included in the study are presented in Table 1. Out of 31 articles reviewed, 22 studies had been conducted in low/middle-income countries. Taking the reporting method of the articles into account, the participants in this study were divided into three groups of dentists (specialist, general), dental students and DHCWs (including dentists, dental students, dental nurses and others). In total, the NSI information of 6,737 people (4,402 dentists, 1,000 DHCWs and 1,335 students) had been reported.

**Table1.** Characteristics of the included studies

author, year	country	Sample size	Participants	Prevalence of NSI (%)	Time period (month)	Unreported NSI (%)	% Hepatitis B virus (HBV) vaccination	Causes of the NSI (%)	Most important procedures causing NSI (%)
Ali K and Hashim 2012 <sup>62</sup>	United Arab Emirates	733	dentists	42	12	-	-	-	-
Heiam A and Ingafou 2015 <sup>63</sup>	libya	340	dentists	35	12	-	-	-	-
Karian M, al:2012 <sup>64</sup>	Iran	137	students	73.7	12	85	-	-	Injection (58.3), Recapping (44.5), wound suturing(33.5)
Dharrab, et al:2012	Saudi Arabia	402	dentists	48.2	-	-	80.5	-	-
Shah A, et 2013 <sup>66</sup>	India	113	dentists	49.5	-	-	88.4	-	-
Odo CC, et 2010 <sup>67</sup>	Nigeria	83	DHCWs	41	12	-	51.8	-	-
Li R, et 2011 <sup>68</sup>	India	12	students	23	12	-	-	-	-
Alfissimo-drigues W, al:2006 <sup>69</sup>	Brazil	135	dentists	31.1	12	-	-	-	-
Attarai S, al:2014 <sup>70</sup>	Nepal	96	students	10	12	-	80.2	Uncooperative patient (33.3), Stress at work (16.7), Particular procedure for the first time (16.7), Not using safety precautions (12.2), Over confidence for particular procedure (5.6), other (15.5)	-
Andra S, et 2014 <sup>71</sup>	India	20	DHCWs	61	-	-	-	-	-
Alkhari K, et 2012 <sup>72</sup>	Saudi Arabia	190	DHCWs	56.2	-	-	-	-	Treating patients (60.9), recapping (43.2), Injection (20.3), washing instrument (35.5)
McCarthy M, and Patton 2000 <sup>73</sup>	UK	33	students	27.2	12	-	100	-	-
Al-Jaber A:2011 <sup>74</sup>	United Arab Emirate	230	students	23	12	61.4	96	-	Recapping (26), scaling (21), Injection (13), washing instrument (11)

eng 2012, <sup>75</sup>	Taiwan	434	Dentists	23	1 week	-	-	-	Treating patients (31), recapping (28), picking up instruments (25), replacing instruments (10), transmitting instruments (6)
ffy RE, et 2004 <sup>76</sup>	Romania	46	Dentists	87	12	-	33	-	-
ssain A:2012 <sup>77</sup>	India	306	students	75.4	12	77.4	37.3	-	Injection (52.3), Recapping (28.1), wound suturing(3), scaling (16.4)
ggat PA d Smith 2006 <sup>78</sup>	Australia	285	Dentists	27.7	12	-	-	-	-
owanadisai et al:2000	Thailand	178	Dentists	50	12	-	-	-	-
ngure EK, al:2010 <sup>80</sup>	Kenya	62	students	29	-	61	27	-	Injection (36), Recapping (18), scaling (23), washing instrument (18), wound suturing(5)
azuwa- ters N, et 2013 <sup>81</sup>	Nigeria	25	DHCWs	40	12	77	-	Lapse in concentration (14.8), Unexpected patient movement(12), Uncooperative patient (8.6), Anxious patient (8.6), Collision (8.6)	-
vithran VK, al:2015 <sup>43</sup>	India	200	DHCWs	27.5	12	26.5	81.5	-	-
elli C, et 2016 <sup>82</sup>	Brazil	173	students	56	6	52	85.5	-	-
abhu A, et 2014 <sup>83</sup>	India	102	dental nurses	33.3	6	-	-	-	-
mkuviene J, al:2011 <sup>84</sup>	Lithuania	1446	Dentists	78.5	during carrier	-	35.9	-	-
ith WA, et 2006 <sup>85</sup>	Jamaica	115	DHCWs	35	-	50	97	-	-
man 2014 <sup>86</sup>	Sudan	48	students	69.6	12	78.1	76.1	-	Treating patients (46.9), Injection (25), recapping (21.9), scaling (37.5), picking up instruments (9.4), washing

									instrument (9.4)
cker S and benau 2010 <sup>87</sup>	Germany	265	DHCWs	54.3	-	71.5	88.8	Stress (50), lapses in concentration and fatigue (32.9), unpracticed procedure (6.7)	-
omi 2006 <sup>88</sup>	Nigeria	112	students	50.7	6	96.4	36.6	-	Treating patients (21.7), scaling (37.7), washing instrument (18.8)
ader Y, et 2009 <sup>89</sup>	Jordan	170	Dentists	66.5	12	77.9	84.1	-	-
rra T and mbrianidis 2013 <sup>90</sup>	Greece	120	Dentists	89	60	-	91	-	-
ang Z, et 2008 <sup>91</sup>	China	126	students	20.6	12	65.6	-	-	-
DHCW= Dental health care workers									

In addition, in eight articles the time periods had not been mentioned; in one article the time period was too long (5 years); and in another study the period was very short (1 week). Hence, these 10 articles were not included in the analysis of NSI prevalence.

The prevalence of NSI among DHCWs (dentists, students, dental nurses and others) with a 95% confidence interval based on the income of the countries (high-income countries, low/middle-income countries) and the information presented by the World Bank [39] is shown in Figure 2.

The average prevalence percentage of NSI among DHCWs was estimated 48% during 11.1 months, 37% in high-income and 52% in low and middle income countries respectively. (See Table 2 for more details).

**Table 2.** Comparison of the rates of NSI prevalence, unreported NSI and full injection of hepatitis B vaccine among different groups of DHCWs based on the countries and participants in the study groups

Heterogeneity Test (95% CI)				Dimension Statues (95% CI)			Variable Level	Variable	
I <sup>2</sup>	P-Value	Q	df	Upper limit	Lower limit	prevalence			
15.5	0.31	7.1	6	54	35	43	Dentists	Participants	Prevalence of NSI
35.9	0.12	14	9	71	44	56	Students		
0	0.94	0.3	3	55	19	33	DHCW		
12.3	0.33	3.4	3	51	26	37	High-income Countries	Country	
13.8	0.29	18.5	16	63	43	52	Low/middle -income Countries		
20.6	0.19	25.2	20	57	41	48	Total		
0	1	0	0	89	46	78	Dentists	Participants	Unreported NSI
0	0	3	7	89	59	72	Students		
34.8	0.20	4.6	3	79	40	57	DHCW		
0	0.65	0.2	1	93	48	67	High-income Countries	Country	
0	0.51	9.1	10	84	57	69	Low/middle income Countries		
0	0.67	9.3	12	81	58	69	Total		
0	0.81	1.5	4	-	65	82	Dentists	Participants	Hepatitis B Virus (HBV) Vaccination
41.3	0.10	11.9	7	89	56	71	Students		
0	0.69	1.4	3	-	65	84	DHCW		
0	0.97	0.53	4	-	72	88	High-income Countries	Country	
16.8	0.27	13.2	11	85	59	71	Low/middle-income Countries		
1.5	0.43	16.2	16	90	69	79	Total		

The prevalence of NSI among dentists, dental students and DHCWs (dentists, students, dental nurses and others) was 43%, 56%, and 33% respectively (Figure 3 - more detailed information in Figure 2).

The results also revealed that about 69% of NSI cases among different groups of DHCWs were not reported. This rate is 67% in high-income countries and 69% in low/middle-income countries (Figure 4 - More detailed information in Table 2). Furthermore, this rate is 82% among dentists, about 84% among DHCW and 71% among students (Figure 5 - more detailed information in Table 2).

The results revealed that about 79% of the different groups of DHCWs had been vaccinated for hepatitis B. This rate is 88% in high-income countries and 71% in low/middle-income countries (Figure 6 - More detailed information in Table 2). In addition, this rate is 82% among dentists, about 84% among DHCWs and 71% among students (Figure 7 - more detailed information in Table 2).

Only three studies had mentioned the factors affecting the occurrence of NSI [29, 40, 41]. Based on the analysis of the results of these three studies, the most important factors affecting the occurrence of NSI were categorized into two groups of individual factors (lapse in concentration, stress, lack of adequate training, and not using safety precautions) and patient-related factors (unexpected patient movements, anxious and uncooperative patients). The occurrence of NSI during treatment procedure (40.1 mean proportion), doing injections (34.2 mean proportion) and recapping (30 mean proportion) were the most important procedures causing NSI among dentists.

## Discussion

From 765 articles reviewed, 31 cases were included in the study. In total, the needlestick information of 6,737 people (4,402 dentists, 1,000 dental health care workers (DHCWs) and 1,335 students) had been reported. The overall prevalence of NSI was 48% at an average of 11.1 months. About 69% of NSI cases were not reported. About 79% of the different groups of DHCWs had injected the hepatitis B virus vaccines. The most important factors affecting the occurrence of NSI were classified into two groups of individual factors (lapse in concentration, stress, lack of adequate trainings, and not using safety precautions) and patient-related factors (unexpected patient movements, anxious and uncooperative patients). The occurrence of NSI during the treatment procedure, doing injections and recapping were the most important procedures causing NSI among dentists.

The overall prevalence percentage of NSI among DHCWs was 48% at an average period of 11.1 months, 37% in high-income countries and 52% in low/middle income ones respectively. Studies evaluating the prevalence percentage of NSI among other health care providers showed lower rate than that among DHCWs [42-45]. Given the high risk of different viral infections such as Human Immunodeficiency Virus (HIV), hepatitis B, hepatitis C and other types of bloodborne infections through blood products in NSI cases, this rate of NSI prevalence is critical [30, 32, 40, 46-50]. The concern increases realizing that according to the results of the studies, about 69% of NSI cases had not been reported by different groups of DHCWs, and about 21% of the workers had not been vaccinated. The results also showed that the prevalence of NSI in low and middle-income countries is significantly higher than high-income countries. Moreover, due to high number of unreported NSI cases in low and middle income countries, the differences between these two countries are expected to be higher than those reported in this study. The possible reasons include: provided with better educational and training courses, using more safety precautions, more appropriate environment and working facilities in high-income countries. Also, the prevalence percentage of NSI among dental students was higher than that of dentists, which can be attributed to the lack of adequate skills and experience.

The results showed that about 69% of NSI cases were not reported by different groups of DHCWs. This rate is 67% in high-income countries and 69% in low and middle-income countries. Also, this rate is 82% among dentists, 84% among DHCWs and 71% among students. The main factors for failure to report NSI cases include: being too busy (especially dentists), lack of awareness, fear of testing and cross-infection, problems with reporting system and the belief that the exposure was not significant [51]. The rate of unreported NSI cases among dentists was higher than that of the students, which can be attributed to the heavy workload of dentists as well as the students' belief that the exposure is significant. The most important measures are: implementation of an appropriate and efficient system for reporting and tracking of injuries, training care providers on the risks and consequences of failure to report (and following up) the injury cases, providing incentives and appropriate cultural settings.

The results showed that about 79% of different groups of DHCWs vaccinated for hepatitis B virus. The results of the study conducted by Pruss-Ustun and colleagues showed that, in 2000, about 66,000 cases of NSI-related hepatitis B infections had been recorded among health care providers all around the world [52]. Other studies also highlighted the high prevalence of hepatitis B caused by NSI [53-59]. Considering the high prevalence of NSI and the risk of hepatitis B among dentists, it is essential to pay a special attention to the NSI prevention guidelines and a full coverage for hepatitis B virus vaccination.

Out of 31 articles which were included in the study, only three articles had mentioned the factors affecting the occurrence of NSI. Since a clear understanding of the effective factors related to NSI incidence can play an effective role in planning preventive measures, it is suggested to be considered in future studies. Lapses in concentration, stress, lack of adequate training and not taking safety precautions were the most important factors affecting the NSI incidence. In this regard, many studies have shown that dentists do not take safety precautions in a sufficient manner [60, 61]. The lack of adequate trainings is also an important factor in NSI incidence. To solve this problem, it is recommended that students and dentists take appropriate courses on the Moulage training programs before starting any new treatment procedure.

It is documented that most NSI occurred while injecting and recapping used needles among dentists. In this regard, the use of safety devices can have a significant effect on reducing the occurrence of NSI among dentists [32, 62, 63]. The results of the study by Zakrzewska and colleagues in England showed that the use of safety syringes reduces the NSI incidence from 11.8 to 0 per 1 million hours of work per year [64]. Therefore, it is necessary to take giant leaps to reduce the occurrence of NSI through such measures as the mass production and optimization of safety syringes, reducing their costs, introduce and make the dentists aware of utilizing them.

The main limitation of the present study is that our search for articles was merely in English and Persian languages and all other languages were ignored. Also, due to the fact that only three articles had mentioned the causes of the NSI, further analysis was not possible for this issue.

## Conclusion

Results of this study show that prevalence of NSI among DHCWs is high (48% at an average of 11.1 months), incidence report of NSI is low (about 69%) and vaccination rate (about 79%) for prevention of bloodborne diseases is inadequate. In this regard it's recommended to design and implemented comprehensive preventive measures to reduction of NSI prevalence, increase reporting of NSI and vaccination rate. These



measures can be cover the use safety syringes, take safety precautions during work, design an efficient NSI reporting system, administer full-doses of vaccines, follow the standards and guidelines and increase the knowledge and awareness of the staff.

## Abbreviations

Iranian Scientific Information Database: SID, Dental Health Care Workers: DHCW, Needlestick Injury: NSI, National Health Service: NH S, Comprehensive Meta-Analysis: CMA, confidence interval: CI, Hepatitis B virus B: HBV-.

## Declarations

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None declared

### Availability of data and materials

The databases used and analyzed during the current study are available online.

### Authors' contributions

F.P.N & S.A collected, reviewed papers, analyzed and prepared the figures. M.G & M.M contributed in designing, analyzing and drafting the paper. N.D & S.A contributed in categorizing the indicators, developing the tool and reviewing and F.P.N & S.A Contributed in analyzing and editing the paper.

### Ethics approval and consent to participate

This article does not contain any studies with human participants or animals performed by any of the authors.

### Consent for publication

All the participants provided consent for publication.

### Competing interests

The authors declare that there is no conflict of interest.

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## Figures

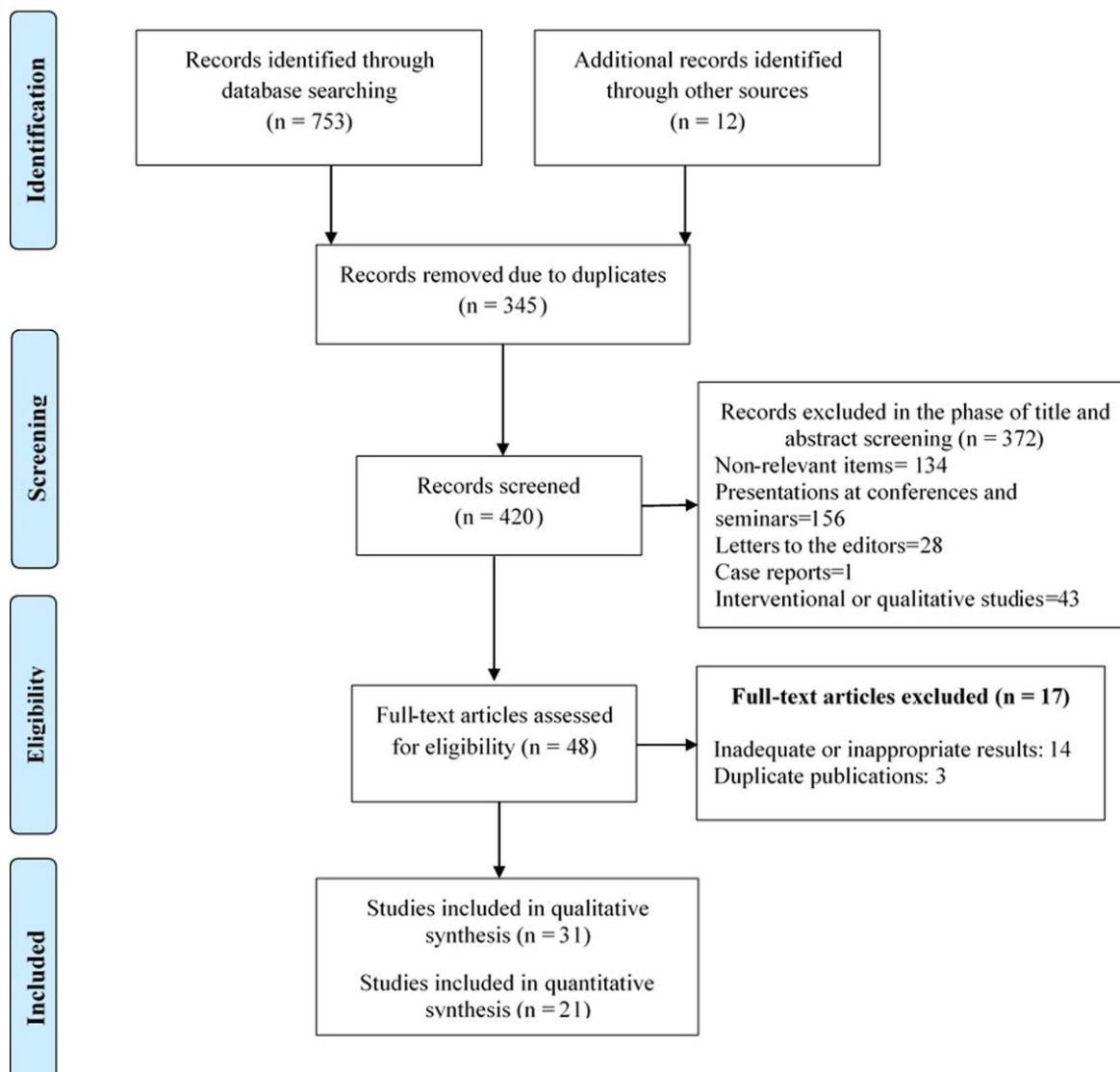


Figure 1

Searches and inclusion process

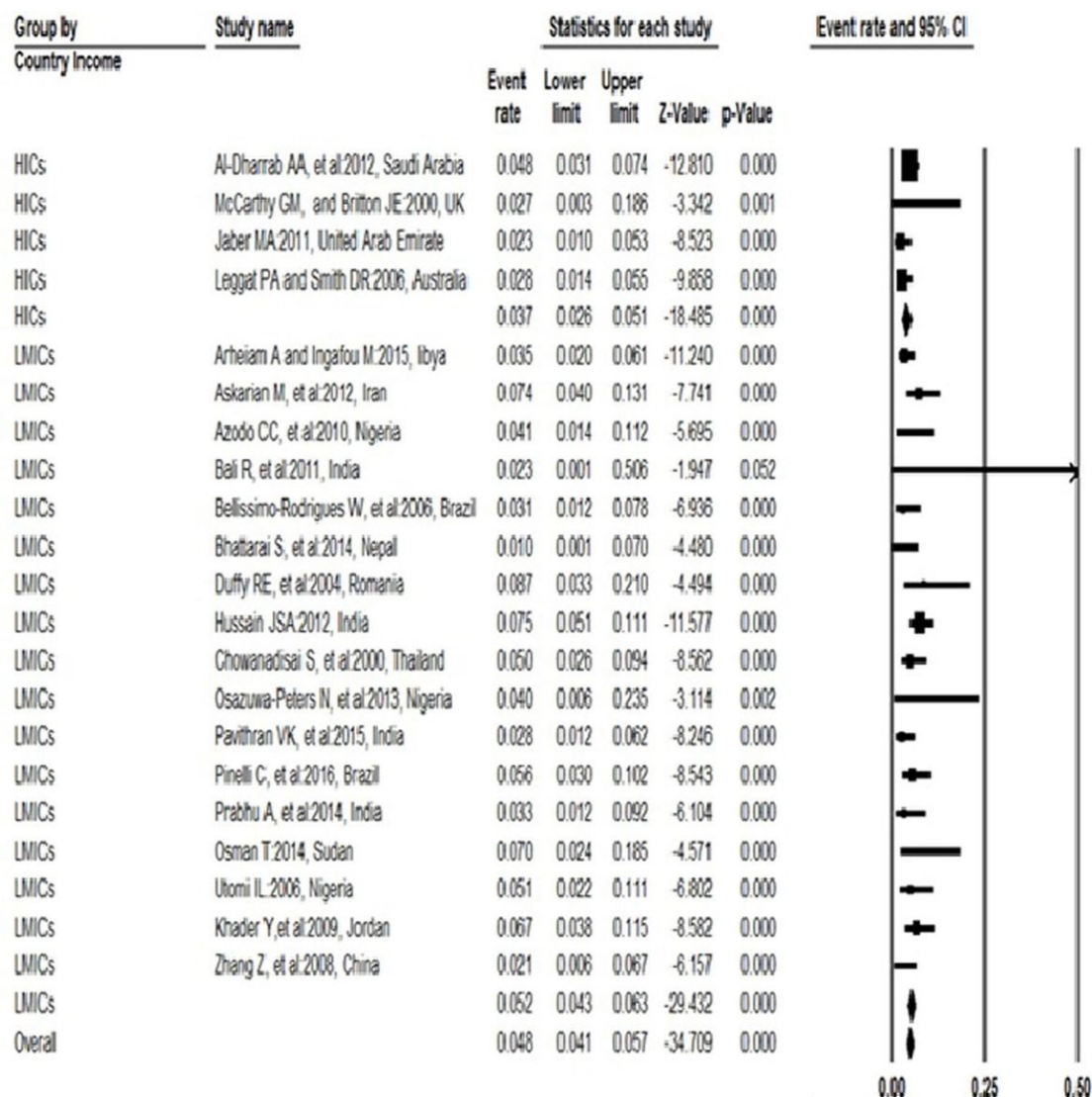


Figure 2

The prevalence of NSI among DHCWs (dentists, students, dental nurses and others) with a 95% confidence interval based on the income of the countries (based on the fixed model)

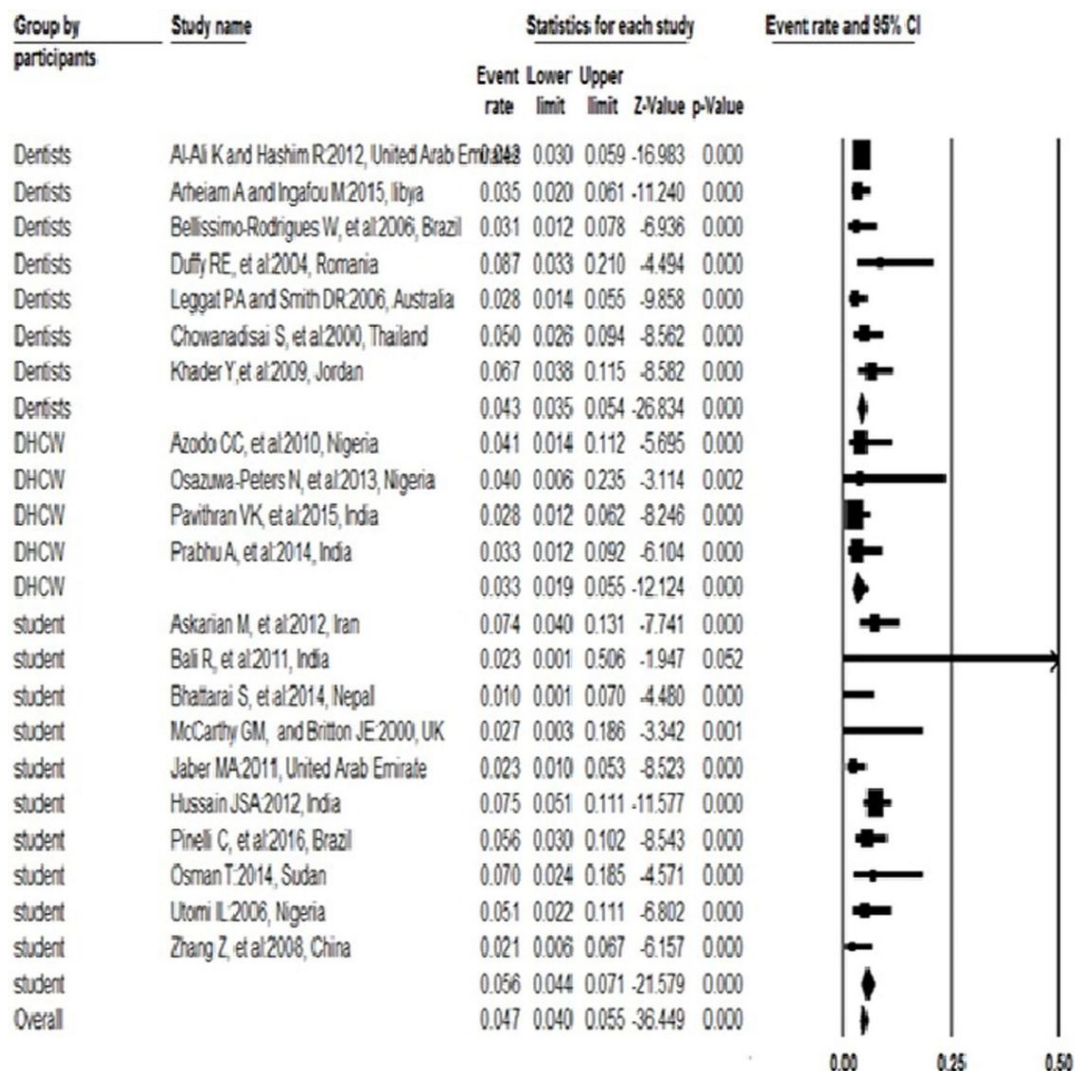
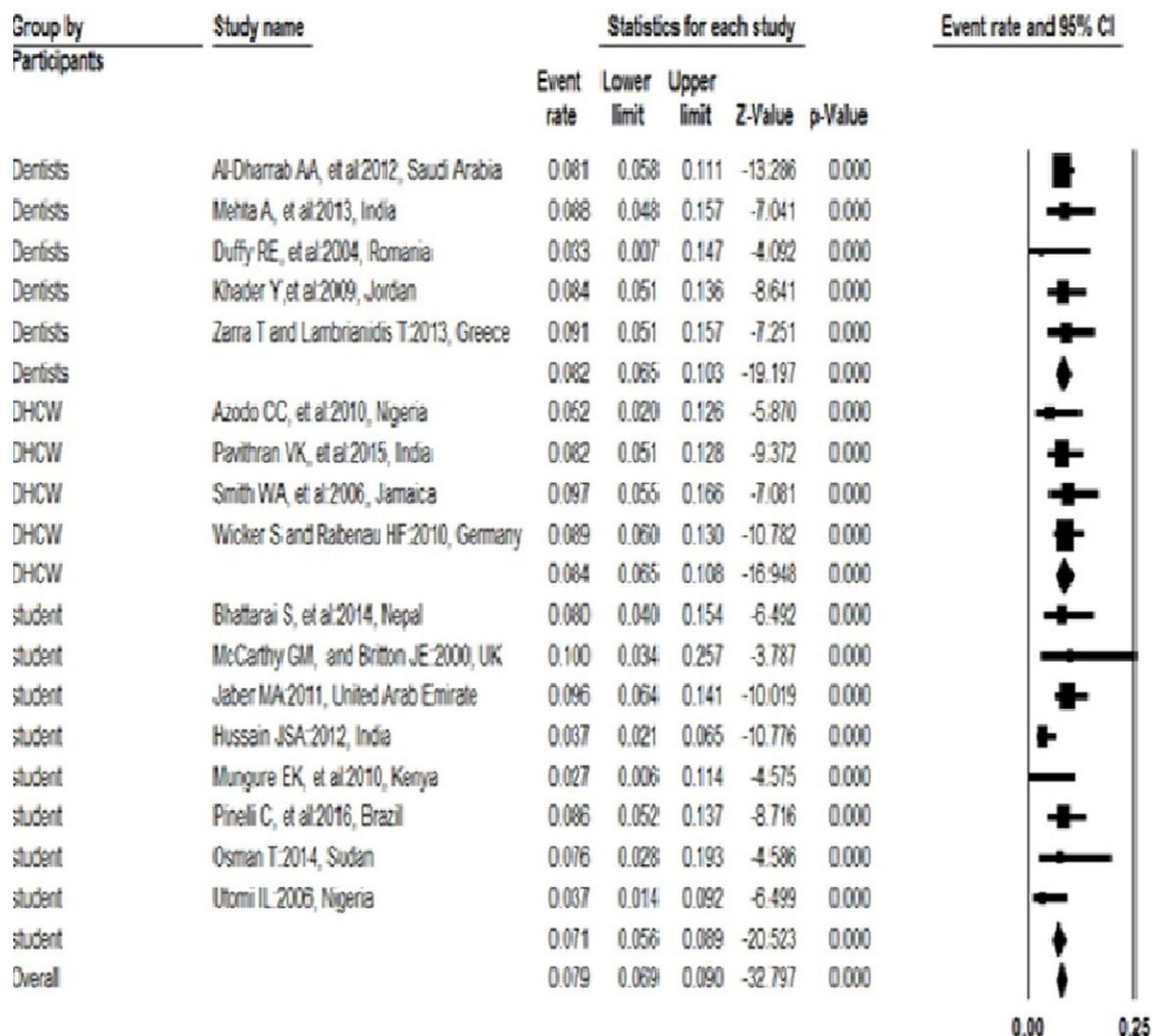


Figure 3

The prevalence of NSI among DHCWs based on different groups (dentists, students, dental nurses and others) with a 95% confidence interval (based on a fixed model)





**Figure 4**

The rate of unreported NSI cases by different groups of DHCWs based on income of the countries with 95% confidence interval (based on the fixed model)

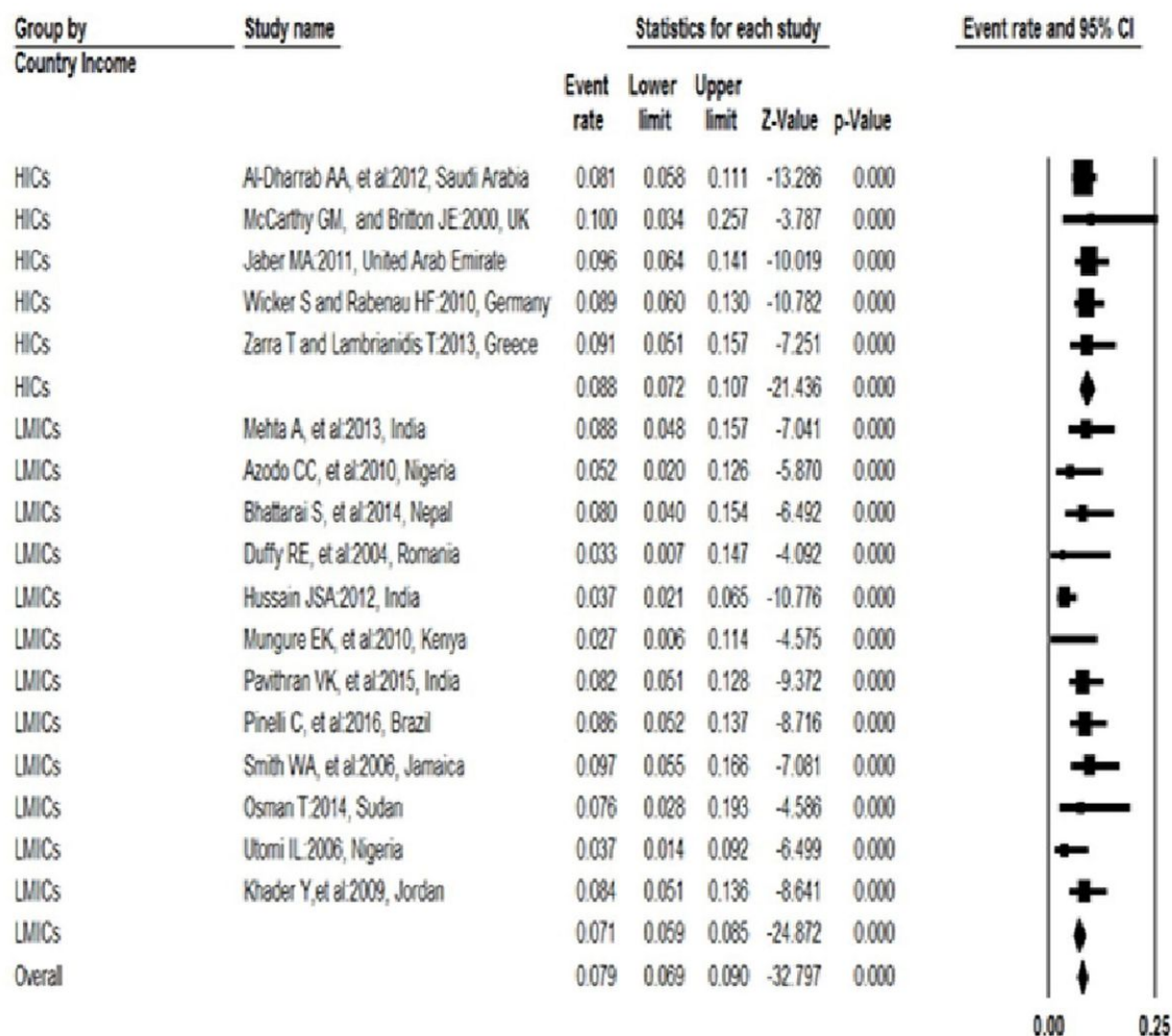


Figure 5

The rate of unreported NSI cases by different groups of DHCWs with a 95% confidence interval (based on the fixed model)



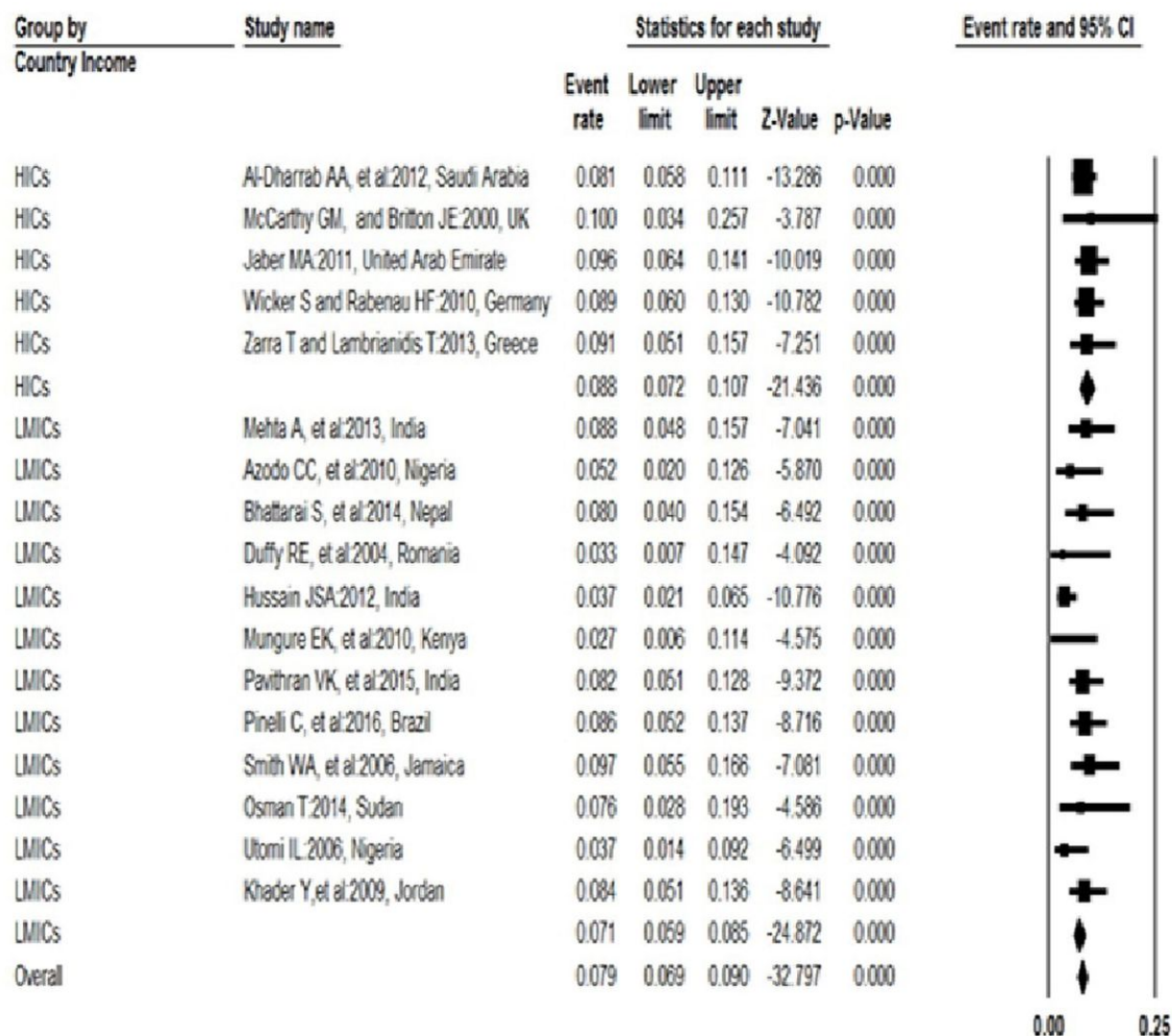
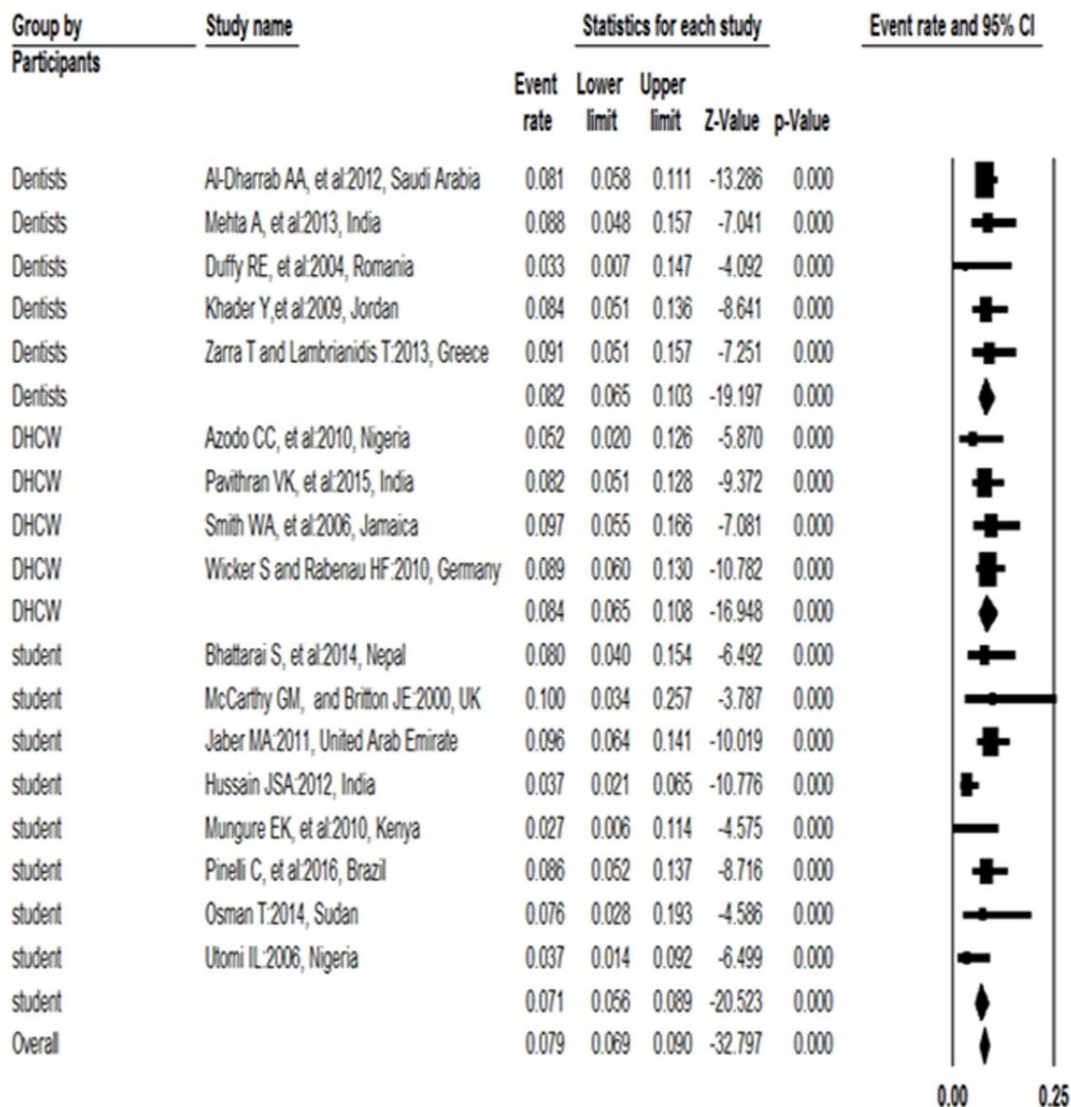


Figure 6

Total injection rate of hepatitis B virus (HBV) vaccines by different groups of DHCWs based on income of the countries with 95% confidence interval (based on fixed model).



**Figure 7**

Total injection rate of hepatitis B virus (HBV) vaccines by different groups of DHCWs with 95% confidence interval (based on fixed model).

## Supplementary Files

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- [PRISMA2009checklist.pdf](#)