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Occupational Health

Global prevalence of percutaneous injuries among healthcare workers: a systematic review and meta-analysis

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Abstract

Background: Healthcare workers (HCWs) are at risk of occupational exposure to blood-borne pathogens through contact with human blood and other body fluids. This study was conducted to estimate the global and regional 1-year prevalence of percutaneous injuries (PCIs) among HCWs.

Methods: We systematically searched EMBASE, PubMed, CINAHL and PsychInfo databases for studies published from January 2008 to January 2018 that reported the prevalence of PCIs among HCWs. A random-effects meta-analysis was conducted to estimate pooled prevalence of PCIs among HCWs.

Results: Of the 5205 articles identified, 148 studies from 43 countries met the inclusion criteria. The pooled global 1-year prevalence estimate of PCIs was 36.4% [95% confidence interval (CI): 32.9–40.0]. There were substantial regional variations in the 1-year prevalence of PCIs, ranging from 7.7% (95% CI: 3.1–12.4) in South America to 43.2% (95% CI: 38.3–48.0) in Asia. The estimates for Africa and Europe were comparable with values of 34.5% (95% CI: 29.9–39.1) and 31.8% (95% CI: 25.0–38.5), respectively. The highest 1-year prevalence by job category was among surgeons, at 72.6% (95% CI: 58.0–87.2). The estimates for medical doctors (excluding surgeons), nurses (including midwives) and laboratory staff (including laboratory technicians) were 44.5% (95% CI: 37.5–51.5), 40.9% (95% CI: 35.2–46.7) and 32.4% (95% CI: 20.9–49.3), respectively. PCIs commonly

occurred among HCWs working in hospital (41.8%, 95% CI: 37.6–46.0) than non-hospital (7.5%, 95% CI: 5.9–9.1) settings.

Conclusions: Our findings suggest high rates of PCIs among HCWs with direct patient care across many regions of the world. However, paucity of data from some countries was a major limitation.

Key words: percutaneous injuries, needlestick injuries, sharps, occupational exposure, blood and other body fluids, healthcare workers

Key Messages

- We found high prevalence of percutaneous injuries (PCIs) among healthcare workers (HCWs) worldwide, with about one in three HCWs at risk of injury annually.
- The risk of PCIs was associated with job category, years of work experience, training status and institutional setting of HCWs.
- The high prevalence found in this review has a great implication in terms of the risk of transmitting blood-borne viruses to HCWs.
- The evidence from this review highlights the need for HCWs to adhere to standard precautions when handling sharps and for national governments and employers to provide a safe working environment and establish policies that would minimize the risk of PCIs in healthcare settings.

Introduction

Occupational exposure to blood-borne pathogens following contact with human blood and body fluids continues to be a serious concern for healthcare workers (HCWs) globally. Although many of these pathogens have been identified, hepatitis B virus (HBV), hepatitis C virus (HCV) and human immunodeficiency virus (HIV) are the three leading causes of occupationally related blood-borne infections among HCWs.[1,2] Occupational exposure to these viruses can occur following percutaneous injury (when a needle or other sharp object penetrates the skin), mucous membrane (such as eyes, nose and mouth) or non-intact skin exposure to blood and body fluids. Percutaneous injuries (PCIs), however, carry a greater risk of infection, as they account for 66–95% of all occupational exposures to blood-borne pathogens.[3] Every year, PCIs result in approximately 66 000 HBV infections, 16 000 HCV infections and 1000 HIV infections.[3] These infections can cause about 1100 deaths and significant disability annually.[3] More than 90% of these infections occur in developing countries where, in particular, adherence to standard precautions is poor.[4]

Little is known about the global prevalence and incidence of percutaneous injury among HCWs. Prüss-Ustün *et al.*[3] estimated that more than 3 million HCWs worldwide have occupationally related PCIs annually. However, this study was conducted over a decade ago, necessitating an updated analysis. Many developed countries including the USA, UK and Canada have established surveillance systems to monitor the occurrence of PCIs among HCWs and to understand the circumstances under which they occur.[5] Despite this, the under-reporting and poor documentation of PCIs by HCWs have rendered these surveillance systems ineffective in determining the true incidence of PCIs in these countries.

Over the past decade, several studies on the prevalence of PCIs among HCWs in different settings have been published. Nevertheless, no systematic review has been conducted to provide a pooled global estimate of the prevalence of PCIs among HCWs. Previous global systematic reviews have focused on identifying the interventions to minimize PCIs among HCWs and in evaluating the cost associated with PCIs.[6,7] However, understanding the extent and circumstances under which PCIs occur among HCWs is an important initial step in prevention. Therefore, we conducted a systematic review and meta-analysis to estimate the global and regional 1-year prevalence of PCIs among HCWs and identify demographic groups at risk.

Methods

Protocol registration and search strategy

The research protocol was registered in the PROSPERO international prospective register of systematic reviews

(CRD42017077201). We searched four databases (PubMed, EMBASE, CINAHL and PsychInfo) on 1 February 2018 to identify studies reporting the 1-year prevalence of PCIs among HCWs globally. These databases were searched for original research articles published from 1 January 2008 to 31 January 2018. We considered this timeframe sufficient to capture a wide range of relevant papers that reflect the current picture of PCIs among HCWs. The following terms were combined using Boolean operators in our literature search: occupational exposure, accidental exposure, percutaneous injuries, needlestick injuries, sharps, blood, body fluid, blood-borne pathogens, HCWs, health workers and health personnel (Supplementary Table 1, available as Supplementary data at *IJE* online). Additional articles including grey literature were identified by checking the reference lists, Google and Google Scholar search. No language restrictions were applied to all the searches conducted.

Eligibility criteria

Two reviewers independently screened studies against the inclusion and exclusion criteria. Papers were included if they contained data on the 1-year (or 12-month) prevalence of PCIs among HCWs. In this review, we considered HCWs to include all paid and unpaid individuals working in healthcare settings who are likely to be exposed to infectious materials including blood and other body fluids. Hence, we included studies that enrolled a variety of participants including doctors, nurses, laboratory technicians, auxiliary HCWs and students undertaking clinical training or experience in healthcare settings.

Studies reporting lifetime and other forms of period prevalence (such as 3- or 6-month prevalence) were excluded. Other inclusion and exclusion criteria relate to the design of the study. Observational studies that used either cohort or cross-sectional designs were included. Case reports, case series, case–control studies and qualitative studies were excluded. Studies involving a review of reported cases or surveillance data were excluded, as under-reporting of exposure to PCIs has been well documented.[8] In addition, reviews, conference abstracts, letters, commentaries, personal opinions and studies that utilized fewer than 100 participants were excluded.

Quality assessment of included studies

All included studies were assessed for quality on nine criteria based on the Joanna Briggs Institute's critical appraisal framework for prevalence studies.[9] These nine criteria assessed the internal and external validity of each included study with each criterion equally weighted (see Supplementary Table 2, available as Supplementary data at *IJE* online). Based on the assessment, each article received a quality grade of low, moderate or high if they met one to three, four to six and seven to nine criteria, respectively.

Data extraction

Two reviewers extracted data and any discrepancy was resolved by consensus. Data on the author, year of publication, country of study, United Nations geographical region, World Bank country income classification (low-, middle- or high-income country), type of institution (hospital or non-hospital including primary care and pre-hospital services), sample size, response rate and prevalence of PCIs were extracted from each included article and entered into a Microsoft Excel spreadsheet (version 2016). Other data extracted were the prevalence of PCIs by health-staff category and the proportion of cases that were due to needlestick injuries.

Data analysis

Statistical analyses were performed using Stata version 14.2 (StataCorp. LLC, College Station, USA). A random-effects meta-analysis based on the DerSimonian and Laird approach[10] was conducted to determine pooled 1-year prevalence estimates [with 95% confidence intervals (CIs)] of PCIs among HCWs. Sensitivity analyses were carried out by excluding low-quality studies and the impact of excluding them was evaluated on the summary results. This was done to test the robustness of our findings. Generally, 1-year prevalence was estimated from studies that reported the proportion of study participants who had at least one percutaneous injury in the 12 months preceding the study.

Inter-study heterogeneity was assessed with Cochran's Q (reported with a X^2-value and p-value) and Higgin's I-squared (I^2) statistic was employed to measure the percentage of total variation across studies that was due to heterogeneity.[11] Subgroup and meta-regression analyses were conducted to explore the causes of heterogeneity. The covariates considered included the United Nations geographical region, World Bank country classification by income level, type of institution, study period, sampling procedure (random vs convenience sampling), sample size and study quality. Covariates were first tested individually and only those with p-values <0.10 were included in the multivariable model.

Stratified analyses were conducted to determine the pooled prevalence of PCIs among different categories of HCWs. In addition, individual data for relative risk were pooled together using a random-effects model to present the relative risk of PCIs between groups.

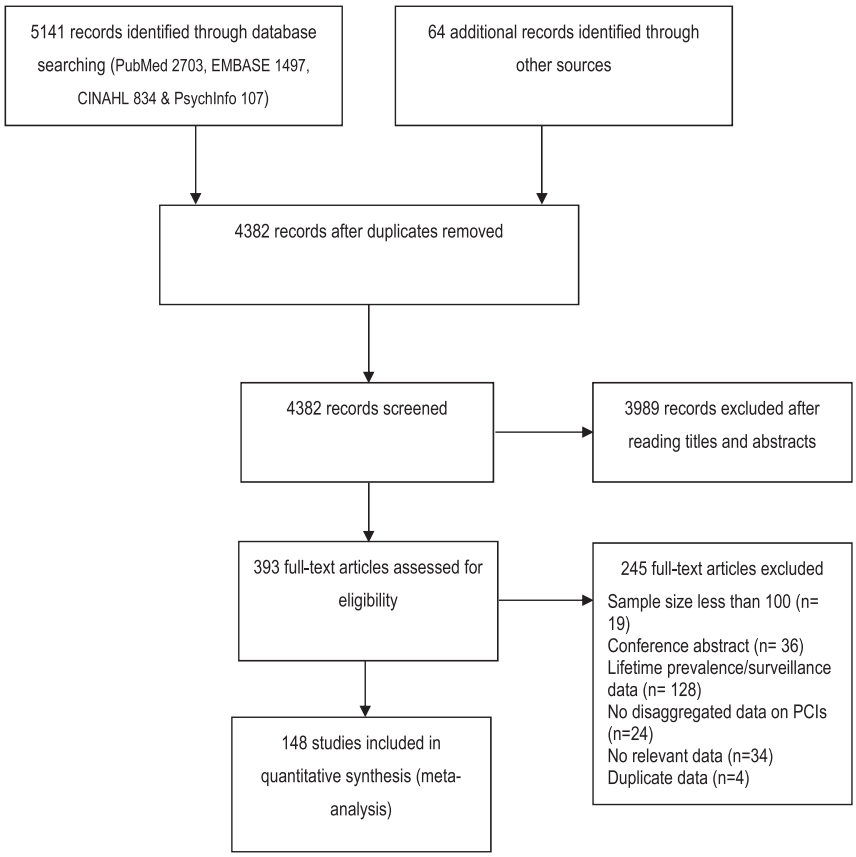

Figure 1. Flow diagram of article-selection process.

Results

Study selection and characteristics

Our literature search identified 5205 records, but only 148 articles met the inclusion criteria (Figure 1). The 148 articles were cross-sectional observational studies and covered 109 267 HCWs from 43 countries. Most of the included studies were conducted in Asia ($n = 77$) and Africa ($n = 36$), followed by Europe ($n = 18$) and North America ($n = 12$) (Supplementary Table 3, available as Supplementary data at *IJE* online). The methodological quality of 15 (10.1%) of the included studies were considered high, 127 (85.8%) moderate and 6 (4.1%) low.

Prevalence of PCIs

The pooled global 1-year prevalence estimate of PCIs was 36.4% (95% CI: 32.9–40.0). These injuries were largely due to needlesticks, with an estimated 1-year prevalence of 35.1% (95% CI: 31.4–38.8). The pooled 1-year prevalence of PCIs obtained following the exclusion of low-quality studies from the analysis was 36.1% (95% CI: 32.5–39.7), which is similar to the global pooled estimate.

There were substantial variations in the 1-year prevalence of PCIs across the world's continents, ranging from 7.7% (95% CI: 3.1–12.4) in South America to 43.2% (95% CI: 38.3–48.0) in Asia (Table 1 and Supplementary Figure 1, available as Supplementary data at *IJE* online). Substantial variations were also observed within sub-continents (Table 1 and Supplementary Figure 2, available as Supplementary data at *IJE* online). Estimated 1-year prevalence of PCIs among HCWs were highest in North Africa, East Asia, Eastern Europe and the Middle East, with values of 49.7% (95% CI: 33.8–65.6), 47.2% (95% CI: 37.8–56.6), 47.3% (95% CI: 27.4–67.1) and 43.8% (95% CI: 35.5–52.1), respectively.

Furthermore, we observed a substantial variation in the country-level estimates of the 1-year prevalence of PCIs (Figure 2). PCIs were commonly reported by HCW in Jordan, Syria and Afghanistan, with the estimated 1-year prevalence of 76.9% (95% CI: 57.4–96.4), 76.6% (95% CI: 72.0–81.2) and 72.6% (95% CI: 69.2–76.0), respectively. Countries with lower 1-year prevalence of PCIs were Singapore, Hong Kong, Brazil and New Zealand, with estimated values of 3.5% (95% CI: 1.1–5.9), 5.9% (95% CI: 4.3–7.5), 7.7% (95% CI: 3.1–12.4) and 9.1% (95% CI: 7.6–10.6), respectively. Country-specific 1-year prevalence estimates and number of participants are shown in Supplementary Table 4, available as Supplementary data at *IJE* online.

Table 1. Regional estimates of 1-year prevalence of PCIs among HCWs

World region	No. of studies included	No. of participants	One-year prevalence of PCI % (95% CI)	Study heterogeneity I^2 (P-value)
Africa	36	12 958	34.5 (29.9–39.1)	97.0% (<0.001)
Sub-Saharan Africa	32	10 663	32.5 (28.3–36.8)	95.9% (<0.001)
North Africa	4	2295	49.7 (33.8–65.6)	98.3% (<0.001)
Asia	77	61 966	43.2 (38.3–48.0)	99.4% (<0.001)
East Asia	21	37 188	47.2 (37.8–56.6)	99.7% (<0.001)
South Asia	25	8647	39.0 (30.4–47.6)	98.9% (<0.001)
Middle East	31	16 161	43.8 (35.5–52.1)	99.2% (<0.001)
Australasia	3	2609	9.5 (6.7–12.4)	80.4% (0.006)
Europe	18	16 191	31.8 (25.0–38.5)	99.3% (<0.001)
Eastern Europe	5	2583	47.3 (27.4–67.1)	99.0% (<0.001)
Northern Europe	5	5343	36.2 (11.3–61.1)	99.2% (<0.001)
Southern Europe	4	2879	21.0 (10.8–31.2)	98.0% (<0.001)
Western Europe	4	5386	18.9 (6.4–31.3)	99.4% (<0.001)
North America	12	14 228	15.7 (12.1–19.3)	98.9% (<0.001)
South America	2	1315	7.7 (3.1–12.4)	80.7% (0.023)
Global	148	109 267	36.4 (32.9–40.0)	99.6% (<0.001)

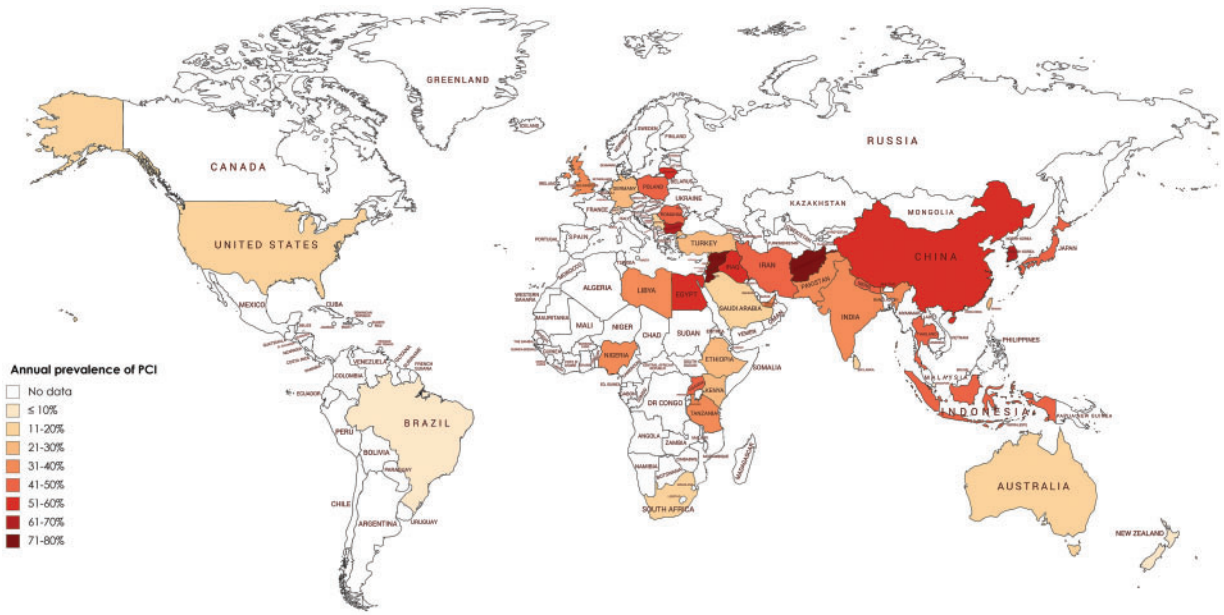

Figure 2. One-year prevalence of PCIs among HCWs by country.

Prevalence of PCIs by job and socio-demographic categories

The highest 1-year prevalence by job category was among surgeons, with an estimated value of 72.6% (95% CI: 58.0–87.2). The estimated pooled 1-year prevalence for medical doctors (excluding surgeons), nurses (including midwives) and laboratory staff (including laboratory technicians) were 44.5% (95% CI: 37.5–51.5), 40.9% (95% CI: 35.2–46.7) and 32.4% (95% CI: 20.9–49.3), respectively (Table 2). There was no difference in the risk of PCIs between doctors and nursing staff (RR of doctors vs nursing staff: 1.082, 95% CI: 0.955–1.225). However, the risk of PCIs among doctors and nurses was higher than that of laboratory staff (RR doctors vs laboratory staff: 1.478, 95% CI: 1.128–1.936; nurses vs laboratory staff: 1.584, 95% CI: 1.253–2.002). Six studies presented data on the prevalence of PCIs among paramedics or emergency medical services personnel, with the pooled 1-year prevalence estimate of 10.5% (95% CI: 6.9–14.1). Similarly, 14 studies reported on the 1-year prevalence of PCIs among clinical nursing and medical students, with a pooled estimate of 38.9% (95% CI: 26.3–51.5).

Table 2. One-year prevalence of PCIs by job category of HCWs

World region	Surgeons		Doctors		Nurses/midwives		Dental staff		Laboratory staff	
	n	Prevalence % (95% CI)	*n*	Prevalence % (95% CI)	*n*	Prevalence % (95% CI)	*n*	Prevalence % (95% CI)	*n*	Prevalence % (95% CI)
Africa	0	ND	9	48.5 (28.5–68.5)	12	40.6 (26.8–54.5)	3	35.4 (30.8–40.1)	7	28.6 (13.3–43.9)
Asia	3	90.9 (86.2–95.6)	21	41.7 (33.5–49.9)	45	46.3 (40.4–52.1)	7	54.8 (43.6–66.0)	13	34.2 (19.0–49.3)
Australasia	0	ND	1	17.8 (12.7–22.9)	2	7.4 (6.3–8.4)	0	ND	0	ND
Europe	2	57.1 (24.9–89.3)	7	51.9 (34.2–69.6)	8	31.9 (22.9–40.9)	2	27.4 (0.5–55.4)	0	ND
North America	1	67.4 (60.7–74.1)	0	ND	3	7.8 (3.9–11.7)	1	6.0 (5.1–6.8)	0	ND
South America	0	ND	0	ND	0	ND	0	ND	0	ND
Overall	6	72.6 (58.0–87.2)	38	44.5 (37.5–51.5)	70	40.9 (35.2–46.7)	13	43.3 (28.2–58.4)	20	32.4 (20.9–43.9)

ND, not determined.

Table 3. One-year prevalence of PCIs among HCWs based on institutional settings

World region	Hospital settings		Non-hospital settings		Mixed settings	
	n	One-year prevalence % (95% CI)	*N*	One-year prevalence % (95% CI)	*n*	One-year prevalence % (95% CI)
Africa	23	36.5 (30.0–43.1)	0	ND	13	30.9 (25.6–36.2)
Asia	66	45.5 (40.3–50.7)	4	13.7 (11.3–16.0)	7	39.1 (23.2–55.1)
Australasia	2	12.3 (5.0–19.6)	0	ND	1	7.3 (5.6–8.8)
Europe	14	35.7 (26.1–45.2)	1	3.2 (1.4–5.0)	3	23.6 (11.9–35.2)
North America	1	64.7 (57.7–71.5)	8	5.9 (4.0–7.8)	3	28.3 (19.0–37.5)
South America	0	ND	2	7.7 (3.1–12.4)	0	ND
Overall	106	41.8 (37.6–46.0)	15	7.5 (5.9–9.1)	27	31.0 (25.8–36.1)

ND, not determined.

We found a higher risk of PCIs among HCWs with ≤ 5 years of work experience when compared with those with >5 years (RR = 1.365, 95% CI: 1.163–1.603). There was no difference in the risk of PCIs between female and male HCWs (RR = 1.087, 95% CI: 0.982–1.205). Six studies reported on the proportion of HCWs who had received training on issues related to infection prevention and occupational risk reduction that were occupationally exposed to PCIs. The pooled relative risk of the data from these studies showed that HCWs without training were more likely to be occupationally exposed to PCIs than trained staff (RR = 1.459, 95% CI: 1.094–1.946).

Table 3 presents the 1-year prevalence of PCIs by health settings. PCIs were more common among hospital staff, with a prevalence of 41.8% (95% CI: 37.6–46.0). The 1-year prevalence of PCIs among HCWs working in non-hospital settings including primary care and pre-hospital emergency services was 7.5% (95% CI: 5.9–9.1). Nine studies reported the 1-year prevalence of PCIs in primary care settings. The estimated pooled prevalence was 5.9% (95% CI: 4.2–7.7).

The subgroup meta-analysis showed that high-income countries had lower 1-year prevalence of PCIs among HCWs, with a pooled estimate of 24.8% (95% CI: 19.4–30.2). The overall estimates for low- and middle-income countries were 36.3% (95% CI: 30.3–42.2) and 41.8% (95% CI: 36.7–46.9), respectively (Supplementary Table 5, available as Supplementary data at *IJE* online). Finally, substantial heterogeneity was observed on the pooled estimate of the global 1-year prevalence of PCIs among HCWs ($X^2 = 40\,855.1$, $p < 0.001$, $I^2 = 99.6\%$). Of the sources of variation investigated through meta-regression, only geographical region, World Bank income classification level and institution type had p-values <0.10. These covariates yielded a multivariate model ($p < 0.001$) that explained 29.3% of between-study variation.

Discussion

This is the first systematic review to provide a comprehensive global overview of the 1-year prevalence of PCIs among HCWs. We found a high prevalence of PCIs among HCWs worldwide. Needlestick injuries account for most of the PCIs, with about one in three HCWs at risk of injury annually. This high prevalence has great implications in terms of the exposed HCWs' mental health and the risk of

acquiring blood-borne infections. Psychological problems including depression, anxiety, post-traumatic stress disorder and job burnout have been linked to occupational exposure to blood and other body fluids among HCWs.[12–14] Furthermore, PCIs come with a significant financial cost to the health system. This cost could be associated with managing the affected HCWs or payment for compensation claims. A recent review estimated the average direct and in-direct cost of managing a needlestick injury to be US$747.[6]

We also identified regional variations in the 1-year prevalence of PCIs, with higher figures in East Asia, Middle East, North Africa and Eastern Europe. The result for North Africa compares well with the findings of a previous analysis of HCWs' occupational exposure to body fluids in 21 countries in Africa.[8] South America had the lowest regional prevalence in our review. This may be because all the studies included in this region were conducted in primary care settings with potentially reduced clinical activities. With the exception of the explanation offered for the low estimate in South America, the reason for the regional variations observed in this review is not entirely clear. It is likely that PCIs were under-reported in some studies, which may have contributed to the observed regional differences even within the same continent. Nonetheless, the observed variations may be a reflection of the differences in national legislation and implementation of measures (including use of safety-engineered devices, education and training) to prevent injuries by sharps. For example, in the USA, where there is a legislative mandate for the use of safety-engineered devices and the adoption of the legislation is high,[15] we observed a low prevalence of PCIs among HCWs. On the other hand, prevalence of PCIs was high in many developing economies, including Jordan, Syria and Afghanistan, where preventive measures such as the use of safety-engineered devices are lacking.

Many factors are known to influence the risk of transmission of HIV and HBV following PCIs, including the volume of blood exposed to, viral load of the source patient, HBV vaccination status and HIV post-exposure prophylaxis (PEP) uptake.[16] It was worrying to observe that sharps injuries were commonly reported in countries where the prevalence of HIV and HBV are high and HBV vaccination coverage and HIV PEP uptake among HCWs are low.[17,18] The high prevalence of these infections coupled with the low uptake of HBV vaccination and HIV PEP could predispose many HCWs to these infections.

Our analysis by job category reveals that surgeons had the highest prevalence of PCIs. Similarly, PCIs were more common among doctors (surgeons excluded), dentists and nurses than laboratory staff or paramedics. This is unsurprising given that these healthcare professionals' roles require a greater level of sharps exposure than others. Contrary to our finding, when rates of PCIs per 100 full-time equivalents were investigated through prospective observation or surveillance, nurses were the job category more frequently at risk.[19,20] Nurses were also more likely to acquire an occupational infection than other professional groups (including surgeons) because procedures with hollow-bore, blood-filled needles that carry greater risk of transmission of occupational infection are commonly performed by them.[20] We also found that PCIs were more common among HCWs working in hospitals than those in non-hospital settings. Although procedures such as phlebotomy and vaccination are frequently performed in non-hospital settings, situations requiring a higher frequency of invasive procedures are more likely to be carried out in hospitals, probably accounting for the observed difference.

Our systematic review did not include surveillance data because of under-reporting of cases of injury by HCWs. Surveillance data tend to underestimate the prevalence of PCIs, as we found higher PCIs rates than those reported in individual studies utilizing surveillance data.[21,22] This implies that PCIs are likely to be much more common than we think. Whereas surveillance data are important in understanding the circumstances under which PCIs occur, the current system has failed to help identify the magnitude of the problem. Many countries including the USA and UK are increasingly relying on surveillance data to inform practice and policy. Hence, further studies are needed to explore or model the difference between actual and reported incidence of PCIs. Furthermore, a significant number of PCIs data collected by healthcare facilities are never reported to the next hierarchical level or published.[23] This presents a challenge to understanding the scope of the problem. Therefore, it is important to explore the reasons for under-reporting of sharps injuries at all levels and efforts made to address them.

This review has some limitations, so our findings need to be interpreted with care. First, our review was limited by a lack of data from many countries, as only data from 43 countries met the inclusion criteria. Also, our review included single or limited reports from some countries and many of the included reports were regional studies that were not nationally representative of the countries in which they were conducted. This could potentially impact on the generalizability of our findings. Second, our estimate of the 1-year prevalence of PCIs largely depended on the intrinsic nature of the papers reviewed. Many of the included studies were conducted in hospital settings where the prevalence of sharps injuries is high. Hence our global 1-year prevalence may have been over-estimated. Third, because the reviewed studies were based on self-reported

retrospective data, they may be prone to recall and social desirability biases. This may account for over-reporting among HCWs wishing to see preventive measures implemented in their setting and under-reporting among those fearing to be blamed for not adhering to standard precautions. Finally, many factors influence the risk of transmission of blood-borne infections following PCIs including the type of device involved, whether hollow-bore needles or solid sharps. We were unable to present prevalence data split by these categories because of the lack of disaggregated data.

Despite these limitations, this review has increased awareness on the prevalence of PCIs among HCWs and should prompt relevant policies and actions across national governments, health systems and healthcare organizations. Since sharps' injuries are preventable, practical and implementable interventions like the use of safety-engineered devices, for instance, needleless intravenous system, auto-disabled syringes and blunt sutures may bring about a significant reduction in the rates of occupational PCIs among HCWs. However, in many resource-limited settings, it may be more critical and cost-effective to address factors contributing to the increased risk of PCIs including behavioural contributors such as needle recapping, lack of training and increased workloads.[8] Whereas it is the responsibility of HCWs to adhere to standard precautions when handling sharps, national governments and employers have a responsibility to provide a safe working environment, educate all HCWs and establish policies that would minimize the risk of PCIs in healthcare settings.

Supplementary Data

Supplementary data are available at *IJE* online.

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References

1. Tarantola A, Abiteboul D, Rachline A. Infection risks following accidental exposure to blood or body fluids in health care workers: a review of pathogens transmitted in published cases. *Am J Infect Control* 2006;**34**:367–75.
2. Elseviers MM, Arias-Guillén M, Gorke A, Arens HJ. Sharps injuries amongst healthcare workers: review of incidence, transmissions and costs. *J Ren Care* 2014;**40**:150–56.
3. Prüss-Ustün A, Rapiti E, Hutin Y. Estimation of the global burden of disease attributable to contaminated sharps injuries among health-care workers. *Am J Ind Med* 2005;**48**:482–90.
4. World Health Organization. *The World Health Report 2002: Reducing Risks, Promoting Healthy Life*. Geneva: World Health Organization, 2002.
5. Dement JM, Epling C, Ostbye T, Pompeii LA, Hunt DL. Blood and body fluid exposure risks among health care workers: results from the Duke Health and Safety Surveillance System. *Am J Ind Med* 2004;**46**:637–48.
6. Mannocci A, De Carli G, Di Bari V *et al*. How much do needlestick injuries cost? A systematic review of the economic evaluations of needlestick and sharps injuries among healthcare personnel. *Infect Control Hosp Epidemiol* 2016;**37**:635–46.
7. Reddy VK, Lavoie MC, Verbeek JH, Pahwa M. Devices for preventing percutaneous exposure injuries caused by needles in healthcare personnel. *Cochrane Database Syst Rev* 2017;**11**: CD009740.
8. Auta A, Adewuyi EO, Tor-Anyiin A *et al*. Health-care workers' occupational exposures to body fluids in 21 countries in Africa: systematic review and meta-analysis. *Bull World Health Organ* 2017;**95**:831–841F.
9. Munn Z, Moola S, Lisy K, Riitano D, Tufanaru C. Methodological guidance for systematic reviews of observational epidemiological studies reporting prevalence and incidence data. *Int J Evid Based Healthc* 2015;**13**:147–53.
10. DerSimonian R, Laird N. Meta-analysis in clinical trials. *Control Clin Trials* 1986;**7**:177–88.
11. Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. *BMJ* 2003;**327**:557–60.
12. Naghavi SH, Shabestari O, Alcolado J. Post-traumatic stress disorder in trainee doctors with previous needlestick injuries. *Occup Med (Lond)* 2013;**63**:260–65.
13. Lee JM, Botteman MF, Nicklasson L, Cobden D, Pashos CL. Needlestick injury in acute care nurses caring for patients with diabetes mellitus: a retrospective study. *Curr Med Res Opin* 2005;**21**:741–47.
14. Wang S, Yao L, Li S, Liu Y, Wang H, Sun Y. Sharps injuries and job burnout: a cross-sectional study among nurses in China. *Nurs Health Sci* 2012;**14**:332–38.
15. Jagger J, Perry J, Gomaa A, Phillips EK. The impact of U.S. policies to protect healthcare workers from bloodborne pathogens: the critical role of safety-engineered devices. *J Infect Public Health* 2008;**1**:62–71.
16. Baggaley RF, Boily MC, White RG, Alary M. Risk of HIV-1 transmission for parenteral exposure and blood transfusion: a systematic review and meta-analysis. *AIDS* 2006;**20**:805–12.
17. Zampino R, Boemio A, Sagnelli C *et al*. Hepatitis B virus burden in developing countries. *World J Gastroenterol* 2015;**21**:11941–53.
18. Auta A, Adewuyi EO, Kureh GT, Onoviran N, Adeloye D. Hepatitis B vaccination coverage among health-care workers in Africa: a systematic review and meta-analysis. *Vaccine* 2018;**36**: 4851–60.
19. Memish ZA, Assiri AM, Eldalatony MM, Hathout HM. Benchmarking of percutaneous injuries at the Ministry of Health hospitals of Saudi Arabia in comparison with the United States hospitals participating in Exposure Prevention Information Network (EPINet). *Int J Occup Environ Med* 2015;**6**:26–33.

20. Puro V, De Carli G, Petrosillo N, Ippolito G; Studio Italiano Rischio Occupazionale da HIV Group. Risk of hepatitis C virus transmission following per-cutaneous exposure in healthcare workers. *Infect Control Hosp Epidemiol* 2001;**22**:206–07.
21. Shiao JS, Lin MS, Shih TS, Jagger J, Chen CJ. National incidence of percutaneous injury in Taiwan healthcare workers. *Res Nurs Health* 2008;**31**:172–79.
22. Himmelreich H, Rabenau HF, Rindermann M *et al*. The management of needlestick injuries. *Dtsch Arztebl Int* 2013;**110**: 61–67.
23. Boden LI, Petrofsky YV, Hopcia K, Wagner GR, Hashimoto D. Understanding the hospital sharps injury reporting pathway. *Am J Ind Med* 2015;**58**:282–89.