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Research article

OCCUPATIONAL RISKS OF HEMOCONTACT VIRAL INFECTIONS FOR HEALTHCARE WORKERS: A SYSTEMATIC LITERATURE REVIEW

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At present, multiple studies report that healthcare workers (HCWs) are a specific occupational category exposed to various infections due to contacts with bloodborne pathogens in blood and other body fluids. Healthcare provision involves risks of transmission of human immunodeficiency virus (HIV), hepatitis B and C viruses (HBV and HCV) and other bloodborne pathogens for healthcare workers due to injuries with sharp objects through damaged skin or mucous membranes.

Literature data indicate that HCWs can get infected with bloodborne pathogens due to influence of several risk factors (peculiarities of a pathogen, its prevalence in a given population and among patients, intensity and duration of a contact with a pathogen). Risks of infection are associated with a division profile, work records, and some other factors. According to published data, the number of actual needlestick injuries and injuries caused by other sharp objects among HCWs prevails over the number of registered injuries and accounts for 22–82 % depending on a country, rules, and methodology applied for identifying the injury rate. Research works aimed at investigating hemocontact risks have established that underestimation of such data influences effectiveness and timeliness of implemented prevention activities. Risks of getting infected with hemocontact infections can grow substantially in case healthcare workers fail to follow personal protective measures or algorithms of relevant post-contact prevention. Observations of post-contact behaviors adopted by healthcare workers have revealed that 3.3–30 % of them either do not use any post-contact practices or do not always follow the relevant procedure of conducting them.

Optimization of activities aimed at identifying and preventing risks of hemocontact infections among healthcare workers will prevent occupational pathology in this contingent.

Keywords: healthcare workers, risks of infection, risk factors, hemocontact infections, hepatitis B, hepatitis C, occupational risks, post-contact prevention.

At present, the global healthcare is facing a very serious challenge associated with risks of hemocontact infections, which can be transmitted in healthcare organizations responsible for healthcare provision. The World Health Organization (WHO) reports the rate of global HAIs to reach 0.14 % and its annual growth to equal 0.06 % [1], which creates risks of occupational infection for healthcare workers (HCWs) [2]. Multiple

studies show that HCWs are a specific occupational group prone to getting infected with various communicable diseases due to contacts with pathogens in blood and body fluids [1, 3–6]. The results obtained by a systematic review and meta-analysis indicate that approximately 36.4 % of HCWs (95 % CI: 32.9–40.0) have occupational contacts with patients' blood every year [7]. As a result, they can get infected with more than 60

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known infectious agents (viruses, bacteria, rickettsia, parasites, and yeasts) [8]. Any patient with viremia [7, 9], parasitemia [10], bacteremia [11], or fungemia¹ is known as a potential source of such infections and can infect HCWs due to a needlestick injury (inflicted with a needle or any other sharp object) through mucosa or damaged skin. Healthcare provision involves risks of transmission of human immunodeficiency virus (HIV), hepatitis B virus (HBV), hepatitis C virus (HCV) [3, 6–7, 9–11], cytomegalovirus, parvovirus B19, simple herpes virus and other microorganisms [8, 11]. Such pathogens as herpes-viruses, including Epstein-Barr virus (EBV) and cytomegalovirus, are established to be able to penetrate the blood periodically or constantly in case of some latent infection forms and under certain conditions [12].

Risks of hemocontact infections are shown to depend on biological peculiarities of a specific microorganism [1, 3–11]. Out of more than 20 blood-borne pathogens, which cause such infections as malaria, syphilis, hemorrhagic fevers, etc., only three viruses (HBV, HCV, and HIV) cause most cases of occupational pathology among HCWs reported in research literature [3, 6, 7, 9–11]. This is due to their prevalence and severity of complications. In addition, literature sources provide data on prospective observation of HCWs, who are exposed to occupational risks, only for HBV, HCV, and HIV. It is rather difficult to assess risks of transmission for other pathogens due to few documented cases [8].

Hepatitis caused by hepatitis B and hepatitis C viruses is established to hold the 6th rank place as a global cause of mortality and morbidity. As estimated, in 2016 ap-

proximately 292 million people had chronic HBV-infection and more than 71.1 million had chronic HCV-infection [13–15]. Multiple published studies give evidence that exposure to HBV is the most prevalent and common occupational health risk for healthcare workers [7, 8, 16–19]. HBV is a hepatotropic virus transmitted through blood or other body fluids and able to cause acute or chronic hepatitis B. It is extremely contagious and risks of skin-to-skin contact HBV-infection can vary between 6 and 30 % [17]. Seroconversion speed after an accidental needlestick injury is estimated to equal approximately 10 % among non-immunized healthcare workers and it can reach 30 % in case a patient is a HBV carrier [8]. At present, vaccines remain the main hepatitis B prevention measure for healthcare workers; they were first introduced as far back as in 1981.

HCV is a hepatotropic virus, which is mostly transmitted under parenteral exposure through blood [17]. Russian researchers estimate HCV prevalence to reach 2.5–4.1 % among the country population [20]. At the same time, the existing HCV prevalence among healthcare workers, which does not always exceed the whole population level, is shown to be able to determine likelihood of infection². The risk of transmission upon a contact with HCV-positive blood is known to equal approximately 1.8 %, which is considerably lower than that of HBV [8, 21, 22]. Risk of HCV infection through contacts with other body fluids and tissues is considered to be low. Infection rarely happens upon contacts with mucosa and undamaged skin [23]. At present, it is impossible to prevent HCV infection after a contact; however, early treatment of hepatitis C in the acute phase

¹ Glaser J., Garden A. Inoculation of cryptococcosis without transmission of the acquired immunodeficiency syndrome. *N. Engl. J. Med.*, 1985, vol. 313, no. 4, pp. 266. DOI: 10.1056/NEJM198507253130414

² WHO. Aide-mémoire for National Blood Programmes: Blood safety. Geneva, WHO, 2002. Available at: <https://www.who.int/publications/i/item/WHO-BCT-02.03> (December 25, 2024).

could significantly reduce the rate of chronicity [24].

HIV is well-known to be less transmissible and less able to survive in the environment as opposed to HBV and HCV. Potentially, the pathogen can be borne in blood and body fluids including sperm and vaginal secretions with visible traces of blood. HIV can be transmitted from person to person upon direct contacts with blood, sperm, rectal secretions, vaginal secretions, or breast milk [25]. The first case of HIV transmission from a patient to a healthcare worker was reported as far back as in 1984 [8]. Mean risk of HIV transmission to healthcare workers is estimated in various studies as equal to approximately 0.3 % (95 % confidence interval CI = 0.2–0.5 %), and approximately to 0.09 % (95 % CI = 0.01–0.5 %) after a percutaneous contact with infected blood [8]. The risk of infection transmission through exposure on undamaged skin was not quantified, but, according to some estimates, it was lower than upon exposure on mucosa. The risk caused by percutaneous exposure was shown to have a positive correlation with contacts with a high volume of blood, high viral burden, a type of a procedure / injury, and damage to deep tissues [8, 26, 27]. The WHO data indicate that these factors can increase the risk of HIV transmission from a contaminated sharp object by 5 % [8, 28]. Timely post-contact prevention (PCP) accomplished within 72 hours after the contact and administration of post-contact preventive drugs are considered effective ways to prevent HIV-infection.

Approximately three million contacts with blood-borne pathogens are established to happen annually across the globe; of them, 170,000 are HIV infection, 2 million are HBV, and 0.9 million are HCV [1, 17]. Needlestick injuries resulted from direct occupational contacts with patients are reported as a significant risk factor causing transmission of hemocontact infections to HCWs [5, 6, 29–34]. Approximately 400 thousand

needlestick injuries happen every year in hospitals across the United States [17, 35]. And needlestick injuries are established to not only increase the risk of hemocontact infections among HCWs but also raise administrative costs for hospitals [36, 37]. A study with its focus on needlestick injuries among HCWs was conducted in the USA in 2016; as a result, the mean costs were 747 USD per person including direct economic costs of 425 USD per injury and indirect costs of 322 USD per injury [36, 38].

The results of a retrospective 10-year study accomplished in hospitals in China show that HCWs can get infected with hemocontact infections due to exposure to a wide range of various factors. Most accidents were caused by sharp injury, with 439 (84.6 %) cases, followed by blood or body fluid splash, with 80 (15.4 %) cases ($P < 0.001$) [2].

According to surveys accomplished by foreign researchers, the rate of needlestick injuries caused by HCWs' occupational activities was 25 % in the study by B. Ouyang et al. and 38.3 and 9.7 % respectively as reported in the studies by D. Wang et al. and S. Voide et al. [37–40]. Differences in these rates are thought to be associated with such factors as inclusion of different HCWs' occupational groups in research, levels of HCWs' occupational competence, as well as with some other reasons. Risks caused by unsafe injection practices were also confirmed in a study by A. Prüss-Üstün et al., where the authors showed that the proportion of infections caused by HBV, HCV, and HIV could reach 39 %, 37 % and 4.4 % respectively for healthcare workers prone to occupational percutaneous injuries [41, 42]. The risk of infection after a needlestick injury reached 23–62 % per hepatitis B and 0–7 % per hepatitis C for healthcare workers who were not provided with post-contact prevention [43].

Findings reported in foreign studies indicate that the risk of hemocontact infections

is determined not only by peculiarities of a specific pathogen but also a place and intensity of a direct contact with blood [44–47]. It can vary depending on duration of a contact, a virus titer and its prevalence in a population [17]. The risk of occupational exposure to hemocontact infections for HCWs grows with their growing prevalence in patients treated by HCWs [8]. The risk of transmission is established to be influenced by such factors as injury depth (deep needlestick, a big diameter of a needle, a big spot of damaged skin), volume of blood, and a host immunity level³ [7, 17]. Multiple studies show that likelihood of hemocontact infection for HCWs is influenced by work records [48, 49], work in operation rooms [18], unsafe use and withdrawal of needles, procedures for used sharps disposal [19, 50–52], and some other factors [19, 53].

Demographic and sex-related peculiarities of healthcare workers exposed to risks of occupational contacts with blood are reported in many foreign studies. A study accomplished by A. Garus-Pakowska et al., found that occupational contacts with blood were almost 3.5 times more frequent among female healthcare workers than among their male peers [18]. People aged ≤ 25 years or junior healthcare workers among the mid-level ones were identified as group risks of hemocontact infections [1, 6, 18, 50, 51, 54, 55]. A. Zafar et al. also reported that young doctors were the most susceptible to needlestick injuries [56].

Comparative characteristic of exposure to risk factors per HCWs' occupational groups revealed that healthcare workers with occupations involving frequent invasive procedures and acute care were the most susceptible to them. Some studies confirm that HCWs' activities in surgical departments, emergency care, and intensive care units

were more largely associated with occupational exposure to blood-borne pathogens [17, 31]. Needlestick injuries rates were established to be authentically higher in surgical hospitals (including operation rooms) than in therapeutic ones ($P = 0.001$) [31]. General surgeons were found to face the highest level of occupational exposures in Italy as well as in some other countries [39, 57, 58]. Chinese researchers report more frequent occupational contacts with pathogens (more than 10.5 %) in neurosurgery departments [19]. Reduction in use of sharps and active PPE use are proven to be an effective way for avoiding most occupational contacts with blood-borne pathogens [59].

Some studies show that the risk of hemocontact infections is far higher for mid-level healthcare workers, who at present account for the highest proportion of all HCWs [2, 7, 16, 29, 48, 58, 60, 61]. For example, a retrospective 10-year study by H. Feng et al. reported the proportion of such HCWs to reach almost 50 % (47.2 %) and most of them were women (75.1 %) aged predominantly 23–27 years (39.9 %) [2].

Nurses who accomplish invasive procedures, have more frequent multiple contacts with blood and body fluids in comparison with physicians or attendants [2, 62]. As a result, they are exposed to considerably higher risks of hemocontact infections. They constantly have to perform various invasive procedures and interventions (blood sampling, intravenous injections, inserting various catheters, etc.) and often get injured when accomplishing their occupational tasks [18, 19, 51, 54, 55, 63]. An acute injury, which accounted for 84.6 %, was shown to be the main reason for occupational exposures among mid-level HCWs [2]. According to data reported in a review by Italian

³ WHO. Aide-mémoire for National Blood Programmes: Blood safety. Geneva, WHO, 2002. Available at: <https://www.who.int/publications/i/item/WHO-BCT-02.03> (December 25, 2024).

researchers, the rate of needlestick injuries varied between 2.2 and 10.77 per 100 nurses a year. The major causes could be traced back to a large night shift, working in the operating block and in the medical departments, and the failure to use adequate devices [64].

R. Praisie et al. showed that the most common exposure was needle prick (86.2 %), followed by splash of fluids (7.4 %). The majority of HCWs were from the nursing department (44.4 %), and the most commonly reported place of exposure was the Emergency Department and Intensive Care Unit (ICU) (30.3 %), followed by inpatient wards [65]. In another study, nurses who worked over 8 hours per day were reported to have higher risks of exposure (OR = 1.199, 95 % CI: 1.130–1.272, $P < 0.001$, respectively) [66]. The occupational risk of exposure to pathogens associated with providing 1–2 types of safety-engineered injection devices was 1.275 times of that of providing 5–6 types (OR = 1.275, 95 % CI: 1.179–1.379, $P < 0.001$) [66].

Data from systemic reviews and meta-analyses published by foreign researchers showed that prevalence of needlestick injuries and associated risk factors was the highest in the morning shift (0.44; 95 % CI: 0.36–0.53, $I^2 = 97.2$ %), in emergency units (0.20; 95 % CI: 0.16–0.24, $I^2 = 93.7$ %) and intensive care units (0.20; 95 % CI: 0.16–0.24, $I^2 = 94.3$ %) [67–69]. Risks of occupational exposures were 1.947 times as high for healthcare workers provided with 1–2 PPE types against their peers provided with 9–10 PPE types (OR = 1.947, 95 % CI: 1.740–2.178, $P < 0.001$) [66]. Unsafe needles disposal and absence of safety devices were two major reasons for needlestick injuries among healthcare workers [66, 70–72].

Findings reported in some studies also show that the number of needlestick injuries among HCWs prevails over the number of registered injury cases. The proportion of unreported needlestick injuries varies between 22 and 82 % in this occupational group depending on a country. Rules and procedures applied to establish the injury rates [19, 38, 73–76]. Thus, J. Sun et al. point out that approximately 77.2 % of hospitals in China face the issue of underreported data about risk factors associated with occupational hemocontacts; only 22.8 % of such contacts are reported [75]. Physicians tend to report infection cases much less frequently than nurses and attendants as authentic differences have been established in frequency of such reports ($\chi^2 = 32.66$; $df = 4$; $p < 0.001$) [43, 47].

In their study, H. Bahat et al. established a high level of underreporting as regards injuries that happened in operation rooms; lack of time and low levels of hemocontact infections in patients were the most common reasons why HCWs did not report about their injuries [77]. Persistent underreporting of needlestick injuries is established to considerably decrease effectiveness of risk management activities and undermines priority and timeliness of preventive activities aimed at eliminating them [78, 79].

Recently, evidence has been reported in some studies that healthcare workers tend to suffer from post-traumatic stress disorder, anxiety and depression after needlestick injuries; this affects their quality of life and mental health⁴ [80]. A longitudinal study on psychological stress reactions of healthcare workers after injury, which was conducted by Y. Liu et al. [19], showed that the highest anxiety and depression levels occurred one month after an exposure H. Wang et al. [81] found that healthcare workers' psycho-

⁴ Protecting health and safety of health workers. WHO, 2016. Available at: <https://www.who.int/activities/protecting-health-and-safety-of-health-workers> (May 12, 2023).

logical stress reactions had been growing for six months after a hazardous contact.

Analysis of literature sources with their focus on observing post-contact behaviors in various occupational groups of healthcare workers gives evidence that from 3.3 % [2] to 30 % of exposed HCWs did not take any post-contact actions [82] and / or not always followed recommended algorithms on taking those [48].

In conclusion, it should be noted that given the global concern as regards this healthcare challenge, the Occupational Safety and Health Administration (OSHA) issued the Bloodborne Pathogens and Needlestick Prevention standard as far back as in 1981. In 2000, the document was revised and added with requirements fixed in the Needlestick Safety and Prevention Act (H.R. 5178) regarding implementation of new technologies and use of effective and safe medical devices [17]. However, effectiveness of any recommendations largely depends on whether healthcare workers take relevant actions and make timely reports about injuries [48].

Actions to mitigate occupational risks associated with HCW's contacts with bloodborne pathogens should concentrate on the following:

- performing stricter control of health-care workers' training on prevention of hemocontact infections;
- standardizing performed invasive practices and procedures;
- developing systems for reporting monitoring and control of hemocontact risks and stricter surveillance over post-contact prevention.

It is important to ensure that future prevention strategies include optimization of screening aimed at revealing markers of hemocontact infections in healthcare workers and vaccine prevention against hepatitis B as well as more active promotion of PPE use [19]. In addition, integrated approaches to labor protection and safety measures including engineering and administrative measures and PPE use should be implemented for controlling, eliminating or mitigating occupational risks for HCWs [6, 83, 84]. Therefore, optimization of activities aimed at identifying and preventing risks of hemocontact infections among healthcare workers will prevent occupational pathology in this contingent.

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