

# Risk of Sharps Injuries to Home Care Nurses and Aides: A Systematic Review and Meta-Analysis

Natalie M. Brouillette, ScD, Margaret M. Quinn, ScD, and David Kriebel, ScD

**Objective:** To evaluate all available literature and develop a pooled estimate of the risk of sharps injuries (SI) among home care (HC) nurses and aides. **Methods:** A systematic literature search was conducted and relevant articles were reviewed following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Primary outcome data from studies identified by the systematic review were pooled using a random effects model to calculate a summary measure of SI risk for nurses and for aides. **Results:** Five articles were included in the final analysis. Nurses had a 5.25% weighted average risk of experiencing at least one SI in the past year while working in HC (95% confidence interval [CI]: 3.11% to 7.40%); aides pooled SI risk was 1.74% (95% CI: 0.72% to 2.77%). **Conclusions:** Combining findings of all available studies demonstrates that there is a serious risk of SI among both the HC nurses and aides.

Home care (HC) is one of the fastest growing industries in the United States, in part due to the rapidly aging population and trend towards reducing hospital stays and increasing medical services in the home.<sup>1</sup> Home medical care often includes diabetes monitoring, medication and vitamin injections, blood collection, chemotherapy, and intravenous (IV) administration of antibiotics, and other infusion therapies. Many of these procedures require the use of sharp medical devices such as needles, syringes, and lancets, collectively called “sharps.” Needlesticks and other sharps injuries (SI) present a risk of serious bloodborne pathogen exposures, including Hepatitis B and C and HIV, to the nurses and aides who work in home care.

In response to growing industry demands, employment in HC nursing and in HC aide assistance is also expanding rapidly. There are approximately 168,000 home care nurses<sup>2</sup> and three million home care aides<sup>3,4</sup> in the US. Personal care aides and home health aides claim the second (48.8%) and third (48.5%) positions, respectively, for fastest growing occupations in the US between 2012 and 2022.<sup>5</sup> Other HC aide job titles include home health aide, home care aide, homemaker, personal care homemaker, hospice aide, certified nursing assistant (CNA), personal care aide/attendant (PCA), companion, and heavy chore worker. While there are differences in the

From the College of Health Sciences, University of Massachusetts Lowell, Lowell, Massachusetts.

**Funding:** The study was funded by the US National Institute for Occupational Safety and Health (NIOSH) (R01 OH008229), which had no role in the study design, data gathering, analysis, interpretation of the data, or writing of the manuscript. The content is solely the responsibility of the authors and does not necessarily represent the official views of the U.S. Centers for Disease Control and Prevention (CDC)/National Institute for Occupational Safety and Health (NIOSH). The corresponding author had full access to all the data and final responsibility for the decision to submit for publication.

**Conflict of Interest:** None declared.

Address correspondence to: Margaret M. Quinn, ScD, College of Health Sciences, University of Massachusetts Lowell, 1 University Avenue, Lowell, MA 01854 (Margaret\_Quinn@uml.edu).

Copyright © 2017 The Author(s). Published by Wolters Kluwer Health, Inc. on behalf of the American College of Occupational and Environmental Medicine. This is an open access article distributed under the terms of the Creative Commons Attribution-Non Commercial-No Derivatives License 4.0 (CCBY-NC-ND), where it is permissible to download and share the work provided it is properly cited. The work cannot be changed in any way or used commercially without permission from the journal.

DOI: 10.1097/JOM.0000000000001160

## Learning Objectives

- Summarize the findings to date on sharps injuries (SI) among home care nurses and aides.
- Discuss the findings of the meta-analysis, including the weighted average risk of SI among this population of workers.
- Discuss the implications of sharps injuries for home care workers as well as the need for improvements in clinical practices and other interventions to reduce risk.

work performed by these jobs, there is considerable overlap with respect to the risk of SI<sup>6-8</sup> and the term HC aide is used throughout this paper to refer to all aide jobs.

Home medical services and supervision of medications are primarily delivered by nurses. HC aides typically assist activities of daily living such as bathing, toileting, dressing, physical exercising, client mobility and transfers, for example from bed to wheelchair, cleaning, and food preparation. While HC aides typically do not use sharps directly, they are sometimes pressured by a client or family member to use a sharp<sup>6,9</sup> and all aides are at risk of SI by encountering sharps left around the home after they have been used by a client or client’s family member.

Hospitals and other healthcare facilities are required to record SI according to the US Occupational Safety and Health Administration Bloodborne Pathogen standard (29 CFR 1910.1030).<sup>10</sup> In hospitals there are often surveillance systems in place to monitor SI rates and possibly the tasks or risk factors related to those injuries. Sharps injuries are usually reported soon after the event occurs so that prophylactic treatment can be administered. Surveillance of SI in HC is not common and reporting of SI does not always occur, especially among client-hired aides.<sup>8,9,11</sup> Reasons cited for not reporting SI in HC include fear of getting in trouble or being blamed, lack of time to stop and report an incident, perceiving the risk of infection is low, concerns over confidentiality, and not knowing how to report SI.<sup>12</sup>

## Objective

The goal of this investigation was to critically and systematically review the literature on SI among HC nurses and aides and to develop pooled estimates of the risks of SI among HC nurses and aides using meta-analysis methods.

## METHODS

The design, implementation, and reporting of the systematic review and meta-analysis were conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.<sup>13</sup>

## Exposure Event Definition

According to the US Occupational Safety and Health Administration Bloodborne Pathogen standard (29 CFR 1910.1030), contaminated sharps are defined as any contaminated object that can penetrate the skin including, but not limited to, needles, scalpels, broken glass, broken capillary tubes, and exposed ends of dental wires.<sup>10</sup> The US Centers for Disease Control and Prevention (CDC) defines percutaneous injuries as interchangeable with SI; an exposure event occurring when a needle or other sharp object penetrates the

skin.<sup>14</sup> Needlestick injury definitions typically refer to needles that penetrate the skin.<sup>15</sup> While these definitions are similar, there are slight variations across definitions. Sharps injuries and percutaneous injuries may include penetration of the skin from needles but may also include other medical and nonmedical devices that can penetrate the skin such as scissors or even human bites, for example. In our systematic review, SI exposure events were defined as percutaneous injuries resulting from penetration of the skin by previously used sharp medical devices, as experienced by nurses and aides while working in HC jobs.

### Systematic Review

A systematic literature review was conducted using the PubMed database, which includes the US National Library of Medicine journal database, and EBSCO, which hosts numerous databases including CINAHL and many other nursing, allied health, and health sciences databases (Fig. 1). The search was not restricted by language, country, or date through July 15, 2017. The search string used the structured search terms in the Medical Subjects Headings (MeSH) dictionary: (((sharp OR needlestick OR percutaneous) AND injury) AND home). The search yielded 276 articles in PubMed and 408 hits in EBSCO, which were further restricted to academic journals and journals (omitting magazines, newspaper articles, dissertations, continuing educational units, and trade publications). The titles and abstracts of the 276 articles resulting from the PubMed search and 330 articles from EBSCO were reviewed to determine whether they met inclusion criteria developed *a priori*. Inclusion criteria were as follows: (1) the study population was direct HC workers (nurses and HC aides were the only identified occupations); (2) findings were specific to SI; and (3) denominator data were reported in a manner that allowed estimation of the incidence of SI, either as a rate or a risk (incidence proportion). The references of all relevant articles were also reviewed to look for

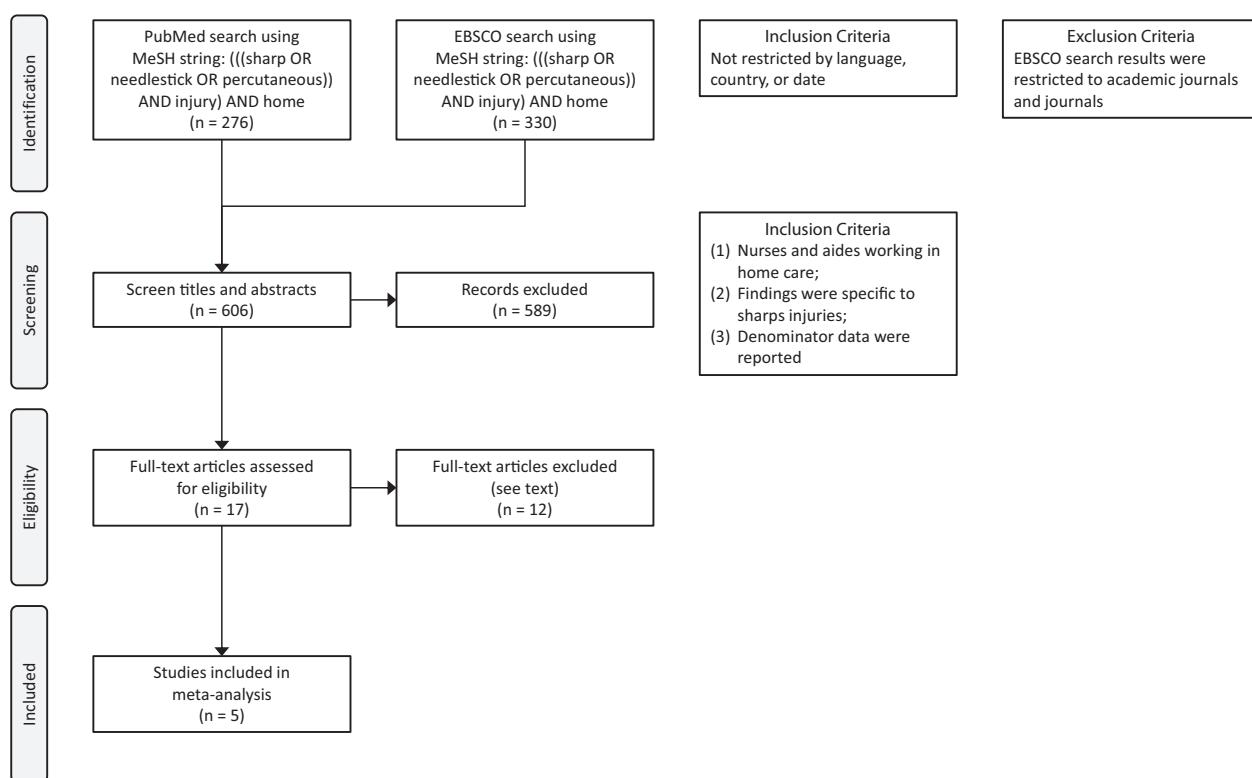
additional studies not found through the PubMed and EBSCO searches. None were found. If there were multiple publications that referred to the same study data, only the most recent publication was used in the analysis. Data were extracted from each article permitting the calculation of SI rates and/or risks by occupational group.

### Bias Assessment

We evaluated all relevant articles for potential biases. Biases were evaluated first by the primary author working independently, then discussed with all authors concurrently. Variations in the recall of an event were identified as a bias within all of the studies. Across the studies, variations in recall period and event definition were also identified as potential biases. These biases are addressed further in the Results section.

### Measures of Risk

In our models an SI event was defined as at least one nurse or aide getting stuck or cut by a previously used sharp medical device. The primary outcome for these studies was the number of SI reported in the past year which we used to calculate the rate. All studies identified in the literature search reported SI in the past 12 months, except one<sup>16</sup> which reported SI in the 3 years prior to the study survey administration. To use the data from this latter study in our meta-analysis we divided the number of SI events reported in 36 months by three to get an estimate of SI within the past 12 months. Rates of SI were reported per 100 full-time equivalent employees (FTE), a measure to standardize work hours across the employees in all of the studies based on a standard 2000 hours/year.<sup>17</sup> Risk was defined as the probability of being injured at least once by a previously used sharp medical device in the past year while working in HC. Though not all studies reported risk we were able to calculate it from the information provided, thus allowing for direct comparison of studies.



**FIGURE 1.** Flow diagram depicting the strategy used for the systematic literature review, including inclusion and exclusion criteria.

**TABLE 1.** Demographic Characteristics of the Study Populations of Home Care Nurses and Aides Selected by the Systematic Review and Included in the Sharps Injury Meta-Analysis

	Population	Location	Age (Mean, yrs)	Years in Home Care (Mean)
Nurses				
Gershon, AJIC, 2009 <sup>16</sup>	738	New York	50	22
Leiss, AJIM, 2009 <sup>27</sup>	833	North Carolina	63	—
Lipscomb, AJIM, 2009 <sup>28</sup>	794	Maryland	49	11
Quinn, AJPH, 2009 <sup>12</sup>	787	Massachusetts	48	11
Aides				
Brouillette, AJIC, 2017 <sup>6</sup>	1,178	Massachusetts	47	6*
Lipscomb, AJIM, 2009 <sup>28</sup>	980	Illinois	46	7
Quinn, AJPH, 2009 <sup>12</sup>	282	Massachusetts	47	11

\*Tenure with current home care employer.

## Pooled Estimate of Risk

We used a random effects model to calculate a summary measure of the SI risk.<sup>18</sup> Heterogeneity of the study risks was assessed using the  $Q$  and  $I^2$  statistics.<sup>19</sup>  $Q$  is Cochran heterogeneity statistic, calculated as the weighted sum of squared differences between individual study effects and the pooled effect across studies, with the weights being those used in the pooling method.<sup>19</sup>  $I^2$  describes the percentage of total variation across studies that is due to heterogeneity rather than chance.<sup>20</sup> When the  $I^2$  value is high (above 50%) a fixed-effects model is generally used, whereas the random-effects model is used when  $I^2$  is low.

## RESULTS

### Literature Review Results

Seventeen articles passed the initial screening and were comprehensively reviewed for relevancy according to the inclusion criteria.<sup>6,12,16,21-34</sup> Of these, 12 did not meet one or more inclusion criteria: study population was not specific to nurses or aides working in home care ( $n = 8$ );<sup>21-25,30,31,33</sup> and/or did not report denominator data ( $n = 4$ ).<sup>25,26,29,32,34</sup> Five articles<sup>6,12,16,27,28</sup> were included in the final analysis (Table 1).

### Details of Relevant Studies Included in the Analysis

Four articles<sup>12,16,27,28</sup> evaluated SI among HC nurses while three articles<sup>6,12,28</sup> included HC aides in their analyses (Table 1). All study populations were located in the United States and their mean

ages ranged between 46 and 63 years. Most study populations were employed in HC for an average of 6 to 11 years,<sup>6,12,28</sup> however, one population of nurses had a tenure of 22 years in HC<sup>16</sup> and the tenure was not reported for one population of nurses.<sup>27</sup> In one study,<sup>6</sup> tenure was defined as the mean number of years with the current home care employer, rather than the entire career.

All studies were surveys of HC workers, administered by mail or in-person (Table 2). Four studies<sup>6,12,27,28</sup> asked about SI in the past year; while the recall period for one study<sup>16</sup> was the previous 3 years, as noted previously.

Among nurses, the rate of SI per 100 FTE ranged from 5.1 to 12.6 (Table 3). The rate of SI per 100 FTE ranged between 1.0 and 6.5 in the aide group. We also calculated the risk of experiencing at least one SI for each study population. Nurses had a 3% to 9% annual risk of SI while the annual risk of SI among aides ranged from 1% to 3%.

The risk of at least one SI in the past 12 months was the most consistently reported measure of risk and the one chosen for pooling (Fig. 2). In the Gershon et al<sup>16</sup> article, nurses were asked to recall any percutaneous injury within the past 3 years, defined as contaminated needles, human bites, and contaminated SI. We omitted human bite incidents ( $n = 3$ ) from our rate and risk calculations. The rate of percutaneous injuries (minus the three human bites) was 7.5 per 100 person-years and we were able to calculate the 95% CI using information provided in the article. Leiss et al<sup>27</sup> did not define fulltime versus part-time and insufficient information was provided to report the rate per 100 FTE. However, Leiss et al<sup>27</sup> did report an

**TABLE 2.** Survey Details From the Selected Studies of Home Care Nurses and Aides and the Risk of Sharps Injuries

	Definition of Sharps Injury	Time Period	Survey Administration Method
Brouillette, AJIC, 2017 <sup>6</sup>	Stuck or cut by a previously used sharp object, such as a needle, lancet or syringe, in home care work	Past year	Mail or in person through events held at agencies or union meetings
Gershon, AJIC, 2009 <sup>16</sup>	Percutaneous injuries by contaminated needles, human bites, or contaminated sharps injuries	Past 3 years	Mail or in person during data collection sessions held at agency headquarters
Leiss, AJIM, 2009 <sup>27</sup>	Stuck by a needle or lancet after it had been used on a patient	Past year	Mailed to nurses listed in the licensing database of NC Board of Nursing as working in home care or hospice in non-administrative positions
Lipscomb, AJIM, 2009 <sup>28</sup>	Needle or sharps exposure	Past year	Mailed to nurses listed in the State Board of Registered Nurses as actively working in home care. Aides were offered in person surveys during mandatory employer-based training sessions
Quinn, AJPH, 2009 <sup>12</sup>	Stuck or cut by a previously used sharp object, such as a needle or lancet, in home healthcare work	Past year	Mail or in person through events held at agencies

**TABLE 3.** Reported Rates and Risks of Sharps Injuries From the Selected Studies of Home Care Nurses and Aides

	<b>n Exposed to Sharps Injuries*</b>	<b>Sharps Injuries</b>	<b>Rate/100 FTE<sup>†</sup></b>	<b>95% CI</b>	<b>Risk (%)</b>	<b>95% CI</b>	<b>Weight<sup>‡</sup> (%)</b>
<b>Nurses</b>							
Gershon, AJIC, 2009 <sup>16</sup>	113 <sup>§</sup>	165 <sup>  </sup>	7.5 <sup>¶</sup>	(7.4, 7.6)	5.1	(3.5, 6.7)	23
Leiss, AJIM, 2009 <sup>#,27</sup>	26	28	—	—	3.1	(1.9, 4.3)	32
Lipscomb, AJIM, 2009 <sup>**,28</sup>	71	—	12.6	—	8.9	(7.0, 10.9)	18
Quinn, AJPH, 2009 <sup>12</sup>	34	34	5.1	(3.7, 7.1)	4.3	(2.9, 5.7)	26
<b>Aides</b>							
Brouillette, AJIC, 2017 <sup>6</sup>	22	49	6.5	(4.9, 8.6)	1.9	(1.1, 2.6)	39
Lipscomb, AJIM, 2009 <sup>**,28</sup>	26	—	3.6	—	2.7	(1.6, 3.7)	30
Quinn, AJPH, 2009 <sup>12</sup>	2	2	1.0	(0.2, 4.0)	0.7	(0.0, 1.7)	31

CI, confidence interval.

\*Number reporting at least one sharps injury.

†Rate per 100 FTE: full time equivalent (FTE) standardizes variations in work hours among employees. In Quinn (AJPH 2009) and Brouillette (AJIC 2017), full time was considered 40 hours per week in a 50 week year.

‡Contribution of each study to the overall summary effect estimate, calculated as the percent of the sum of the inverse variance study weights.<sup>19</sup>

§Past 3 years.

||Contaminated needlesticks and contaminated sharps injuries.

¶Rate reported per 100 person-years.

#Did not report rate per 100 FTE, however, incidence rate of needlesticks reported to be 7.9 per 100,000 home visits (95% CI: 5.3, 10.5).

\*\*Reported as "at least one sharps injury in the past year."

incidence rate of 7.9 per 100,000 HC visits (95% CI: 5.3, 10.5). Lipscomb et al<sup>28</sup> did not report the number of SI, thus we were unable to calculate the 95% CI for this rate.

## Synthesis Results

We calculated the weighted average risk of experiencing at least one SI while working in HC for both nurses and aides using random-effects models. A random effects model is preferred when the studies appear to be based on populations that differ from each other in systematic ways that could affect the size of the SI risk.<sup>18</sup> This appeared to be the case here, although the number of studies

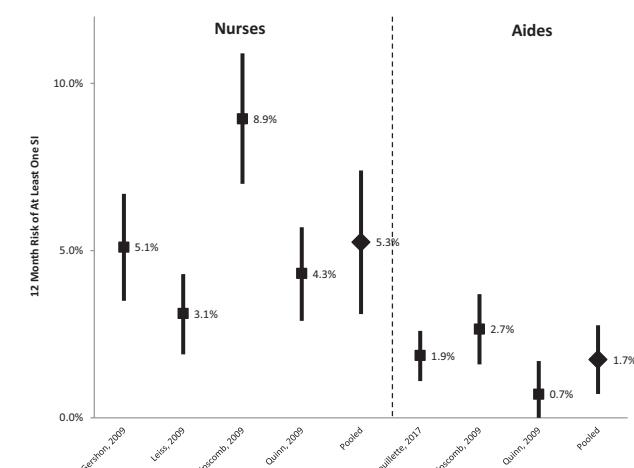
was limited. Among nurses, the fixed-effects model resulted in a *Q* value of 23.08 (*df*=3) which was substantially larger than the critical value of 7.82, indicating that we should reject the null hypothesis that the study risks were homogeneous and thus use the random effects model. Similarly, the *I*<sup>2</sup> was 87%, which means that a substantial majority of the variability was explained by differences among the studies. Among aides, the homogeneity results were qualitatively similar; the fixed-effects model resulted in a *Q* value of 7.41 (*df*=2) with an *I*<sup>2</sup> value of 73%, while the random-effects model resulted in a *Q* value of 2.23 (*df*=2) and an *I*<sup>2</sup> value of 10%.

Nurses working in HC had a 5.25% weighted average risk of experiencing at least one SI in the past year (95% CI: 3.11% to 7.40%). Aides had a 1.74% weighted average risk of experiencing at least one SI in the previous year while working in HC (95% CI: 0.72% to 2.77%).

## DISCUSSION

After the Needlestick Prevention Act (Public Law 106-430, 114 STAT.1901, November 6, 2000) was passed in 2000 as an amendment to the US Occupational Safety and Health Administration (OSHA) Bloodborne Pathogen standard (29 CFR 1910.1030),<sup>10</sup> the National Institute for Occupational Safety and Health (NIOSH) funded several studies that aimed to evaluate the rate and risk of SI and associated risk factors among HC nurses and aides. The five studies that were identified in our systematic review were all funded by NIOSH under this initiative.<sup>6,12,16,27,28</sup> The coordination and collaboration that resulted from the NIOSH funding helped to ensure that the results of these independent, investigator-initiated projects would be sufficiently comparable to allow formal meta-analytic estimation of a combined risk. Our literature search did not find any other studies that met the inclusion criteria.

Two studies were identified which did not meet the inclusion criteria, but had findings qualitatively similar to those reported here. Haiduven and Ferrol<sup>26</sup> conducted an assessment of SI among HC nurses in the San Francisco Bay area. This cross-sectional pilot study was conducted using exposure reports submitted from three local HC agencies during 1993 to 1996. The study identified 52 SI, 92% of which were reported by registered nurses.<sup>26</sup> Ultimately, this study was not included in our final analysis because denominator data were not reported; however, the finding provides support for



**FIGURE 2.** Annual risks of sharps injury (SI) among home care nurses and aides. Black squares represent the risk of experiencing at least one SI found in the studies of home care nurses or aides evaluated in the systematic review. Diamonds represent the weighted averages of the risks of experiencing at least one SI among nurses or aides working in home care. Error bars represent 95% confidence intervals for the risk. There was little variation in study weights (Table 3) therefore all studies are represented by the same size symbols.

those reported here and is an important contribution to the SI literature overall.

Trinkoff et al<sup>31</sup> reported survey findings of needlestick injuries primarily among hospital-based nurses. Home care and hospice nurses were included in the analysis, but they were grouped with assisted living nurses and it was not possible to separate them. Nevertheless, the Trinkoff et al<sup>31</sup> results are fairly similar to the results of the meta-analysis reported here (Table 1). The Trinkoff et al<sup>31</sup> study found that 8.5% of nurses employed by a home health agency, hospice, or assisted living facility ( $n = 164$ ) reported at least one needlestick injury in the past year (95% CI 4.3% to 12.8%). The 12 months risk of at least one needlestick injury was reported for various nursing specialties. For comparison, nurses in the Trinkoff et al<sup>31</sup> study who reported working in a hospital had 244 needlestick injuries in the past year resulting in an annual risk (18.5%,  $n = 1317$ ) approximately twice the risk of the home hospice and assisted living nurses.

Although aides typically do not use sharps directly to perform medical procedures, they are also at risk of SI in HC. We learned through previous research, including surveys and focus groups, that aides' SI risks are primarily from used sharps, often without engineered SI protections, stored for reuse and/or improperly disposed in the home.<sup>6,8,9,12</sup> A recent study of HC aides identified important SI risk factors including male sex and being born outside the United States, as well as helping a client use a sharp, seeing used sharps lying around the home during a visit, and experiencing physical aggression while caring for a client.<sup>6</sup>

In addition to the occupational health and safety impacts, SI have wide public health significance. A recent study found that sharps enter the home via multiple pathways: (1) HC agencies, hospice, or other medical service providers bring them into the home when they visit a client; (2) the clients or other sharps users in the home bypass HC providers and obtain the sharps themselves, for example, over the internet; and (3) selection and use of particular sharps can be influenced by physicians, insurance coverage, or even personal preference of the user.<sup>7</sup> Not only are HC workers at risk, but so too are clients, their family members or visitors within the home, as well as waste disposal workers. Risks of SI are also costly for HC agency employers because they require resources for training, management, prophylactic treatment, lost work time, and workers compensation insurance.

As the medicalization of HC intensifies, including with procedures that involve sharps, the risk of SI may increase. Ideally, preventive interventions for SI should be aimed at eliminating sharps use, including through the development of needless medical devices and procedures. In the meantime, sharps with engineered sharp injury protection (SESIPs) should be used in HC. Patients being discharged from hospitals to HC should be educated about safe sharps handling and disposal and elder services managing HC should account for safe sharps use in clients' initial assessment for HC services and in clients' ongoing care plan. Additionally, HC agencies and other employers and occupational medicine physicians and nurses providing services for HC agencies should provide occupational safety and health training on SI prevention and protection.

## Limitations

There were several limitations in this study. Only five studies were included in the final analysis. The majority of reviewed studies focused on registered nurses, however, two studies included a smaller population of aides and one study focused solely on aides. Nevertheless, the rates reported in the five studies analyzed here were in agreement.

Another limitation inherent to all five studies is that the SI data were based on recall of up to 12 months (36 months in one study). The SI events may have been either over- or underestimated

through errors of memory. Hospital workers' SI experience is frequently underestimated<sup>35</sup> probably due to a variety of factors including fear of blame for carelessness, lack of time for following reporting procedures, and failure to recognize the risk. In an earlier pilot study<sup>12</sup> on SI reporting in a small sample of HC agencies that participated in a SI surveillance system evaluation, we estimated that approximately 50% of SI were not reported. If the data in the five studies analyzed here were subject to under-reporting, our risk estimates would be lower than the actual risk. Further evaluation of SI reporting in HC is needed.

A potential limitation related to the choice of the statistical model is the use of the *Q*-test to determine heterogeneity. The *Q*-test is susceptible to low power due to a small number of studies included in the meta-analysis.<sup>19,20</sup> However, power does not directly affect the  $I^2$  measure of heterogeneity as it is not dependent on the number of studies.<sup>20</sup> We used both the *Q*-test and  $I^2$  measure to determine which model (fixed- or random-effects) was appropriate given the parameters of the data.

## CONCLUSIONS

This meta-analysis found a significant risk of SI among HC nurses and aides. Coordination by the independent investigators at the initial research design stage was an effective approach for developing SI assessment methods and producing data that could be compared across studies and combined for more powerful risk estimates. Effective public health interventions include medical device re-design to eliminate sharps and changing clinical policies and practices to improve sharps safety.

## ACKNOWLEDGMENTS

The authors wish to thank the following for assistance with the Safe Home Care Study sharps injuries data collection, management and interpretation used for part of this meta-analysis: Drs Pia Markkanen, Susan Sama, Rebecca Gore, Daniel Okyere, Chuan Sun, Nancy Goodear, and Ms Catherine Galligan at the University of Massachusetts Lowell, and Dr Letitia Davis and Ms Angela Laramie at the Massachusetts Department of Public Health, Occupational Health Surveillance Program.

The authors gratefully acknowledge the home care agencies, trade associations, labor unions, and home care nurses and aides for making this study possible and for providing care that enables so many to live in their homes safely and with dignity.

## REFERENCES

- National Research Council. Health Care Comes Home: The Human Factors. Washington, DC: The National Academies Press; 2011. Available at: <http://www.nap.edu/catalog/13149/health-care-comes-home-the-human-factors>. Accessed April 2, 2017.
- Bureau of Labor Statistics. Occupational Outlook Handbook, 2016–17 Edition, Registered Nurses. Washington, DC: US Department of Labor; 2015. Available at: <https://www.bls.gov/ooh/healthcare/registered-nurses.htm>. Accessed April 10, 2017.
- Bureau of Labor Statistics. Occupational Outlook Handbook, 2016–17 Edition, Home Health Aides. Washington, DC: US Department of Labor; 2015. Available at: <https://www.bls.gov/ooh/healthcare/home-health-aides.htm>. Accessed April 10, 2017.
- Bureau of Labor Statistics. Occupational Outlook Handbook, 2016–17 Edition, Personal Care Aides. Washington, DC: US Department of Labor; 2015. Available at: <https://www.bls.gov/ooh/personal-care-and-service/personal-care-aides.htm>. Accessed April 10, 2017.
- Bureau of Labor Statistics. Employment Projections: Fastest Growing Occupations, 2012 and Projected 2022. Washington, DC: US Department of Labor; 2012. Available at: [https://www.bls.gov/news.release/archives/ecopro\\_12192013.pdf](https://www.bls.gov/news.release/archives/ecopro_12192013.pdf). Accessed April 2, 2017.
- Brouillette NM, Quinn MM, Kriebel D, et al. Risk of sharps injuries among home care aides: results of the safe home care survey. *Am J Infect Control*. 2017;45:377–383.
- Markkanen P, Galligan C, Laramie A, Fisher J, Sama S, Quinn M. Understanding sharps injuries in home healthcare: the safe home care qualitative

methods study to identify pathways for injury prevention. *BMC Public Health.* 2015;15:359.

8. Quinn MM, Markkanen PK, Galligan CJ, et al. Occupational health of home care aides: results of the safe home care survey. *Occup Environ Med.* 2016;73:237–245.
9. Markkanen P, Quinn M, Galligan C, Sama S, Brouillet N, Okyere D. Characterizing the nature of home care work and occupational hazards: a developmental intervention study. *Am J Ind Med.* 2014;57:445–457.
10. Occupational Safety and Health Administration (OSHA). Standards Code of Federal Regulations 29 CFR: Bloodborne Pathogens 1910.1030. Washington, DC: US Department of Labor; 1991. Available at: [https://www.osha.gov/pls/oshaweb/owadisp.show\\_document?p\\_table=STANDARDS&p\\_id=100051](https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=100051). Accessed April 2, 2017.
11. Markkanen P, Quinn M, Galligan C, Chalupka S, Davis L, Laramie A. There's no place like home: a qualitative study of the working conditions of home health care providers. *J Occup Environ Med.* 2007;49:327–337.
12. Quinn MM, Markkanen PK, Galligan CJ, et al. Sharps injuries and other blood and body fluid exposures among home health care nurses and aides. *Am J Public Health.* 2009;99(Suppl):S710–S717.
13. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *J Clin Epidemiol.* 2009;62:e1–e34.
14. Centers for Disease Control and Prevention (CDC). Blood/Body Fluid Exposure Option. Atlanta, GA: US Department of Health and Human Services; 2013. Available at: <http://www.cdc.gov/nhsn/pdfs/hps-manual/exposure/3-hps-exposure-options.pdf>. Accessed April 2, 2017.
15. Canadian Centre for Occupational Health and Safety. OSH Answers Fact Sheet: Needlestick and Sharps Injuries. Ontario, Canada: Canadian Centre for Occupational Health & Safety (CCOHS); 2014. Available at: [https://www.ccohs.ca/oshanswers/diseases/needlestick\\_injuries.html](https://www.ccohs.ca/oshanswers/diseases/needlestick_injuries.html). Accessed April 2, 2017.
16. Gershon RR, Pearson JM, Sherman MF, Samar SM, Canton AN, Stone PW. The prevalence and risk factors for percutaneous injuries in registered nurses in the home health care sector. *Am J Infect Control.* 2009;37:525–533.
17. Kim H, Kriebel D, Quinn MM, Davis L. The snowman: a model of injuries and near-misses for the prevention of sharps injuries. *Am J Ind Med.* 2010;53:1119–1127.
18. Borenstein M, Hedges LV, Higgins JPT, Rothstein HR. *Introduction to Meta-Analysis.* Chichester, UK: John Wiley & Sons, Ltd; 2009.
19. Neyeloff JL, Fuchs SC, Moreira LB. Meta-analyses and forest plots using a microsoft excel spreadsheet: step-by-step guide focusing on descriptive data analysis. *BMC Res Notes.* 2012;5:52.
20. Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. *BMJ.* 2003;327:557–560.
21. Alamgir H, Cvitkovich Y, Astrakianakis G, Yu S, Yassi A. Needlestick and other potential blood and body fluid exposures among health care workers in British Columbia, Canada. *Am J Infect Control.* 2008;36:12–21.
22. Backinger CL, Koustenis GH. Analysis of needlestick injuries to health care workers providing home care. *Am J Infect Control.* 1994;22:300–306.
23. Beltrami EM, McArthur MA, McGeer A, et al. The nature and frequency of blood contacts among home healthcare workers. *Infect Control Hosp Epidemiol.* 2000;21:765–770.
24. Chen GX, Jenkins EL. Potential work-related bloodborne pathogen exposures by industry and occupation in the United States part I: an emergency department-based surveillance study. *Am J Ind Med.* 2007;50:183–190.
25. Gillen M, McNary J, Lewis J, et al. Sharps-related injuries in California healthcare facilities: pilot study results from the Sharps Injury Surveillance Registry. *Infect Control Hosp Epidemiol.* 2003;24:113–121.
26. Haiduven D, Ferrol S. Sharps injuries in the home health care setting: risks for home health care workers. *AAOHN J.* 2004;52:102–108.
27. Leiss JK, Lyden JT, Mathews R, et al. Blood exposure incidence rates from the North Carolina study of home care and hospice nurses. *Am J Ind Med.* 2009;52:99–104.
28. Lipscomb J, Sokas R, McPhaul K, et al. Occupational blood exposure among unlicensed home care workers and home care registered nurses: are they protected? *Am J Ind Med.* 2009;52:563–570.
29. Perry J, Parker G, Jagger J. Percutaneous injuries in home healthcare settings. *Home Healthc Nurse.* 2001;19:342–344.
30. Perry J, Parker G, Jagger J. EPINet report: 2001 percutaneous injury rates. *Adv Expo Prev.* 2003;6:32–36.
31. Trinkoff AM, Le R, Geiger-Brown J, Lipscomb J. Work schedule, needle use, and needlestick injuries among registered nurses. *Infect Control Hosp Epidemiol.* 2007;28:156–164.
32. Amuwo S, Sokas RK, McPhaul K, Lipscomb J. Occupational risk factors for blood and body fluid exposure among home care aides. *Home Health Care Serv Q.* 2011;30:96–114.
33. van Wijk PT, Pelk-Jongen M, de Boer E, Voss A, Wijkmans C, Schneeberger PM. Differences between hospital- and community-acquired blood exposure incidents revealed by a regional expert counseling center. *Infection.* 2006;34:17–21.
34. Vos D, Gotz HM, Richardus JH. Needlestick injury and accidental exposure to blood: the need for improving the hepatitis B vaccination grade among health care workers outside the hospital. *Am J Infect Control.* 2006;34:610–612.
35. Laramie AK, Pun VC, Fang SC, Kriebel D, Davis L. Sharps injuries among employees of acute care hospitals in Massachusetts, 2002–2007. *Infect Control Hosp Epidemiol.* 2011;32:538–544.