EXPO-S.T.O.P. 2015: A national survey of sharps injuries and mucocutaneous blood exposures among healthcare workers in USA hospitals

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ABSTRACT

Background: National blood exposure (BE) surveys are valuable to healthcare facilities striving to reduce percutaneous sharps injuries (SI) or mucocutaneous (MC) exposures among their healthcare workers (HCW). In EXPO-S.T.O.P 2015 we surveyed hospital BE incidence among members of the Association of Occupational Health Professionals in Healthcare.

Methods: A 23-item electronic survey requested 2015 data on: Total SI and MC; SI in nurses, doctors, surgery; staffed beds; teaching status; full time equivalent staff (FTE), Nurse FTE, average daily census (ADC) and adjusted patient days (APD).

Results: 181 hospitals in 34 states reported 9,343 BE (71% SI; 29% MC). SI rates were: 25.2/100 ADC (17.5 in non-teaching hospitals; 30.4 in teaching hospitals) ; 2.1/100 FTE (significantly less than that in 2001); 3.2/100 Nurse FTE; 0.36/1000 APD; 38% occurred during surgery. Mucocutaneous incidence rates were: 10.5/100 ADC (8.6 in non-teaching hospitals; 11.7 in teaching hospitals); 0.86/100 FTE; 0.14/1000 APD.

Conclusions: BE incidence rates have fallen slowly but significantly since 2001 but the reduction is far less than hoped. Occupied beds (ADC) has become a less useful denominator. We estimate over 300,000 HCW sustain SI annually in hospital and non-hospital settings. Greater resources are needed for more frequent and correct use of safety devices, training-to-competency, and root-cause investigation of all SI.

Key Words: Sharps injuries; Needlestick; Blood exposure; EXPO-S.T.O.P., Healthcare workers, Hospital, USA.

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INTRODUCTION

Blood exposure (BE) among healthcare workers (HCW), either from percutaneous sharps injury (SI) or mucocutaneous (MC) exposure, is a serious occupational risk that healthcare facilities (HCF) strive to reduce. Reporting and recording of these exposures, both institutionally and nationally is vital as surveillance underpins control and commitment.[1]

The University of Virginia Health System's International Healthcare Worker Safety Center's Exposure Prevention Information network (EPINet), now conducted by the International Safety Center, has published BE data predominantly from south-eastern states since 1993.[2] In 1995 the Center for Disease Control and Prevention's (CDC) National Surveillance System for Healthcare Workers (NaSH) began collecting BE numbers from HCF but ceased in 2007.[3] Since 2002 the Massachusetts Department of Public Health (MADPH) Sharps Injury Surveillance System has annually collected and published sharps injury (SI) data from all state-licensed hospitals in MA.[4]

To ascertain BE incidence nationally, the **E**xposure **S**urvey of **T**rends in **O**ccupational **P**ractice (EXPO-S.T.O.P.), was established to survey members of the Association of Occupational Health Professionals in Healthcare (AOHP). The first EXPO-S.T.O.P. survey found incidence rates in 2011 to be higher than that reported in EPINet or MADPH databases,[5] and EXPO-S.T.O.P. 2012, 2013 and 2014 surveys showed a rising incidence rate when occupied beds was used as the denominator.[6,7] However, this rising incidence was at odds with databases using denominators more closely related to true workloads.[8] This paper presents the results of the EXPO-S.T.O.P. 2015 survey, which uses multiple denominators to examine trends in U.S. BE incidence rates, and discusses BE denominators and differences in BE data-gathering in U.S. HCF.

METHODS

The 15-item questionnaire used for the 2014 calendar year survey[7] was enlarged to 23-items to ascertain more detailed information on BE, particularly the incidence among non-employee doctors (questionnaire available from corresponding author upon request). Data from 2015 calendar year was requested on: SI and MC incidence in all staff: SI in nurses, employee doctors and non-employee doctors; Total SI (OSHA Form 300 exposures plus other "non-OSHA reportable" SI), and proportion of total SI occurring in surgical procedures; and hospital bed size, location and teaching status. Four denominator metrics were requested: full time equivalent staff (FTE); Nurse FTE; average daily overnight-patient census (ADC); and adjusted patient days (APD) calculated by dividing total revenue by inpatient revenue and multiplying by total inpatient days.

The questionnaire was distributed via e-mail to AOHP members who used Survey Monkey™ to insert their data or emailed data directly. Accompanying the survey was an explanation of the purpose and goals of the survey and investigator contact information. Participants were given the option of providing their contact information if willing to be contacted for further information about their data and their hospital's exposure management program and were assured no hospital name would be revealed without their permission. To encourage participation, AOHP provided a free conference registration as the prize in a drawing for those completing the survey by a specified deadline. Participants with contact details were contacted if their data was incomplete or contained 'outlier' data. Participants with nonsensical data who could

not be contacted had their data excluded from that calculation.

Hospital incidence rates for SI and MC per: 100 ADC; 100 FTE, 100 Nurse FTE; 1000 APD were calculated for Teaching and Non-teaching facilities, and these, together with the Nurse, MD and OR proportions, were compared with EXPO-S.T.O.P, EPINet and MADPH surveys. To compare with MADPH 2015 results, MA licensed beds were converted to occupied beds (ADC) using hospital-specific occupancy data for MADPH-licensed hospitals for 2015.[9]

WinPepi v11.26 was used to calculate Chi^2, log-transformation risk ratios (RR) at 95% confidence limits (CL). Statistical significance was set at $p \leq 0.05$.

RESULTS

One hundred and eighty-one hospitals in 34 states supplied usable data. An additional 12 hospitals were excluded because they failed to supply sufficient data to complete any incidence calculations. A further 41 sets of data from facilities in the non-hospital setting were excluded from this analysis and are the subject of a separate study.

Of the 180 hospitals answering the question whether non-employee doctors (NED) were included in their OSHA 300 Log, 77 (43%) said Yes. In the 103 hospitals excluding NED from their OSHA Log, of the 1156 MD reporting SI, 268 (23.2%) were NED. Of the 181 hospitals participating, 46% supplied usable APD data. Of the 141 hospitals answering whether they were teaching or non-teaching hospitals, 60 (43%) were teaching and 81 (57%) were non-teaching.

Table 1 shows an overview of the EXPO-S.T.O.P. 2015 survey numbers and Figure 1 depicts the national distribution (states and contributing hospitals) of the 181 participating hospitals. Table 2 displays the SI and MC incidence rates for EXPO-S.T.O.P. 2015 participating hospitals. The annual incidences of SI per 100 ADC for small, medium and large EXPO-S.T.O.P. hospitals for 2011-2015 is shown in Figure 2. Figure 3 displays the SI incidence rates per 100 ADC over time for: EXPO-S.T.O.P. hospitals (2011-2015);[5-7] EPINet hospitals (2000-2014);[2] and MADPH hospitals (2002-2015).[4]

Table 1

EXPO-S.T.O.P. 2015 hospital survey overview

Total hospitals participating	Hospital size range (ADC)	Total BE exposures	Total sharps injuries	Total mucocutaneous exposures	Number USA states participating
181	5 - 985	9343	6698	2735	34

ADC Average Daily Census; BE Blood Exposure

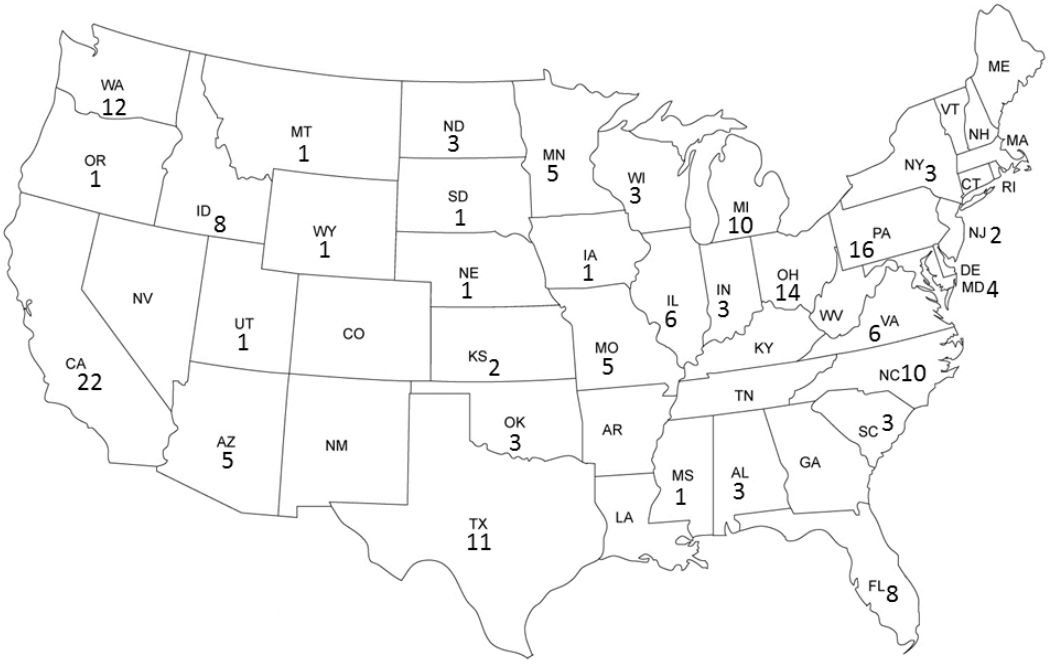

Fig 1. States (and number of hospitals) participating in EXPO-S.T.O.P. 2015

Table 2

EXPO-S.T.O.P. 2015 sharps injury and mucocutaneous exposure incidence

Blood Exposure Indices	Sharps Injuries	Mucocutaneous
Per 100 ADC(all)	25.2	10.5
Non-teaching hospitals	17.5	8.6
Teaching hospitals	30.4	11.7
Per 100 FTE (all)	2.1	0.86
Non-teaching hospitals	1.73	0.85
Teaching hospitals	2.36	0.86
Per 100 Nurse FTE (all)	3.2	NR
Non-teaching hospitals	2.8	NR
Teaching hospitals	3.5	NR
Per 1000 Adjusted patient days (all)	0.36	0.14
Non-teaching hospitals	0.22	0.12
Teaching hospitals	0.43	0.15
Nurse as % of Total SI	45.6%	NR
MD as % of Total SI	32.8%	NR
Surgical Procedure as % of Total SI	38.3%	NR

ADC average daily overnight-patient census (synonymous with “Occupied Beds”);
FTE full-time equivalent staff; MD medical doctor; SI sharps injuries; NR not requested.

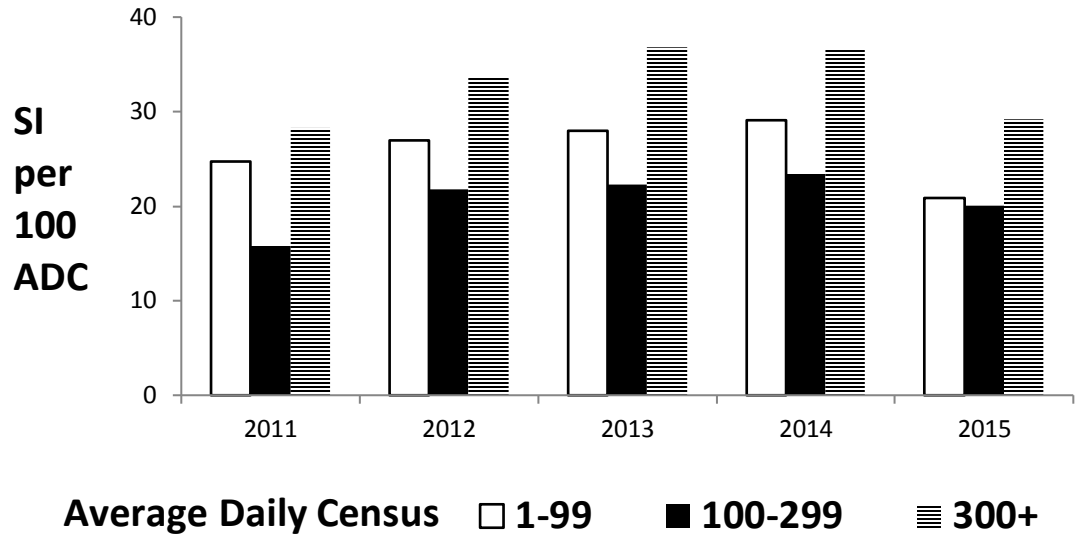

Fig 2. Sharps injury incidence EXPO-S.T.O.P. 2011-2015 by hospital size
ADC average daily census of overnight inpatients ("occupied beds")

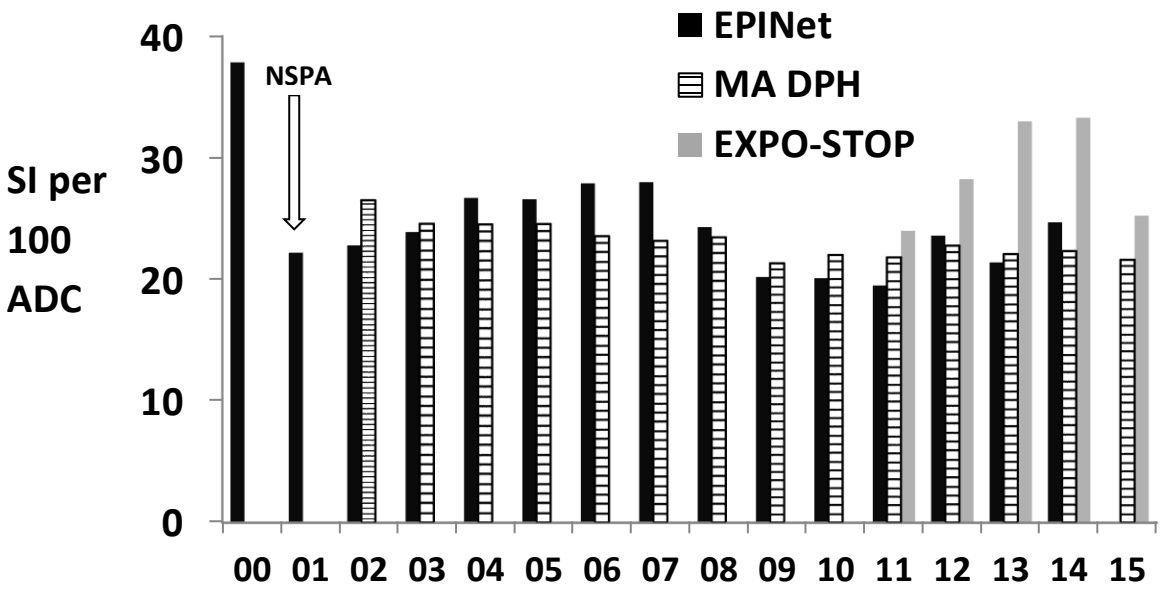

Fig 3. Comparison of EXPO-S.T.O.P. exposure rates with EPINet and MADPH rates
ADC average daily overnight-patient census; NSPA Needlestick Safety and Prevention Act; EPINet Exposure Information Network; MADPH Massachusetts Department of Public Health.

DISCUSSION

National BE databases are valuable for: determining incidence rates and trends; calculating national prevalences; provoking informed, evidence-based discussions on prevention guidelines, resource allocation and legislation; determining best practice and successful intervention strategies; and for benchmarking between hospitals of similar patient-mix and size.

EXPO-S.T.O.P. surveys are conducted as a broad overview of exposure incidence and not as a detailed database of exposure mechanisms, a purpose served by other valuable databases.[2,4] The survey tool is constructed to promote maximum response by asking minimal pertinent questions to enable a national BE incidence rate to be expressed in multiple indices and denominators. Reporting on data from 181 hospitals in 34 states across the 8 American Hospitals Association hospital sizes,[10] EXPO-S.T.O.P. 2015 is larger and more comprehensive than previous EXPO-S.T.O.P. surveys. Future EXPO-S.T.O.P. surveys will endeavor to increase the number of states participating however it may not be possible to obtain/confirm full representation as: several members chose not to insert their state to preserve absolute anonymity; AOHP members may not reside in every state; members may already be participating in other BE databases such as EPINet or MADPH; workload pressures may restrict participation; and permission to participate may not be granted by hospital leadership.

Incidence rates and trends

The survey's 2015 SI incidence rate of 25.2 per 100 ADC (Table 2) is significantly higher than MADPH 2015[4] (calculated at 21.6/100 occupied beds) ($p = 0.007$), but not significantly different from EPINet 2014 (24.7/100 ADC).[2] No other denominators are annually available from EPINet or MADPH databases for comparison. The lower SI incidence in MA is likely due to MA being a "sharps-aware" state, where by law, all licensed hospitals have submitted and had their SI incidence data annually published since 2002[4] and such regular and prominent data-gathering may raise safety awareness.[8]

Overall, MC exposures accounted for 29.3% of BE, however, unlike SI incidence, the MC incidence rate in teaching hospitals was similar to that non-teaching hospitals (Table 2). This finding also occurred among EPINet hospitals,[2] and this needs further investigation as it is not clear whether fewer MC are reported, or fewer MC occur, in larger hospitals. The MC incidence rate of 10.5 per 100 ADC (Table 2) is significantly higher than EPINet 2014 (8.9/100 ADC),[2] ($p=0.013$; 0.85; (0.74-0.97)). Incidences for MC are not published by MADPH.

Comparing EXPO-S.T.O.P. 2015 with the next largest EXPO-S.T.O.P. study (2012),[6] SI/100FTE has significantly decreased (2.1 vs 2.2; $p=0.02$), so too has SI per 1000 APD (0.36 vs 0.43; $p<0.001$) and SI/100 ADC (25.2 vs 28.2; $p<.001$). It is heartening to see the SI decrease (albeit small) in EXPO-S.T.O.P. hospitals: In Massachusetts hospitals the SI incidence/100 ADC had steadily fallen since 2002 but has plateaued since 2009[4] (Fig 3) (2015 not significantly different from 2009); and EPINet hospitals' 2014 incidence was significantly higher than their 2010 rate.[2] These differences may reflect region-specific parameters but may also reflect the use of ADC (occupied beds) as a denominator (see BE Denominators below).

The incidence of SI among EXPO-S.T.O.P. nurses was not significantly different in 2015 (3.2/100 nurse FTE) than in 2012 (3.3). This is disappointing as safety engineered devices

(SED), by OSHA law, must be readily available to nurses and all other HCW whose use of sharps exposes them to blood and body fluids. The lack of SI reduction among nurses may mean SED are not being activated correctly,[11] perhaps through insufficient training,[12] high workloads,[13] or less safe SED are being used.[14]

Of the hospitals participating in EXPO-S.T.O.P. 2015, 43% were teaching hospitals. The increased SI rate in teaching hospitals over non-teaching hospitals (Table 2) mirrors that of previous EXPO-S.T.O.P.,[5-7] EPINet[2] and MADPH[4] surveys and is indicative of a teaching hospital's higher procedure intensity with concomitant higher use of sharps[15] and their training role for nursing students[16] and medical students,[17] together with the added SI incidence in research (non-bed) departments in teaching hospitals.

In terms of clinical work groups, of the total reported SI, 45.6% were reported by nurses and 32.8% by doctors. The proportion reported by doctors is significantly less than EXPO-S.T.O.P. 2012[6] (p=0.007; 0.92; (0.87-0.98)) and is of concern if it indicates doctors are reporting less of their SI. In the 2014 MADPH survey, doctors accounted for 39% of total SI reported, higher than nurses (36%), and may reflect increased reporting by doctors or greater adoption of SED by nurses,[4] or both. In EXPO-S.T.O.P.-2015 hospitals, 38.3% of SI were reported during surgical procedures, not significantly different from the 39.5% in EPINet hospitals in 2014[2] but significantly less than that the 43.9% in MADPH hospitals in 2015[4] (p<0.001; 0.87(0.83-0.92)) and may be further evidence that EXPO-S.T.O.P. doctors are reporting less of their SI.

By international comparison, the EXPO-S.T.O.P. nurse SI incidence of 3.2 per 100 FTE is below that of: the 2015 national French figure of 3.8;[18] the 4.4 in a large German teaching hospital in 2011;[19] and the 5.1 of Canada sentinel hospitals in 2011.[20] However, EXPO-S.T.O.P. SI per 100 nurse FTE, per 100 total FTE and per 100 ADC (Table 3) are considerably less than those found in the recent staff questionnaire survey of 206,711 HCW in 361 hospitals in China by Gao et al – their rates were 124.7/100 Nurse FTE, 101.6/100 FTE and 121.3/100 ADC - with the high rates being due to rare use of SED, lack of safety culture and heavy clinical workloads.[21]

Some reassurance can be gained by looking at SI trends over a longer period (Fig 3). EXPO-S.T.O.P. hospitals' SI incidence of 2.1/100 FTE is significantly less than the 2.7/100 FTE found in EPINet hospitals in 2001,[8] the year of Needlestick Safety and Prevention Act (NSPA)[22] enactment (p<0.001; 0.79 (0.75-0.83)). In 2001 the EPINet incidence rate dropped 38% in a single year;[8] however in the 16 years since, the decrease has been 22.2%, or 1.4% per year. The reduction in 2001 was so profound that 2001 CDC set the lofty challenge of eliminating SI within 5 years.[23] Unfortunately, 16 years later, we have not been able to match that first-year fall, and we are at a considerable distance from zero. However, effective reduction strategies exist. The 10 EXPO-S.T.O.P. teaching and non-teaching hospitals with the lowest SI incidences (73% below the national average) stated their effective strategies were: education and competency-based training; communication; incident investigation; and staff engagement.[12]

BE reporting by non-employee staff

Aside from voluntary reporting by employees, several additional factors can confound the accuracy of exposure surveys. In the U.S., OSHA's NSPA requires percutaneous injuries, if they occur in an employee and the sharp was contaminated with blood or other potentially infectious material, to be recorded with incident and device details in a sharps

injury log.[22] From Jan 2002, OSHA CFR 29 1904.8 required such injuries to be further recorded and summarized in specific OSHA forms.[24] However, in several states medical staff are prohibited by law from being hospital employees[25] (and OSHA laws pertain only to employees). Furthermore, some hospitals include non-employee doctors (NED) in their OSHA logs and some do not (In our survey 57% included NED, 43%, did not); and some hospitals encourage/require non-employees to report their BE, others do not. In EXPO-S.T.O.P. 2015, of the hospitals who do not include NED in their OSHA logs, the majority supplied a figure for SI among NED, indicating that although not required by law, at least some NED report their SI in most hospitals. It must also be noted that OSHA laws do not require recording of MC unless the incident results in the HCW acquiring a BBP disease.[24]

Notwithstanding the above reporting/recording variation among participating hospitals, the survey, by asking confirming-questions, solicited the total exposures reported to the facility irrespective of whether they were OSHA or non-OSHA reportable, or in employees or non-employees, or SI or MC. We asked hospitals for their OSHA SI figure and their SI figure for "others". Overall, "others" (non-employees) were an additional 8.6% on the OSHA log total for all hospitals, however in hospitals excluding non-employees from their OSHA logs, the "Other SI" added 46.1% to the OSHA figure. We believe that to obtain a true picture of a facility's BE incidence, all SI and MC exposures, in all people working on that site, whether employees or non-employees, need be reported and recorded. A No shame-No blame culture and a convenient reporting system must also be adopted.[12,26]

BE Denominators

The number of day-procedures (that previously required overnight stay) and outpatient visits has markedly increased in U.S hospitals in the last 15 years.[27] The increased workload from day-procedures (and outpatient clinics, emergency visits, home healthcare visits, etc), and commensurately the increase in BE exposure risk, is not captured using the traditional ADC (occupied overnight beds) denominator. The number of BE will rise with increased day-procedures and ADC will fall with decreased overnight inpatients, thus the resultant BE incidence per 100 ADC will markedly rise giving the impression that BE prevention strategies are failing. We and others have highlighted the ADC denominator issue[6,28] however although occupied beds is a "sub-optimal" denominator, we include it for historical comparisons.

A denominator that captures all the above clinical workloads is Adjusted Patient Days (APD) as it converts outpatient procedures to "inpatient day equivalents". However, APD does not capture facility-differences in staff involved in non-revenue activities, i.e. research staff in teaching hospitals. Also, it appears somewhat difficult to obtain as only 46% of hospitals supplied this figure.

Equally useful as APD and easier to obtain, is total FTE. Total FTE accurately reflects a hospital's total workload as it includes the entire staff, irrespective of roles, and total FTE will increase with increasing workloads no matter what the cause of the increase (patient throughput, research, teaching, home healthcare, etc.). We believe it valuable for all BE incidence publications to include "per 100 FTE" as a denominator.

A more valuable denominator for benchmarking is one that isolates a single staff cohort, e.g. Nurse FTE. Such worker-specific denominators enable genuine

comparisons as they are "undiluted", exclude non-clinical worker cohorts, are present in every hospital, and target a cohort that is at high BE risk.

Irrespective of the denominator chosen, benchmarking is ill-advised unless "like" hospitals are compared i.e. those with similar patient mix, workloads, teaching status and size – the four parameters most impacting BE exposures.

The "high-low-higher" hospital size phenomenon

When EXPO-S.T.O.P.-2015 hospitals were stratified into small, medium and large ADC sizes (Fig 2), their 'high-low-higher' SI incidence per 100 ADC mirrors that found in previous EXPO-S.T.O.P.[5-7] and MADPH[4] surveys. Both databases[5-8] found hospitals with >300 ADC have increased likelihood of being teaching hospitals and as such they have the highest SI incidence for the reasons mentioned above. The higher rate in hospitals with <100 ADC compared to hospitals with 100-299 ADC, may reflect better reporting with the "no secrets" atmosphere of a smaller facility, where everyone is more aware of all that goes on ("all one family – can't hide anything"); the necessity for staff to function as "generalists" filling multiple roles; and/or less use of SED. Investigative studies are warranted to more accurately clarify the reasons behind this consistent finding.

No data, No problem, No action

Sharps injury prevention as an issue has been less widely discussed since the heady days surrounding the implementation of the NSPA in 2001.[29] Blood exposures need to have a high profile to avoid the "No data, No problem, No action"[30] phenomena whereby without constant publically-available reporting of incidence rates, the "urgency" falls away as, without data, there is no "seen" problem, and without a problem, there is no allocation of scarce healthcare resources. Hospitals are one of the most hazardous environments for workers.[31] Of the OSHA-reportable injuries to HCW, BE are well below strains, sprains, bruising, and even fractures.[31] This is because SI and MC exposures seldom incur "days off work" – nevertheless BE can have serious disease consequences[32] and be emotionally stressful to the injured HCW and their family.[33] Occupational health managers and staff are struggling to handle and prevent the gamut of injuries to their colleagues - and BE exposure prevention has to compete with these for time and resources.

Currently the infection issue attracting resources is Healthcare Associated Infections (HAI) – for three reasons: HAI is patient-related, has attracted "public outrage", and attracted government interest.[34] One reason stated for the BE interest wane is that *"HCW are no longer at high risk because HIV and HCV can be effectively treated, and we have an effective HBV vaccine."* This mindset is spurious as these pathogens represent only three of the 60 other pathogens such as parasites (malaria), viruses (dengue), fungi (Cryptococcus) and bacteria (Brucella) that HCW are at risk of contracting with sharps injury.[32] Newer emerging viral pathogens, such as Ebola and Zika may also be transmitted to healthcare workers via sharps injuries or mucocutaneous exposures. An irony is that BE transmission of infectious diseases to HCW is classified by the World Health Organization as an HAI[35] and their reduction-strategies[36] mirror the recently published strategies of low-incidence hospitals.[12] As an HAI, staff-related infection risk should have a high priority in resource-allocation.

The EXPO-S.T.O.P. 2015 results, extrapolated nationally to the HCW workforce in hospitals, non-hospital and non-healthcare workforce, indicate that over 300,000 HCW sustain SI annually in the U.S. – over 800 every day. The reduction in incidence rates has been markedly slower than expected. Blood exposures among HCW are a significant issue of national importance which needs increased attention and resources. But to record and investigate all BE takes a good deal of resources – more than currently allocated in most hospitals. Reporting, recording and publishing BE incidence studies is vital at an institutional and national level. Unlike Australia, UK, Canada and New Zealand who have no publically available national BE databases, U.S. is fortunate in having EPINet, MADPH and EXPO-S.T.O.P.. Publication of these databases provides the data, confirming there is a problem, and we need action to solve the problem. In late 2017 the new OSHA law requiring employers to electronically submit an annual summary of their workplace injuries and illnesses takes effect and it also has an anti-retaliation rule to encourage workers to report injuries and requires reporting systems to be easy to use.[37] The Department of Labour states making injury information publicly available "nudges" employers to focus on safety.[37] We hope EXPO-S.T.O.P., EPINet, MADPH and the new OSHA database achieve such a focus. But not just with employers – it is also the responsibility of the person using the sharp.[12]

Strengths and Limitations

Strengths of the survey were: the number of hospitals participating (181), geographic dispersion (34 states), hospital size representiveness, contemporary data (2015), most survey questions pertained to annual records required by OSHA law, and incidence rates were expressed using four denominators. Limitations were: the reliance on voluntary reporting by individuals of their exposure incidents; voluntary participation in the survey (with potential for selection bias); the potential for misinterpretation of questions and definitions; participating hospitals may not be representative of hospitals nationally; and non-employee exposures may not have been captured by all hospitals.

CONCLUSIONS

As a nation the U.S. has not been able to achieve our SI reduction goals. Greater emphasis needs be placed on correctly and more frequently using engineering controls and more assiduous follow-up and investigation of each exposure. These intervention strategies need greater hospital administration involvement and engagement to enable resourcing at a higher level than that currently. Incidence reporting, recording, investigation, action and publishing are vital at institutional and national level.

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Conflict of Interest

The authors declare no conflict of interest.

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