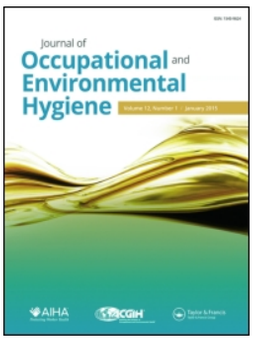

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Effects of organizational safety practices and perceived safety climate on PPE usage, engineering controls, and adverse events involving liquid antineoplastic drugs among nurses

David M. DeJoy[a], Todd D. Smith[b], Henok Woldu[c], Mari-Amanda Dyal[d], Andrea L. Steege [e], and James M. Boiano [e]

[a]Department of Health Promotion and Behavior, College of Public Health, University of Georgia, Athens, Georgia; [b]Department of Applied Health Science, School of Public Health, Indiana University, Bloomington, Indiana; [c]Department of Epidemiology and Biostatistics, College of Public Health, University of Georgia, Athens, Georgia; [d]Department of Health Promotion and Physical Education, Kennesaw State University, Marietta, Georgia; [e]Division of Surveillance, Hazard Evaluations and Field Studies, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, Cincinnati, Ohio

ABSTRACT

Antineoplastic drugs pose risks to the healthcare workers who handle them. This fact notwithstanding, adherence to safe handling guidelines remains inconsistent and often poor. This study examined the effects of pertinent organizational safety practices and perceived safety climate on the use of personal protective equipment, engineering controls, and adverse events (spill/leak or skin contact) involving liquid antineoplastic drugs.

Data for this study came from the 2011 National Institute for Occupational Safety and Health (NIOSH) Health and Safety Practices Survey of Healthcare Workers which included a sample of approximately 1,800 nurses who had administered liquid antineoplastic drugs during the past seven days. Regression modeling was used to examine predictors of personal protective equipment use, engineering controls, and adverse events involving antineoplastic drugs.

Approximately 14% of nurses reported experiencing an adverse event while administering antineoplastic drugs during the previous week. Usage of recommended engineering controls and personal protective equipment was quite variable. Usage of both was better in non-profit and government settings, when workers were more familiar with safe handling guidelines, and when perceived management commitment to safety was higher. Usage was poorer in the absence of specific safety handling procedures. The odds of adverse events increased with number of antineoplastic drugs treatments and when antineoplastic drugs were administered more days of the week. The odds of such events were significantly lower when the use of engineering controls and personal protective equipment was greater and when more precautionary measures were in place. Greater levels of management commitment to safety and perceived risk were also related to lower odds of adverse events.

These results point to the value of implementing a comprehensive health and safety program that utilizes available hazard controls and effectively communicates and demonstrates the importance of safe handling practices. Such actions also contribute to creating a positive safety climate.

KEYWORDS

Antineoplastic drug administration; hazardous drugs; healthcare workers; organizational factors; safe handling practices; safety climate

Introduction

It is well established that antineoplastic drugs (AD) pose potential risks to the healthcare workers who handle them.[1,2] Acute health effects of occupational exposure include skin rashes, chronic cough and sore throat, eye irritation, dizziness, hair loss, and allergic reactions.[3,4] Studies of exposed female healthcare workers have shown a variety of adverse pregnancy-related outcomes including infertility, miscarriage, and birth defects.[5,6] Oncology nurses have also been found to be at increased risk of leukemia and other cancers.[6] In response, both professional organizations[7,8] and government agencies[9,10] have issued guidelines for the safe handling of hazardous drugs, including antineoplastic drugs. These national guidelines address specific procedures and equipment for safeguarding workers who handle these highly toxic substances.

Although the potential risks of AD are widely acknowledged, the use of engineering controls, personal protective equipment (PPE), and other precautionary measures

CONTACT David M. DeJoy dmdejoy@uga.edu College of Public Health, University of Georgia, 341C Wright Hall, Health Sciences Campus, Athens, GA 30603.

remains inconsistent and often quite poor.[11–17] The reasons for this limited adoption of protective measures remain much less clear, and such knowledge is crucial to making improvements. Available evidence points to a mismatch between healthcare workers' knowledge of occupational exposure risks and their behaviors when handling these drugs.[11,18–20] In other words, having an adequate knowledge of risks does not automatically produce commensurate precautionary action. Results from a recent large-scale survey[11,19] suggest that many healthcare workers do not use recommended PPE because they judge the risk of skin exposure to be minimal or because certain PPE are not part of their employer's protocol.

Many, if not most, occupational safety problems can be traced back to organizational factors[21,22] as their basic or primary causes. Organizational factors typically involve safety-related actions taken or not taken at the management and supervisory levels of the organization. Research on occupational exposure to AD has begun to move in that direction. In a 2005 commentary, McDiarmid and Condon[23] drew a parallel between compliance with hazardous drug guidelines and the prior lessons learned from bloodborne pathogens showing the importance of safety culture/climate to compliance.[24,25] They made a persuasive case for an increased focus on safety culture/climate as a major source of interventions for improving compliance with safe handling procedures. Safety culture and safety climate both focus on the relative importance assigned to safety in a particular work setting or organization. The organization's enacted policies and practices related to worker safety are products of its safety culture and serve to shape employee perceptions about the importance of safety (i.e., safety climate).[26–29] These perceptions give rise to relevant behavior-outcome expectations and subsequent safety-related behaviors.

Friese and colleagues[13] examined the role of selected organizational factors on exposures to AD among nurses working in an ambulatory oncology setting. Their findings showed lower likelihoods of exposure when staffing and resources were adequate and when orders and doses were consistently verified by two nurses. Polovich and Clark[20] included a measure of safety climate in their study of 165 oncology nurses. Using a modified version of the Hazardous Drug Handling Questionnaire[15] as their dependent measure, they reported that total precaution scores were higher when nurses had fewer patients, when barriers to PPE use were lower (time pressure, peer acceptability, etc.), and when safety climate was more positive. Their measure of safety climate was a modified version of the one developed by Gershon and colleagues[30] to study bloodborne pathogens and universal precautions. Polovich and Clark,[20] however, did not assess exposures in their study.

The present research sought to continue and expand this line of inquiry. The 2011 NIOSH Health and Safety Practices Survey of Healthcare Workers provided an opportunity to examine how pertinent organizational safety practices and safety climate perceptions influence the use of both PPE and engineering controls to reduce exposure risks among nurses who administer AD. This survey included a sample of approximately 2,000 nurses who administer different types of AD in various healthcare settings.[31] The survey included questions pertaining to several organizational practices directly pertinent to safe handling of AD, namely, having specific safe handling procedures in place, having up-to-date employee training in safe handling, and implementing recommended precautionary measures (spill kits, etc.). These activities are acknowledged elements of a comprehensive and proactive approach to employee risk reduction in the area of hazardous drugs. The survey also contained a series of safety perception questions that asked respondents about different aspects of safety where they work. These questions formed the basis of a safety climate measure.

Methods

Study sample

The data for this study came from the 2011 NIOSH Health and Safety Practices Survey of Healthcare Workers, an anonymous, multi-module, web-based survey. Respondents for this cross-sectional survey were primarily members of various professional practice organizations whose members routinely use or come into contact with selected chemical agents. Recruitment for individual respondents was through email using the membership lists of the participating organizations. Invitation and reminder emails were sent to members from their organizations using a NIOSH-developed template that included a hyperlink to the survey. The survey was accessible 24 hr a day, seven days a week, for a period of eight weeks. The details of survey development and administration have been described previously.[31] The present sample included those nurses (N = 1,814) who had administered liquid AD in the 7 calendar days prior to the survey, and whose employer was either a hospital or ambulatory healthcare center. Our analyses used questions from two of the survey modules. The measures used to assess demographic characteristics, work setting, and safety climate were from the core module of the survey. Measures specific to AD administration were taken from the hazard module specifically addressing AD administration. Questions on exposure controls in the hazard module were based on the specific engineering controls, administrative controls, and PPE included in national safe handling guidelines available at the time of the survey.[7–10]

Measures

The measures were organized into five categories: (1) demographics and work setting, (2) AD training and familiarity with safe-handling guidelines, (3) perceived safety climate, (4) organizational safety practices, and (5) outcomes.

Demographics and work setting. These measures included respondent age, sex, race, and education; number of years in current occupation and with current employer; experience administering AD (years); and number of AD administered during the last seven days. Three work setting characteristics were assessed: employer type (hospitals or ambulatory healthcare services), ownership type (non-profit, for-profit, or government), and size (number of employees).

AD training and familiarity with guidelines. Two measures were included: recency of AD training and familiarity with established safe handling guidelines. OSHA recommends that workers who handle hazardous drugs receive information and training at the time of initial assignment and annually thereafter.[10] Therefore, AD training was assessed according to whether respondents had ever received training and whether they had been trained within the past 12 months (yes or no for each). Familiarity with established guidelines was rated on a three-point scale. Respondents received a score of 2 if they indicated that they were very familiar with any of the four sets of guidelines, 1 if they were somewhat familiar, and 0 if they were not at all familiar with any of the guidelines. This scoring system was used because familiarity with more than a single set of guidelines does not necessarily imply greater overall knowledge of safe handling procedures. Since having employees with appropriate and up-to-date safety training is generally considered to be an employer responsibility, these measures were treated as organizational practices in the analyses.

Safety climate. The questionnaire's core module included a set of 18 safety perception questions that asked respondents about various aspects of safety where they work. Most of these questions were similar to those typically included as part of safety climate scales. Each question was responded to using a five-point scale (strongly disagree, disagree, agree, strongly agree, not applicable). For purposes of analyses, not applicable responses were coded as missing and the scale was treated as a 4-point scale (1 = strongly disagree to 4 = strongly agree). The safety perception questions were factor analyzed using Principal Axis Factoring and Promax rotation with Kaiser Normalization. An examination of Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Sphericity Tests were completed to determine if the data were appropriate for factor analysis. The results of the KMO was 0.948, which is considered "excellent" and worthy of factoring.[32] In addition, the significance of Bartlett's test at $p = 0.001$ ($\chi 2 = 13{,}137$, $df = 136$) also indicated that the original correlation matrix was not an identity matrix and met the criteria for factor analysis.[33]

Other organizational safety practices. Two additional organizational measures were included in the analyses: whether certain generally recommended precautionary measures were in place, specifically, spill kits, exposure monitoring (air and/or wipe sampling, etc.), and medical surveillance of at-risk employees (yes = 1, no or don't know = 0 for each; scores could range from 0–3), and whether the employer had specific procedures in place that address safe administration of AD (yes = 1, no or don't know = 0). Both of these measures are recommended elements of a comprehensive safety program with respect to AD (e.g., NIOSH;[9] OSHA[10]).

Outcomes. Three outcomes were examined: use of engineering controls, adherence with PPE, and adverse events. All survey questions comprising these measures focused on actions and experiences during the previous seven calendar days. The engineering controls measure assessed three actions: use of a closed system drug-transfer device (CSTD), use of luer-lock fittings for needleless systems, and use of needleless systems (always = 1, sometimes or never = 0 for each). A total score for each participant was calculated as the sum of the three dichotomized items (total score range 0–3). PPE adherence was assessed in terms of the four PPE actions for administering liquid AD: use of chemotherapy gloves, double gloves, eye or face protection, and non-absorbent gown (always = 1, sometimes or never = 0 for each). Total scores for PPE were the sum of the four PPE actions (total score range 0–4). ASHP,[7] ONS,[8] NIOSH,[9] and OSHA[10] guidelines all specify that double chemotherapy gloves, eye protection, and nonabsorbent gowns should always be worn during administration of liquid AD. Single chemotherapy gloves were added to this list because single gloves are protective when not damaged or worn for too long a time period. Adverse events were assessed as a binary measure (yes, no) and included spills/leaks and/or skin contact during the previous seven days.

Statistical analysis

All statistical analyses were performed using SAS 9.4 software (SAS Institute Inc., Cary, NC, USA). Analyses

were conducted in three stages. The first stage consisted of descriptive analyses, factor analysis of safety perception items, and psychometric analyses. In stage two, Multiple Imputation by Chained Equations (MICE) was used to address missing data in several of the multi-item measures: PPE (missing = 8.4%), management commitment (6.3%), risk report (5.3%), risk perception (5.1%) and engineering controls (2.4%). Little's Missing Completely at Random (MCAR) and logistic regression significance tests were first performed to check the assumption of missing at random (MAR), which is a good starting point for the MICE to perform well. Following imputation and bivariate analyses, three multiple regression analyses were examined in the final stage: two Poisson regression models, with engineering controls and PPE as outcomes, and a multiple logistic regression model with adverse events involving liquid AD as the outcome. The Poisson models were used to identify predictors associated with better use of engineering controls and PPE. Both of these models were adjusted using the available option (dscale) in SAS for over and under dispersion. The multiple logistic regression model with spill or leak of liquid AD as outcome was fitted to identify risk factors for adverse events involving AD. In all three models, a backward stepwise regression procedure was used with an inclusion criteria of p-value <0.05. Only variables found to be statistically significant at the bivariate level were included in the final regression models. All inferences were made using a two-tailed tests with significance level of alpha = 0.05.

Institutional review board

The NIOSH Human Subjects Review Board determined that the activities comprising this project were surveillance and did not meet the criteria for research according to 45CFR 46.1101(b)(2) and The Centers for Disease Control and Prevention (CDC) Guidelines for Defining Public Health Research and Public Health Non-Research.[34]

Results

Respondent and work setting characteristics are summarized in Table 1. Of all nurses who responded "yes" to having administered liquid AD during the previous seven days, 96% were female, 92% were white, 83% were age 41 or older, and 72% had earned at least a bachelor's degree. 60% of the nurses had more than 10 years of experience administering AD. There was considerable variation in the number of liquid AD administered during the prior seven days. 45% of the nurses had administered four or fewer treatments during the past seven days, 37% had administered between five and 20 treatments, and 18% had administered more than 20 treatments. In terms of work setting, 62% of the nurses were employed by hospitals and 38% by ambulatory healthcare centers. 69% worked for non-profit or governmental organizations and 31% for for-profit organizations. Fully 62% of the nurses reported working in organizations having 250 or more employees, while 31% worked where there are fewer than 100 employees.

Table 1. Sample characteristics.

Attribute (n)	Frequency	Percent
Age (n = 1761)		
18–25	5	< 1
26–40	298	17
41–55	790	45
56–70	658	37
71–75	10	1
Sex (n = 1790)		
Female	1722	96
Male	68	4
Race (n = 1772)		
White	1634	92
Black or African American	61	3
Asian	73	4
Native Hawaiian/Pacific Islander	6	<1
American Indian/Alaskan Native	15	1
Education (n = 1779)		
Associate Degree and Less	503	28
Bachelor Degree	923	52
Master Degree or Higher	353	20
Employer (n = 1814)		
Ambulatory Healthcare Services	695	38
Hospital	1119	62
Ownership type (n = 1787)		
For-Profit	561	31
Non-Profit	961	54
Government	265	15
Number of employees (n = 1805)		
9 or fewer	136	7
10–99	426	24
100–249	131	7
250–1000	409	23
More than 1000	703	39
Experience (in years) administering AD (n = 1813)		
5 or fewer	362	20
6–10 years	357	20
11–20 years	558	31
More than 20 years	536	29
Number of AD treatments administered in past 7 days (n = 1812)		
4 or fewer	802	45
5 – 20	674	37
21–40	242	13
More than 40	94	5

Note. Number of respondents varied by item (i.e., number of eligible respondents minus those who chose not to answer the item).

Training and familiarity with safety guidelines

One-third of the nurses (33%) had not received training in safe handling of AD within the previous 12 months as is recommended, and 4% had never been trained. Respondent familiarity with the various guidance documents on the safe handling of AD showed that 81% of the nurses were very familiar with at least one of the four guidance documents, 17% were somewhat familiar, and

2% not all familiar with any of the guidance documents. Respondents who indicated familiarity were mostly familiar with the ONS guidelines as would be expected in a sample of nurses. The mean score for familiarity with AD safe handling was 1.80 ($SD = 0.44$). The maximum possible mean score was 2 for this measure.

Safety climate

Factor analysis of the 18 safety perception questions yielded a satisfactory three factor solution (factor loadings of .45 or greater). The three-factor model explained 59.6% of the variance. The first factor consisted of 9 items and reflected overall *management commitment to safety*. This factor accounted for most of the explained variance (46.3%). Factors two and three each included two items and were labelled *risk perception* and *safety voice*, respectively. The remaining five questions did not load on any of the factors (factor loadings <.45). Management commitment to safety is generally considered to be the most prominent and robust dimension of safety climate.[35–38] Table 2 summarizes the results of the factor analysis and includes the coefficient alpha for each factor and the mean and standard deviation for each item. Some items (e.g., risk perception) were reverse coded so that higher scores represented a more positive safety climate. All of the items comprising the three factors had means of at least 3.0 (4-point scale), with one exception, the question asking whether co-workers were exposed to dangerous or risky situations ($M = 2.93$). The highest means were for availability of PPE ($M = 3.41$) and being able to report injuries without job repercussions ($M = 3.37$), respectively. Mean scores for each factor were used in the regression models.

Table 2. Means (SDs) for the items comprising the three safety climate dimensions.

Safety Climate Factor	Mean (SD)
Management commitment (Cronbach alpha = .89)	
The health and safety of workers is a major priority for management	3.14(0.77)
I feel safe from work-related injury or illness	3.07(0.73)
I usually have enough time to take safety precautions while completing my duties	3.18(0.70)
I feel free to express my concerns about health and safety conditions to management	3.27(0.76)
Proper personal protective equipment is available to me	3.41(0.74)
I feel managers and supervisors set proper examples by following safety rules and work practices	3.08(0.84)
My work area is periodically inspected to identify potential health and safety hazards	3.00(0.87)
Unsafe working conditions are corrected in a reasonable time period	3.02(0.85)
I have received adequate training from my current employer to recognize health and safety hazards in my job	3.28(0.71)
Risk perception (Cronbach alpha = .71)	
I am often required to do a task that makes me feel like I might be at risk of getting hurt	3.09(0.77)
People working with me are frequently exposed to dangerous or risky situations	2.93(0.86)
Safety voice or reporting (Cronbach alpha = .84)	
I can report injuries to my manager without worrying about how it will affect my job	3.37(0.74)
I can report injuries to my manager without worrying about how it will affect my department's safety record	3.34(0.77)

Note. Each item was scored using a four-point scale (1 = strongly disagree to 4 = strongly agree). The risk perception items were reverse coded for consistency.

Other organizational measures

In terms of precautionary measures, almost all respondents (98%) indicated that spill kits were available where they work. The percentages were much lower, however, for medical surveillance (23%) and exposure monitoring (9%). The mean score for precautionary practices was 1.29 ($SD = 0.58$) out of a maximum of 3. 95% of nurses indicated that their employer had specific procedures in place that address safe handling of AD.

Use of PPE and engineering controls

For the three engineering controls, 94% of the nurses indicated that they "always" used luer-lock fittings for needleless systems, 91% claimed that they "always" used needleless systems, but only 45% "always" used CSTDs. The mean score for engineering controls was 2.30 ($SD = 0.72$) of a possible 3. Concerning the four PPE-related actions, most nurses (87%) indicated that they "always" wore chemotherapy gloves when administering AD. However, only 20% indicated that they "always" used double gloves, and nearly 60% indicated that they "never" used double gloves. 59% of respondents said that they "always" wore a nonabsorbent gown. Eye or face protection was only rarely used, with only 11% indicating that they "always" used eye or face protection. The mean score for PPE was 1.87 ($SD = 0.91$) out of a maximum score of 4.

Adverse events involving liquid AD

During the previous week, 256 of the nurses or about 14% experienced either a spill/leak and/or skin contact while administering AD. Broken down by type of event, 224 respondents (about 12%) experienced a spill or leak; 79 respondents (about 4%) experienced skin contact during this time period.

Regression models for engineering controls and PPE

Stepwise Poisson regression analyses with backward elimination were performed using the summary measures for engineering controls and adherence with PPE, respectively, as outcome variables. Tables 3 and 4 show the

Table 3. Poisson regression for engineering controls.

Predictors	Rate Ratio (95% Confidence Interval)
Ownership type (Government)	1.09 (1.03, 1.14)
Ownership type (Non-Profit)	1.08 (1.04, 1.12)
Trained in safe handling (<= 12 months)	1.20 (1.08, 1.34)
Trained in safe handling (>12 months)	1.17 (1.05, 1.30)
Familiarity with safe-handling guidelines	1.12 (1.07, 1.17)
Safe-handling procedures (No)	0.78 (0.71, 0.86)
Management commitment score	1.01 (1.00, 1.02)

Note. Reference groups for the categorical predictors: Ownership type = Profit; Trained in safe handling = Never trained; Safe-handling procedure = Yes.

statistically significant predictors of engineering controls and PPE use. The use of engineering controls was greater in government and non-profit organizations. It was also greater when employees were trained in safe handling of AD, when they were more familiar with safe-handling guidelines, and when perceived management commitment to safety was greater. The absence of safe-handling procedures was associated with less use of engineering controls.

PPE adherence was better for nurses working in non-profit, government, and larger organizations. Being more familiar with safe-handling guidelines, having a higher precautionary measures score, and perceiving greater management commitment to safety were also associated with better use of PPE. In contrast, working for an ambulatory healthcare center, not having specific safe handling procedures in place, administering more AD treatments, and having more experience administering AD were all linked to poorer adherence.

Multiple logistic regression model with adverse events as the outcome

The results for the third model are presented in Table 5. Spills/leaks and/or skin contact were more likely when the number of AD treatments was greater and when AD was administered on more days of the week. The odds of such events were substantially lower when engineering controls and PPE usage were greater and when more precautionary measures were in place. Higher levels of management commitment to safety and perceived risk were also related to lower odds of adverse events involving AD. Not surprisingly, engineering controls and PPE were the strongest predictors of not being exposed, followed closely by the presence of more precautionary measures.

Table 4. Poisson regression for personal protective equipment.

Predictors	Rate Ratio (95% Confidence Interval)
Ownership type (Non-Profit)	1.12 (1.05, 1.18)
Ownership type (Government)	1.08 (0.99, 1.17)
Work setting (Ambulatory)	0.90 (0.85, 0.96)
Safe-handling procedures (No)	0.87 (0.76, 0.99)
Familiarity with safe-handling guidelines	1.11 (1.04, 1.17)
Precautionary measures score	1.05 (1.01, 1.09)
Experience in AD administration	0.96 (0.94, 0.98)
Number AD administered past 7 days	0.96 (0.94, 0.98)
Number of employees	1.03 (1.01, 1.05)
Management commitment score	1.01 (1.00, 1.02)

Note. Reference groups for the categorical predictors: Ownership type = Profit; Work setting = Hospital; Safe handling procedures = Yes.

Table 5. Multiple logistic regression for adverse events involving liquid antineoplastic drugs.

Predictors	Odds Ratio (95% Confidence Interval)
Number AD administered in past 7 days	1.34 (1.18, 1.53)
Number of days AD administered	1.20 (1.04, 1.37)
PPE score	0.55 (0.46, 0.66)
Engineering controls score	0.56 (0.47, 0.68)
Precautionary measures score	0.58 (0.44, 0.78)
Management commitment score	0.96 (0.93, 0.99)
Risk perception score	0.84 (0.75, 0.93)

Discussion

The aim of this study was to examine predictors of the use of PPE and engineering controls and adverse events involving liquid AD in a relatively large and diverse sample of nurses. Particular interest was with examining the role of safety-related organizational practices and perceived safety climate. As with previous research, the results of this study show that the use of engineering controls and adherence to recommended PPE remains quite variable. Adverse events involving liquid AD were also relatively frequent, with 14% of respondents reporting such an event during the past 7 days.

Engineering controls and PPE are the primary proximal defenses for those who administer chemotherapy drugs in clinical settings. The regression results for PPE and engineering controls reveal an interesting pattern of results involving the work setting, training, and familiarity with safe handling guidelines, nurse workload and experience, other pertinent organizational safety practices, and perceived safety climate. The use of both engineering controls and PPE was greater in non-profit and government settings. Familiarity with safe-handling guidelines was also a relatively strong positive predictor for both outcomes. Higher levels of perceived management commitment to safety were also associated with greater use of engineering controls and PPE. The absence of specific safe-handling procedures, on the other hand, was associated with diminished use of both types of protective measures.

The engineering controls and PPE results also produced a couple of findings that might seem counterintuitive. For example, PPE adherence was poorer among nurses who had more experience administering AD

and who had administered more AD during the previous seven days. PPE as a protective strategy requires that the indicated device or devices be used each and every time they are called for, and that they be used correctly. Administering AD involves multiple PPE and each must be donned and doffed correctly. Nurses with higher workloads have more opportunities for error, and those with more experience may have accumulated more benign experience: administering AD in the absence of full PPE adherence without knowingly experiencing adverse effects. Over time, benign experience can persuade workers that PPE, or perhaps certain PPE, are less necessary and more burdensome to use. This is sometimes referred to as the normalization of deviance in the safety literature and this term has been applied to healthcare situations.[39] Workload has been linked to a variety of adverse outcomes in healthcare, including worker errors and injuries.[40,41] PPE usage in this study was also lower among nurses working for an ambulatory healthcare center. Such employers may have less formalized safety programs and perhaps less direct supervision of those administering AD. Both of these factors could lead to diminished adherence.

Also, training in safe handling was a relatively strong predictor for engineering controls but not PPE adherence. Indeed, the opposite pattern might be expected. In all likelihood, these results reflect the fact that most engineering controls for AD administration are not purely passive measures. That is, they do not provide full automatic protection. The healthcare worker needs to employ engineering controls such as CSTDs correctly in order to receive maximal protection. In addition, most of the recommended PPE for AD administration are well established and commonly recommended for other healthcare activities. Thus, it is likely that most nurses are quite familiar with these particular PPE and probably have received relevant training in other work contexts. The fact remains, however, that device specific training may be important to achieving the full benefits of these particular engineering controls.

Not surprisingly, engineering controls and PPE adherence were the strongest predictors of not having an AD-related adverse event. Having more precautionary measures in place was also a strong protective factor. Implementing precautionary measures, especially beyond simply providing spill kits, shows that management takes the problem of AD exposures seriously and values the health and safety of employees. The results for AD-related adverse events also show that risk perception, as a component of safety climate, was linked to not being exposed. Nurses who perceived greater risk had lower odds of adverse events. This fits with previous analyses of these data which showed that poor adherence with PPE occurs when healthcare workers perceive the risk of exposure as minimal.[11,19] Although risk perception may at first seem to be more an individual attribute than a component of safety climate, risk-related parameters have often been part of safety climate instruments.[35] A positive safety climate should contribute to workers having more veridical perceptions of risk. Workload also impacted the occurrence of adverse events. Administering more AD in the previous seven days and administering AD on more days were both associated with higher odds of such events. These results parallel the results for PPE adherence and suggest that the burden of using multiple PPE for each administration may lead to shortcuts and increased risk-taking, especially when job demands are high. Workload-related effects have also been reported for hospital pharmacists who prepare AD.[42]

Management commitment to safety, as a key component of safety climate, was a statistically significant predictor for all three major outcomes in this study. However, it was not as strong a predictor as a number of other variables. Safety climate is typically viewed as an emergent property that comes about as employees actively process safety-related information and experiences and try to make sense of their work environment.[29,37,43] As such, the raw materials of safety climate include the various actions taken or not taken by management, supervisors, and coworkers. Enacted as opposed to espoused safety policies and practices are particularly important ingredients of safety climate perceptions.[29] The integration of a formal safety management system, such as ANSI/AIHA Z10-2012 or other recommended injury and illness prevention programs can be an effective way to boost both safety climate and safety performance. Similar guidance specific to healthcare can be found in the 2012 Joint Commission monograph on patient and worker safety.[44]

The present study assessed perceived safety climate but it also addressed a number of key organizational practices directly associated with the safe handling of AD. That these practices were stronger predictors of safe work practices and reduced adverse events than perceived safety climate should not be surprising. The overall results of this study show that safety climate perceptions, particularly those pertaining to management commitment to safety, contribute to the use of engineering controls and PPE, and to reduced adverse events above and beyond pertinent organizational practices directly relevant to safe handling of AD. Safety voice as a dimension of safety climate was not related to any of the three outcomes in this study. Within the safety literature, safety voice, or the freedom and ability to speak up about safety issues, is typically seen more as a behavior or proximal outcome rather than as a dimension of safety climate.[45–47]

In interpreting the results of this study, several limitations should be considered. First, this was a cross-sectional study and such designs limit the ability to make causal interpretations. Second, survey respondents were primarily solicited from the membership rolls of professional organizations. As such, they may not be fully representative all nurses who administer AD. Respondents may have been further along in their careers, more educated, and/or more aware of pertinent safety and health issues. Of course, the sample was also limited to nurses working in the U.S. Third, data collected were analyzed at the individual level. Because respondents were recruited through professional organizations, they could not be clustered by specific employer or workplace. Some researchers have argued that safety climate analyses should be conducted at the group and organizational levels.[48] The basic idea is that climates involved shared perceptions among members of workgroups and organizations. Last, the data collected in these analyses were self-report. In a more controlled study, multiple forms of data could be collected to minimize bias and to ensure more precise outcome interpretations.

These limitations notwithstanding, the present study produced some valuable and interesting findings. This study adds to a growing body of research demonstrating that safety practices in this particular area of healthcare remain in need of improvement. Viewed together, the results underscore the value of implementing a comprehensive health and safety program that utilizes available hazard controls and effectively communicates and demonstrates the importance of safe handling practices. Such actions also contribute to creating a positive safety climate which should further support and reinforce good safe practices.

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Disclaimer

The findings and conclusions presented in this article are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health. Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

ORCID

Andrea L. Steege http://orcid.org/0000-0001-5665-2559
James M. Boiano http://orcid.org/0000-0003-2738-4588

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