



Published in final edited form as:

*Am J Nurs.* 2019 January ; 119(1): 28–35. doi:10.1097/01.NAJ.0000552583.69729.51.

## Antineoplastic Drug Administration by Pregnant and Nonpregnant Nurses: An Exploration of the Use of Protective Gloves and Gowns

Christina C. Lawson<sup>1</sup>, Candice Y. Johnson<sup>1</sup>, Feiby L. Nassan<sup>2</sup>, Thomas H. Connor<sup>3</sup>, James M. Boiano<sup>1</sup>, Carissa M. Rocheleau<sup>1</sup>, Jorge E. Chavarro<sup>2</sup>, Janet W. Rich-Edwards<sup>4</sup>

<sup>1</sup>Division of Surveillance, Hazard Evaluations, and Field Studies at the National Institute for Occupational Safety and Health (NIOSH) in Cincinnati, OH.

<sup>2</sup>Harvard T. H. Chan School of Public Health at Harvard Medical School in Boston, MA.

<sup>3</sup>Division of Applied Research and Technology at the National Institute for Occupational Safety and Health (NIOSH) in Cincinnati, OH.

<sup>4</sup>Mary Horrigan Connors Center for Women's Health and Gender Biology at Brigham and Women's Hospital and Harvard Medical School in Boston, MA.

### Abstract

**Background:** Many antineoplastic (chemotherapeutic) drugs are known or probable human carcinogens, and many have been shown to be reproductive toxicants in cancer patients. Evidence from occupational exposure studies suggests that health care workers who have long-term, low-level occupational exposure to antineoplastic drugs have an increased risk of adverse reproductive outcomes. It's recommended that, at minimum, nurses who handle or administer such drugs should wear double gloves and a nonabsorbent gown to protect themselves. But it's unclear to what extent nurses do so.

**Purpose:** This study assessed glove and gown use by female pregnant and nonpregnant nurses who administer antineoplastic drugs in the United States and Canada.

**Methods:** We used data collected from more than 40,000 nurses participating in the Nurses' Health Study 3. The use of gloves and gowns and administration of antineoplastic drugs within the past month (among nonpregnant nurses) or within the first 20 weeks of pregnancy (among pregnant nurses) were self-reported via questionnaire.

**Results:** Administration of antineoplastic drugs was reported by 36% of nonpregnant nurses at any time during their careers, including 10% who reported administering these drugs within the past month. Seven percent of pregnant nurses reported administering antineoplastic drugs during the first 20 weeks of pregnancy. Twelve percent of nonpregnant nurses and 9% of pregnant nurses indicated that they never wore gloves when administering antineoplastic drugs, and 42% of nonpregnant nurses and 38% of pregnant nurses reported never using a gown. The percentage of nonpregnant nurses who reported not wearing gloves varied by type of administration: 32% of

---

Contact author, Christina C. Lawson: clawson@cdc.gov.

Findings from this cross-sectional study indicate a need for expanded training in safe handling practices.

those who administered antineoplastic drugs only as crushed pills never wore gloves, compared to 5% of those who only administered such drugs via infusion.

**Conclusion:** Despite longstanding recommendations for the safe handling of antineoplastic and other hazardous drugs, many nurses—including those who are pregnant—reported not wearing protective gloves and gowns, which are considered the minimum protective equipment when administering such drugs. These findings underscore the need for further education and training to ensure that both employers and nurses understand the risks involved and know which precautionary measures will minimize such exposures.

### Keywords

antineoplastic drugs; hazardous drugs; health care workers; personal protective equipment; occupational exposure; pregnancy

---

Nurses administer antineoplastic (chemotherapeutic) drugs to patients to treat many types of cancers. The use of these drugs has expanded beyond oncology to several other specialties, including dermatology, neurology, and rheumatology, as well as to the operating room setting.<sup>1, 2</sup> The International Agency for Research on Cancer lists about a dozen antineoplastic drugs as known human carcinogens and another dozen as probable human carcinogens.<sup>3</sup> The reproductive toxicity of antineoplastic drugs has long been recognized, based on evidence from studies of patients treated with these drugs.<sup>4</sup> Yet over the past 20 years, only a few studies have explored associations between occupational exposures to antineoplastic drugs and reproductive outcomes.<sup>5</sup> One recent review concluded that health care workers with long-term, low-level occupational exposure to such drugs “seem to have an increased risk of adverse reproductive outcomes.”<sup>6</sup>

Recommendations for the safe handling of antineoplastic and other hazardous drugs have been in place since the 1980s and have been updated by numerous government and professional organizations ever since.<sup>7–11</sup> In 2004, for example, the National Institute for Occupational Safety and Health (NIOSH) described the adverse health effects of occupational exposure to antineoplastic and other hazardous drugs, and made recommendations for workers on how to handle these drugs safely.<sup>8</sup> Many occupational safety groups have sought to increase awareness and training regarding the hazards of such exposure; improve workplace controls, including engineering controls such as biological safety cabinets and administrative controls such as work practices and policies; and encourage the provision and use of personal protective equipment (PPE) when handling these drugs.<sup>7, 10–12</sup>

All occupational health authorities in the United States and Canada—as well as numerous professional nursing, oncology, and pharmacology societies—recommend that, at minimum, health care workers should wear double chemotherapy or latex gloves (two pairs of gloves, one worn over the other) and a nonabsorbent gown when administering antineoplastic and other hazardous drugs to patients. But whether these basic recommendations are consistently being followed by nurses remains unknown.

## Study purpose.

The purpose of this study was to assess glove and gown use among nonpregnant female nurses who had administered antineoplastic drugs within the past month and among pregnant nurses who had administered such drugs during the first 20 weeks of pregnancy.

## METHODS

### Recruitment.

The Nurses' Health Study 3 (NHS3; [www.nurseshealthstudy.org](http://www.nurseshealthstudy.org)) is an entirely web-based study of U.S. and Canadian nurses and nursing students born on or after January 1, 1965. Open recruitment started in 2010 and is ongoing. RNs, licensed practical nurses (LPNs), licensed vocational nurses (LVNs), and nursing students are eligible to participate. Historically the cohort included only female nurses; in 2015 eligibility was extended to male nurses.<sup>13</sup> Our analysis involves only data collected on female nurses, since male nurses were only recently enrolled. The NHS3 participants complete online questionnaires at enrollment and every six months thereafter.

### Survey instruments.

The baseline NHS3 questionnaire, administered to all participants, contained a module specific to antineoplastic drugs. This included the following questions: whether the nurse had ever administered antineoplastic drugs (possible responses: yes, no); number of years' experience the nurse had in administering antineoplastic drugs; number of times the nurse had administered such drugs during an average week in the past month; how often in the past month latex or chemotherapy gloves were worn when administering such drugs (always, sometimes, never); and how often in the past month a water-resistant gown or outer garment with closed front and tight cuffs was worn when administering these drugs (always, sometimes, never). (Because gloves and gowns are considered the minimum necessary PPE for workers administering antineoplastic drugs, for this study we looked only at their use.) Additional questions on the mode of antineoplastic drug administration were added partway through the study (and thus weren't available to all participants). These questions asked whether the nurse had administered such drugs via infusion (yes, no); whether the nurse had administered such drugs via oral pills (yes, no); and whether the nurse "typically" handled crushed pills?" (yes, no).

Pregnant nurses completed an additional questionnaire which asked whether, during the first 20 weeks of pregnancy, the nurse had administered antineoplastic drugs to patients (yes, no); how often during those 20 weeks latex or chemotherapy gloves were worn (always, sometimes, never), and how often during those 20 weeks a water-resistant gown or outer garment with closed front and tight cuffs was worn (always, sometimes, never). On the two-year follow-up questionnaire, nurses were asked to report their current primary job (non-nursing, student, ED, operating room, ICU, oncology, other inpatient, nursing education or administration, outpatient or community, school, home health, other hospital, nursing outside hospital, homemaker, retired, not currently employed, or other).

The study was approved by the institutional review boards of Brigham and Women's Hospital and NIOSH. Completion of the web-based questionnaires implied informed consent.

### Data analyses.

We used SAS version 9.4 (Cary, NC) to conduct all analyses. Enrollment in the NHS3 is ongoing; these analyses were based on data that were available on October 15, 2017, for all questionnaires.

## RESULTS

### Sample.

From the 44,612 nurses who completed the baseline questionnaires, we excluded the 535 male nurses, 3,656 female nurses who did not provide data regarding their history of working with antineoplastic drugs, and 1 nurse who was over the age of 55 years, leaving 40,420 female nurses who contributed data to analyses when they were not pregnant (39,124 nurses) or who did so when they were pregnant (4,269 nurses). Some nurses became pregnant after completing the baseline questionnaire, and thus were in both the nonpregnant and pregnant study groups. Some respondents answered questions for more than one pregnancy; we included responses associated with only the first pregnancy occurring during the study. See Figure 1 for more details.

### Findings.

The 39,124 nonpregnant women had a mean age of 33.7 years (SD,  $\pm$  7.26). Thirty-six percent of the nonpregnant nurses (14,171 of 39,124) reported that they had administered antineoplastic drugs at some point during their career, and 27% (3,845 of 14,140 who reported this information) had administered such drugs recently (within the past month). Of these 3,845 nurses, 24% (924) had administered such drugs more than three times per week. Drug administration status—whether or not nurses had administered antineoplastic drugs—did not vary notably by age among either nonpregnant or pregnant nurses.

The 4,269 pregnant women had a mean age of 29.5 years (SD,  $\pm$  4.05). Among these, 7% (315) had administered antineoplastic drugs during the first 20 weeks of pregnancy. Information on how chemotherapy was administered (via pills or infusion) was not available on the pregnancy questionnaire.

Use of gloves and gowns when administering antineoplastic drugs varied by pregnancy status (see Table 1). Among nurses who had recently administered antineoplastic drugs, the percentage who reported that they always wore gloves when doing so was higher among pregnant nurses (86%) than nonpregnant nurses (80%). Similarly, the percentage who reported that they always wore a gown was higher among pregnant nurses (52%) than nonpregnant nurses (41%). This also indicates that 14% of pregnant nurses didn't always wear gloves, and nearly half (48%) didn't always wear gowns, when administering antineoplastic drugs during the first 20 weeks of pregnancy. (Note that reported percentages

are based on all reported data, including “missing” values.) Gown and glove use did not vary notably by age among either nonpregnant nurses or pregnant nurses.

Information on the mode of antineoplastic medication administration was added to the baseline questionnaire partway through the study period. These data were available for a subset of nonpregnant nurses. Because the pregnancy questionnaire didn’t ask about mode of administration, no data were available for pregnant nurses.

Among the 1,492 nonpregnant nurses who administered chemotherapy recently and who provided this information, 46% reported administering pills only, 12% reported infusion only, and 43% reported both. Always wearing gloves was most common among nurses who reported administering the drugs by infusion only (89%) and those who did so via both infusion and pills (89%); this was less common among nurses who reported administering only intact pills (66%) or crushed pills (54%). While gown use was less common than gloves, in general, a similar pattern was found. Gown use was most common among nurses who administered antineoplastic drugs by infusion only or who did so via both infusion and pills, and was rare among nurses who administered only pills. (See Table 2.)

In the two-year follow-up questionnaire, we asked respondents to report their current primary job. Of the nurses who answered this question, 786 reported working in oncology. Of the 7,257 pregnant and nonpregnant nurses who answered this question and had provided data regarding their history of working with antineoplastic drugs, 11% (786) reported working in oncology.

## DISCUSSION

In this cross-sectional study, we found that 36% of nonpregnant nurses reported having administered antineoplastic drugs during their career, including 27% who reported doing so recently (within the past month). Among pregnant nurses, 7% reported having administered antineoplastic drugs during the first 20 weeks of pregnancy.

Nurses reported using PPE with varying frequency. Among all nurses who had recently administered antineoplastic drugs, 20% of nonpregnant and 14% of pregnant nurses did not always wear gloves when doing so; and 59% of nonpregnant and 48% of pregnant nurses did not always wear gowns. In general, glove use was markedly lower among those who administered antineoplastic drugs in pill form compared to those who administered via infusion. Overall, the use of gloves and gowns was higher among pregnant than nonpregnant nurses.

Yet despite longstanding and widespread recommendations regarding the safe handling of antineoplastic and other hazardous drugs, health care workers continue to be at risk—and even to put themselves at risk. Of particular concern to us was the number of nurses in our study population who reported not wearing protective gloves and gowns, which are considered the minimum protective equipment when administering antineoplastic drugs.<sup>10</sup> (Indeed, although the NHS3 questionnaire asks about the use of latex and chemotherapy gloves, the current standard calls for wearing two pairs of chemotherapy gloves, one on top of the other.<sup>14</sup>)

Although pregnant nurses in our study were more likely than nonpregnant nurses to report using gloves and gowns when administering antineoplastic drugs, about one in 10 did not always wear gloves and one in two did not always wear a gown when doing so during the first 20 weeks of pregnancy—a time during which the fetus is highly susceptible to exposure. The proportions of nonpregnant nurses who weren't using gloves (one in five) and gowns (one in two) is also of concern, given that most nurses were of reproductive age and could have become pregnant. The higher prevalence of glove and gown use among pregnant nurses suggests that in general, nurses are either less aware or less concerned about the potential harm these drugs might pose to their own health. Yet in addition to being reproductive toxicants, many antineoplastic drugs are known or probable carcinogens.

These data underscore the need for continued education and training to ensure that both employers and nurses—pregnant and nonpregnant—are fully aware of such hazards and of precautionary measures. As an added precaution, many organizations (including the Oncology Nursing Society, among others) have proposed offering employees who are actively trying to conceive, pregnant, or breastfeeding alternative work assignments that would allow them to avoid handling antineoplastic drugs.<sup>9</sup> This could be one reason why the percentage of pregnant women administering antineoplastic drugs during the first 20 weeks of pregnancy (7%) was substantially lower than that of nonpregnant women administering such drugs within the past month (27%).

As noted earlier, safe handling guidelines recommend that both double chemotherapy gloves and water-resistant gowns be worn when handling and administering antineoplastic drugs; this applies not only to liquid but also to solid forms (pills or capsules), especially when these are crushed or otherwise manipulated.<sup>14, 15</sup> Yet in our study, among nonpregnant nurses, use of gloves and gowns varied considerably by mode of administration, with such use markedly lower among those administering antineoplastic drugs via pills only. Moreover, nurses who handled intact pills were more likely to report always wearing gloves (66%) than did those who handled crushed pills (54%). Our results show less compliance with recommended glove and gown use than did a national study of 2,069 health care workers (98% were nurses) by Boiano and colleagues, in which 85% of nurses reported always wearing at least one pair of chemotherapy gloves and 58% reported always wearing a nonabsorbent gown when handling antineoplastic drugs.<sup>16</sup> In a 2012 study of oncology nurses by Polovich and Clark, compliance was similar to what we found in this study, although the use of double gloves was much lower.<sup>17</sup>

Because nursing personnel have had to rely on gloves and gowns for their sole source of protection, the U.S. Pharmacopeia's "General Chapter USP <800>: Hazardous Drugs—Handling in Healthcare Settings" states that closed-system drug-transfer devices must be used as adjuncts for antineoplastic drug administration "when the dosage form allows."<sup>11</sup> And OSHA recommends that workers who handle such drugs receive information and training at the time of initial assignment and annually thereafter on hazards and means to control exposure.<sup>9</sup>

Occupational exposure to antineoplastic and other hazardous drugs can be complex. It can occur not only through direct handling and administration, but also as a result of

contamination in areas where drugs are prepared and administered.<sup>18–20</sup> Numerous studies in the United States and several other countries show that workplace contamination with antineoplastic drugs is still occurring.<sup>21–29</sup> In one study among hospital workers, Hon and colleagues found that 20% of the provided dermal wipe samples had detectable amounts of one antineoplastic drug—and the highest levels were found among workers who did not directly handle or administer the drug, pointing to workplace contamination.<sup>18</sup>

Exposure to active drug and drug metabolites can also occur through handling patient waste, and it's recommended that nurses and other facility staff take precautions when changing bed linens, washing patients, and disposing of bodily waste (including blood, feces, urine, and vomit).<sup>8, 12, 19</sup> In the study by Polovich and Clark, nurses' glove use was lower when handling patient waste than it was when they were preparing or administering antineoplastic drugs.<sup>17</sup> Contaminated work clothes can be another source of exposure to antineoplastic drugs. In the study by Boiano and colleagues, 12% of health care workers who administered antineoplastic drugs reported taking home clothing that had come into contact with these drugs, and another 11% didn't know whether they had or not.<sup>16</sup> And drug spills, which are not uncommon and can be yet another source of exposure, appear to be underreported. A study by He and colleagues found that just 20% of oncology nurses reported a recent spill.<sup>30</sup>

In our study, no information was available regarding why some nurses did not use the recommended minimal PPE (gloves and gowns). But previous studies indicate that several factors may influence nurses' adherence to safe handling recommendations. In a study by Silver and colleagues of 1,094 hospital nurses who administer antineoplastic drugs, factors associated with more PPE use included the perception that adequate PPE was available, familiarity with safe handling guidance documents, training in safe handling, and working in a hospital that had procedures for safe handling.<sup>31</sup> Silver and colleagues also found that giving nurses enough time to don and doff PPE before moving on to other nursing functions could reduce the potential for contamination.

In the study by Boiano and colleagues, respondents had collectively administered over 90 specific drugs in the week prior to taking the survey.<sup>16</sup> The most common reason given for not wearing gloves during such administration was "skin exposure was minimal," followed by "not provided by employer" and "not part of our protocol." Those who didn't wear gowns offered an additional reason: "no one else who does this work uses them." And Polovich and Clark found that many oncology nurses, despite having been trained in safe handling, had misconceptions about exposure; for example, 15% of respondents indicated believing that "[c]hemotherapy cannot be absorbed from contaminated surfaces."<sup>17</sup> In that study, the most common reported barriers to PPE use were the perceptions that PPE were uncomfortable, that PPE interfered with job duties; and that their coworkers did not use PPE. Having fewer patients per day to whom one administered chemotherapy was associated with greater use of PPE. Similarly, He and colleagues found that higher workloads were associated with both reduced PPE use and more drug spills.<sup>30</sup>

It's worth noting that, in our study, only 26% of the nurses who reported at baseline that they had administered antineoplastic drugs within the past month were working in oncology two years later. This suggests either that some nurses had changed specialties or that a majority

of respondents who administered such drugs were doing so outside of oncology settings. It's also of interest that of the 786 oncology nurses in the two-year follow-up questionnaire, 16.9% (133) held more than one job. If some nurses were administering antineoplastic drugs during a part-time or temporary job, or at a job outside an oncology setting, they might have been less likely to receive adequate training on safe handling practices. These results indicate a need for expanded training of health care personnel working outside oncology settings.

### Limitations.

First, we did not collect information on the use of double versus single gloves, engineering controls, training on safe handling practices, and reasons or barriers for not following safe handling recommendations. Second, we had no information on the nursing specialties of respondents; that said, antineoplastic drugs are widely used outside oncology settings. We expect that the study population included nurses from various specialties, and the extent of training in safe handling practices may vary across specialties. Third, we had no information on facility type or size, which might also affect the training provided and the procedures in place with regard to safe handling of antineoplastic drugs.

## CONCLUSION

This is one of the first studies to explore antineoplastic drug administration and the use of PPE among pregnant as well as nonpregnant female nurses. Given the increasing use of such drugs in health care and the potential adverse effects of chronic occupational exposure, we recommend that administrators and nursing educators continue to raise awareness among health care employers and workers about these matters. We further urge employers to provide improved training, adequate PPE, and adequate time for workers to handle these drugs safely.

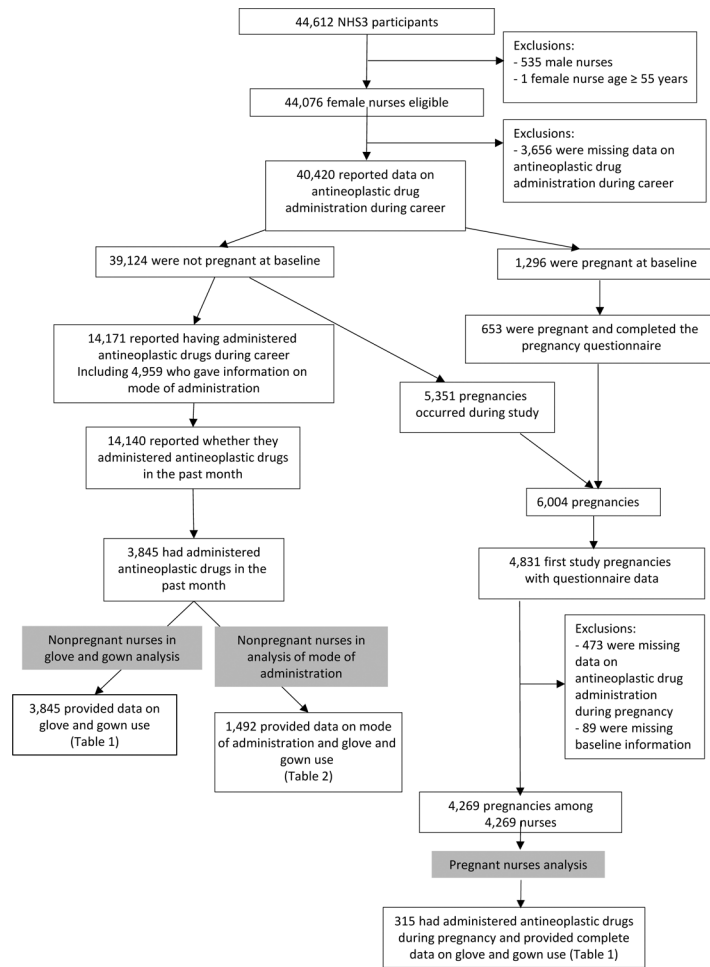
## REFERENCES

1. Menonna-Quinn D Safe handling of chemotherapeutic agents in the treatment of nonmalignant diseases. *J Infus Nurs* 2013;36(3):198–204. [PubMed: 23558919]
2. Polovich M, Giesecker KE. Occupational hazardous drug exposure among non-oncology nurses. *Medsurg Nurs* 2011;20(2):79–85, 97. [PubMed: 21560958]
3. International Agency for Research on Cancer. IARC monographs on the evaluation of the carcinogenic risk of chemicals to humans. Lyon, France: World Health Organization 2018.
4. Bradbury AR, Schilsky RL. Infertility following cancer chemotherapy. In: Chabner B, Longo DL, editors. *Cancer chemotherapy and biotherapy: principles and practice* 5th ed. Philadelphia, PA: Wolters Kluwer/Lippincott Williams and Wilkins Health; 2011. p. 773–84.
5. Lawson CC, et al. Occupational exposures among nurses and risk of spontaneous abortion. *Am J Obstet Gynecol* 2012;206(4):327 e1–8. [PubMed: 22304790]
6. Connor TH, et al. Reproductive health risks associated with occupational exposures to antineoplastic drugs in health care settings: a review of the evidence. *J Occup Environ Med* 2014;56(9):901–10. [PubMed: 25153300]
7. American Society of Health-System Pharmacists. ASHP guidelines on handling hazardous drugs. *Am J Health Syst Pharm* 2006;63(12):1172–91.
8. National Institute for Occupational Safety and Health. Preventing occupational exposures to antineoplastic and other hazardous drugs in health care settings. Atlanta, GA: Centers for Disease



- Control and Prevention; 2004. DHHS (NIOSH) Publication Number 2004–165. NIOSH alert; <https://www.cdc.gov/niosh/docs/2004-165/>.
9. Occupational Safety and Health Administration (OSHA). Controlling occupational exposure to hazardous drugs. Washington, DC: U.S. Department of Labor; 2016 Aug 1. [https://www.osha.gov/SLTC/hazardousdrugs/controlling\\_occup\\_hazardousdrugs.html](https://www.osha.gov/SLTC/hazardousdrugs/controlling_occup_hazardousdrugs.html).
  10. Polovich M, Olsen MM, editors. Safe handling of hazardous drugs. 3rd ed. Pittsburgh, PA: Oncology Nursing Society; 2018.
  11. U.S. Pharmacopeia. USP General Chapter <800>Hazardous drugs—handling in healthcare settings. In: USP 40—NF 35, Second Supplement. Rockville, MD: United States Pharmacopeial Convention; 2017. <http://www.usp.org/sites/default/files/usp/document/our-work/healthcare-quality-safety/general-chapter-800.pdf>.
  12. National Institute for Occupational Safety and Health (NIOSH) of the Centers for Disease Control and Prevention (CDC), Department of Health and Human Services (HHS). Request for information on alternative duty: temporary reassignment for health care workers who work with hazardous drugs [Docket Number NIOSH–150] Washington, DC: Federal Register/vol. 74, no. 178/Wednesday, Sep 16 2009 47594–5
  13. Bao Y, et al. Origin, methods, and evolution of the three nurses' health studies. *Am J Public Health* 2016;106(9):1573–81. [PubMed: 27459450]
  14. Oncology Nursing Society. Personal protective equipment for use with hazardous drugs. Pittsburgh, PA; n.d.; <https://www.ons.org/sites/default/files/PPE%20Use%20With%20Hazardous%20Drugs.pdf>.
  15. Rudnitzki T, McMahon D. Oral agents for cancer: safety challenges and recommendations. *Clin J Oncol Nurs* 2015;19(3 Suppl):41–6. [PubMed: 26030392]
  16. Boiano JM, et al. Adherence to safe handling guidelines by health care workers who administer antineoplastic drugs. *J Occup Environ Hyg* 2014;11(11):728–40. [PubMed: 24766408]
  17. Polovich M, Clark PC. Factors influencing oncology nurses' use of hazardous drug safe-handling precautions. *Oncol Nurs Forum* 2012;39(3):E299–309. [PubMed: 22543401]
  18. Hon CY, et al. Antineoplastic drug contamination on the hands of employees working throughout the hospital medication system. *Ann Occup Hyg* 2014;58(6):761–70. [PubMed: 24644303]
  19. Hon CY, et al. Antineoplastic drug contamination in the urine of Canadian healthcare workers. *Int Arch Occup Environ Health* 2015;88(7):933–41. [PubMed: 25626912]
  20. Kibby T A review of surface wipe sampling compared to biologic monitoring for occupational exposure to antineoplastic drugs. *J Occup Environ Hyg* 2017;14(3):159–74. [PubMed: 27676216]
  21. Berruyer M, et al. Multicenter study of environmental contamination with antineoplastic drugs in 36 Canadian hospitals: a 2013 follow-up study. *J Occup Environ Hyg* 2015;12(2):87–94. [PubMed: 25105559]
  22. Connor TH, et al. Evaluation of antineoplastic drug exposure of health care workers at three university-based US cancer centers. *J Occup Environ Med* 2010;52(10):1019–27. [PubMed: 20881620]
  23. Hon CY, et al. Antineoplastic drug contamination of surfaces throughout the hospital medication system in Canadian hospitals. *J Occup Environ Hyg* 2013;10(7):374–83. [PubMed: 23668810]
  24. Kopp B, et al. Evaluation of working practices and surface contamination with antineoplastic drugs in outpatient oncology health care settings. *Int Arch Occup Environ Health* 2013;86(1):47–55. [PubMed: 22311009]
  25. Odraska P, et al. Association of surface contamination by antineoplastic drugs with different working conditions in hospital pharmacies. *Arch Environ Occup Health* 2014;69(3):148–58. [PubMed: 24325745]
  26. Sessink PJ, et al. Reduction in surface contamination with antineoplastic drugs in 22 hospital pharmacies in the US following implementation of a closed-system drug transfer device. *J Oncol Pharm Pract* 2011;17(1):39–48. [PubMed: 20156932]
  27. Sessink PJ, et al. Reduction in surface contamination with cyclophosphamide in 30 US hospital pharmacies following implementation of a closed-system drug transfer device. *Hosp Pharm* 2013;48(3):204–12. [PubMed: 24421463]

28. Siderov J, et al. Surface contamination of cytotoxic chemotherapy preparation areas in Australian hospital pharmacy departments. *Journal of pharmacy practice and research: official journal of the Society of Hospital Pharmacists of Australia* 2009;39(2):117–21.
29. Sottani C, et al. Occupational exposure to antineoplastic drugs in four Italian health care settings. *Toxicol Lett* 2012;213(1):107–15. [PubMed: 21477641]
30. He B, et al. Personal protective equipment use and hazardous drug spills among ambulatory oncology nurses. *Oncol Nurs Forum* 2017;44(1):60–5. [PubMed: 28067030]
31. Silver SR, et al. Predictors of adherence to safe handling practices for antineoplastic drugs: A survey of hospital nurses. *J Occup Environ Hyg* 2016;13(3):203–12. [PubMed: 26556549]



**Figure 1.**  
Flowchart of Sample Selection

**Table 1:**

Use of protective gloves and gowns among nonpregnant and pregnant nurses who reported recently administering antineoplastic drugs<sup>a</sup>

	n	Frequency of Wearing Personal Protective Equipment n (%)			Missing
		Always	Sometimes	Never	
<b>Latex or chemotherapy gloves</b>					
Nonpregnant nurses	3,845	3,059 80%	281 7%	446 12%	59 2%
Pregnant nurses	315	271 86%	6 2%	28 9%	10 3%
<b>Water-resistant gown or outer garment with closed front and tight cuffs</b>					
Nonpregnant nurses	3,845	1,574 41%	540 14%	1,608 42%	123 3%
Pregnant nurses	315	164 52%	21 7%	119 38%	11 3%

<sup>a</sup>“recently” meaning for nonpregnant nurses, within the past month; for pregnant nurses, during the first 20 weeks of pregnancy.

Note: All percentages are based on all reported data, including “missing” values. Totals may not sum to 100% because of rounding.

**Table 2:**

Use of protective gloves and gowns among nonpregnant nurses who administered antineoplastic drugs within the past month, comparing types of administration

	n	Frequency of Wearing Personal Protective Equipment n, %			Missing
		Always	Sometimes	Never	
<b>Latex or chemotherapy gloves</b>					
Infusion only	175	156 89%	6 3%	9 5%	4 2%
Pills only, typically crushed	259	141 54%	22 8%	84 32%	12 5%
Pills only, typically intact	420	277 66%	38 9%	86 20%	19 5%
Combination of infusion and pills	638	565 89%	35 5%	34 5%	4 1%
<b>Water-resistant gown</b>					
Infusion only	175	98 56%	21 12%	52 30%	4 2%
Pills only, typically crushed	259	34 13%	19 7%	187 72%	19 7%
Pills only, typically intact	420	63 15%	27 6%	277 66%	53 13%
Combination of infusion and pills	638	366 57%	105 16%	160 25%	7 1%

Note: All percentages are based on all reported data, including “missing” values. Totals may not sum to 100% because of rounding.

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript