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REPORT



Assessing variability of antineoplastic drugs handling practices in clinical settings

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ABSTRACT

The United States Pharmacopeia (USP) Chapter <800> guidelines will be adopted in the U.S. and Canada in 2019, requiring regular surface sampling for antineoplastic drug (AD) surface contamination as a means of environmental surveillance. USP Chapter <800> does not provide guidance on when and where to sample. Research to support the development of such guidance within a broader sampling strategy is limited. This study was conducted to help address some of the underlying information gaps by identifying surfaces pharmacy and nursing staff are likely to contact, presenting a potential dermal exposure risk. Observations were conducted at one regional and one urban clinic, providing insight into inter- and intra-worker variability and between-clinic differences based on size and patient load. Thirteen surfaces in the compounding pharmacies and 14 surfaces in the patient administration were initially selected for video observations. Following a preliminary assessment to eliminate surfaces that were touched infrequently or not at all, five commonly touched surfaces in the compounding pharmacy areas (vials, syringes, IV lines, IV bags, waste bags) and six commonly touched surfaces in the patient administration area (yellow containment bag, IV bag, IV line, patient port, computer workstation) were assessed further. Variability between healthcare staff and clinics in pharmacy staff was low for both the mean frequency and duration of touch to surfaces. Differences between clinics in frequency of contact among nursing staff in patient administration areas were significant (two-way ANOVA) for five of the six surfaces. Duration of contact was not significantly different except for duration of touching the IV pump. These insights will be used to give guidance in selecting locations for a longitudinal surveillance study and help tailor worker training to reduce exposure risks.

KEYWORDS

Chemotherapy; environmental contamination; exposure assessment; oncology nursing; oncology pharmacy; surveillance

Introduction

Despite more than three decades of research and interventions aimed at reducing occupational exposures to antineoplastic drugs (AD), environmental contamination in cancer clinics remains widespread.^[1,2] Contact with contaminated surfaces puts healthcare workers potentially at risk of continuous, low-level exposures through dermal exposure that may result in adverse outcomes including reproductive effects^[3] and increased risk of cancer.^[1,4]

While AD contamination has been reported in multiple locations and stages of preparation and administration, including manufacturing, distribution, pharmacies, hospitals, and clinics^[2,5,6] the sources of occupational exposures to AD are not clearly known. Despite the recent contributions to the literature of numerous surveillance studies, knowledge of exposure

pathways and the work practices and habits that contribute to surface contamination of AD are limited.

The United States Pharmacopeia (USP) Chapter <800> Hazardous Drugs – Handling in Healthcare Settings presents a set of requirements associated with receiving, preparing, administering, transporting, or otherwise coming into contact with hazardous drugs.^[7] The chapter covers the roles and responsibilities of healthcare workers, facility and engineering controls, procedures for decontamination and cleaning, spill control, and documentation. Revisions taking effect in 2019^[8] include routine surface sampling in facilities with hazardous drugs. Guidelines for surface sampling are broad but lack sufficient detail to flesh out effective and efficient sampling strategies. For example, these revisions will require routine surface sampling in areas where contamination may occur but lack guidance on how and when to sample.

This observational study was conducted to provide preliminary insights into work processes, practices, and habits that potentially lead to surface contamination, and transmission and subsequent dermal exposure risks resulting from surface contact by healthcare staff. The study focused on two specific objectives: (1) identify surfaces likely to come into contact with AD and subsequently touched by healthcare staff through work practices and habits. The subsequently identified surfaces would serve as candidate surfaces for an upcoming longitudinal study; (2) assess potential differences in workers' behaviors between clinics, and within- and between-worker variability in AD handling behaviors as potential factors in the underlying causes of surface contamination. Addressing the latter gap is a critical first step in developing effective interventions aimed at reducing surface contamination, transmission, and worker exposure. Quantifying frequency and duration of touch when conducting these tasks provides the additional benefit of informing dermal exposure models that are used for population-wide exposure assessments. Since publicly available contact frequency and duration data are scarce, the values reported through this work will help address another knowledge gap.

Methods

An observational study was conducted to assess work practices and workflow during the compounding and administration of AD. Work practice details were recorded using video-capture and time-activity documentation. Potential exposure pathways were assessed by following the workflow from compounding to patient administration at one regional and one community infusion clinic. Surface contact frequency and duration were quantified and compared between and within clinics to identify surfaces likely to be contaminated.^[9]

Data source

Observational studies were conducted in two Midwest-based infusion clinics: one large urban infusion clinic (60+ antineoplastic doses/day) and one smaller regional infusion clinic (15+ antineoplastic doses/day). Observational data of two main tasks, compounding and administering AD, were collected. These tasks were performed primarily by pharmacy technicians (compounding) and nurses (administering) who were recruited to participate in the study. Eligible participants were any pharmacy or nursing

staff who compounded AD or administered AD to patients. To balance the need to observe the broadest range of work practices possible while minimally disrupting work routines among healthcare staff with heavy workloads, participants were selected based on an informal stratified random approach taking work schedules, patient load, and time-of-day into consideration. Days of the week and time of day on which observations were conducted were varied, to minimize measurement bias. Whenever possible, replicate observations of staff were conducted so that within-worker variability could be assessed. Nurses were subdivided into two groups: primary nurses directly handling and administering AD to a patient, and secondary nurses, confirming patient information and dosing prior to drug infusion. This study was exempted as nonhuman study research by the University of Minnesota Institutional Review Board (IRB), and participants were free to withdraw from the study at any time. Staff across both sites ($n = 18$) were observed (6 pharmacy technicians, 12 nurses) over a 2-week period. A total of 36 observations were made.

Data collection

Observations in the pharmacy covered all compounding steps performed in the Biological Safety Cabinet (BSC). Video-documented observations of AD compounding were conducted using a GoPro HERO Sessions HD camera (GoPro Inc., San Mateo, CA) with suction mount. The camera was mounted to the glass of the BSC where AD was compounded, allowing researchers a close-up view of the work practices without crowding the individual working at the cabinet. Observations of nurses administering AD to patients were video documented using an iPad Pro (Apple Inc., Cupertino, CA). These observations focused on hand movements and movement of the AD that occurred while infusion associated tasks were performed. The observation period concluded once the infusion was started. All video observations were voluntary, and faces, identifying features, and audio were not recorded.

Communal surfaces, defined as surfaces touched by multiple staff and potentially contributing to transmission of environmental AD contamination, were identified at both clinics. Two surfaces at the urban clinic were observed. Visual observations of pharmacy and nursing staff accessing the medicine storage cabinet by touching the cabinet handles ($n = 4$) were made on three separate days.

A second communal area was observed at both clinics, capturing surface contact and PPE use. Primary and secondary nursing staff were observed using the computer workstation during the final preparation steps were completed before initiating the patient infusion. The primary nurse was responsible for all infusion associated tasks, while the role of the secondary nurse was primarily patient safety. The secondary nurse confirmed that the treatment (AD type and dose) was correct, before the primary nurse could start the infusion. The computer station was also observed at the regional clinic, with primary and the secondary nurse's contact with the computer workstation observed.

Unique study participant identification codes were used to maintain confidentiality of subjects being observed. A field diary was kept by the research team for all video observations to record the location, date, time, unique participant ID, and AD being handled. Patients receiving AD during our observations were asked for their verbal consent prior to filming. Care was taken to avoid capturing patient faces or any identifying information. Supplementary visual observations were made by a second researcher during AD administration to record hand-to-surface touch frequencies of secondary nurses.

Videos were viewed using Microsoft Windows Media Player and manually analyzed for frequency and duration of hand-to-surface contacts. Surfaces contacted, number of touches, frequency and duration of touch for each surface, and average contact time were quantified from each video. Use of PPE was also characterized. Frequency of touch to a surface (λ) was calculated using Eq. (1), and duration of touch to a surface (δ) was calculated using Eq. (2) for all surfaces touched in all video-observations:

$$\lambda = \frac{x}{t}, \quad (1)$$

where x is the total number of touches to a surface by an individual during the observational period, and t is the total period of time (min) the individual was observed.

$$\delta = \frac{\Delta}{x}, \quad (2)$$

where Δ is the total time an individual was observed touching a surface (sec) during the entire observational period, and x is the total number of touches to that surface during the observational period. The five most frequently contacted surfaces in the compounding pharmacy, and the six most frequently contacted

surfaces in the patient administration area were selected for further data analysis.

Data analysis

We identified a preliminary list of 13 commonly contacted surfaces in the pharmacy area. To focus our resources within this pilot study the list was distilled down to include the five most frequently contacted surfaces in-pharmacy and six most frequently contacted surfaces in the patient administration areas by eliminating surfaces that were not touched or rarely touched during the observation period. Descriptive statistics (mean, SD) of the number of touches observed, duration, and frequency of touch, and average contact time were calculated for these surfaces. The average contact time is a measure of the duration of touch per number of touches, providing a normalized metric for contact time. Between-clinic and within- and between-worker variabilities in touch frequencies and durations for each surface were assessed for both pharmacy and patient administration areas using a two-way ANOVA test ($\alpha = 0.05$). All statistical analyses were run using R software (version 3.5.1, R Foundation for Statistical Computing, Vienna, Austria).

Results

A total of 191.4 min ($n = 19$) of video observations of pharmacy staff compounding AD were collected, with an average observation time of 10.1 min (± 6.8 SD). Video observations of nursing staff administering AD in patient administration areas totaled 88.1 min ($n = 17$), with an average observation time of 5.2 min (± 2.2 SD). Four surfaces (scanner, mouse, keyboard, and computer counter) identified in the patient administration areas were combined to create the computer workstation.

Pharmacy

At the larger urban clinic, 132.6 min ($n = 15$) of video observations of pharmacy staff conducting tasks associated with compounding antineoplastic drugs were collected, with an average observation time of 8.8 min (± 4.7 SD). Similarly, 58.8 min ($n = 4$) of video observations of pharmacy staff were collected at the regional clinic, with an average observation time of 14.7 min (± 11.7 SD). Clinic characteristics are shown in Table 1. Descriptive statistics for the number of touches observed, touch duration, and frequency, and

average contact time were calculated for the five most frequently touched surfaces and were found to be similar for the two clinics (Table 2). Between-clinic and within- and between-worker touch frequency and duration were not significantly different (results not shown).

Nursing

Among oncology nursing staff working in the patient administration area at the urban clinic, 41.9 min (n = 9) of video observations of were collected, with an average observation time of 4.7 min (± 2.5 SD). Video observations of nursing staff at the regional clinic administering AD were collected, totaling 46.2 min (n = 8), with an average observation time of 5.8 min (± 1.8 SD). For the six most frequently contacted surfaces, descriptive statistics were calculated (Table 3). Mean frequency of touch was significantly different between clinics for five of the six surfaces analyzed in the patient administration areas, with the urban clinic having significantly higher mean frequencies of touch.

Within- and between-worker touch duration did not vary significantly. Only the between-clinic variability for duration of touch to Intravenous (IV) pumps ($p = 0.025$) was significantly different.

Table 1. Clinic characteristics.

| Description | Urban Clinic | Regional Clinic |
|---|--------------|-----------------|
| Estimated antineoplastic drug doses per day | 60+ | 15+ |
| Compounding pharmacy | | |
| Number of pharmacy technicians | 4 | 2 |
| Number of observations | 15 | 4 |
| <i>Time observed, min</i> | | |
| Total | 132.6 | 58.8 |
| Range | 3.9–17.1 | 5.9–31.4 |
| Antineoplastic drug doses handled | 23 | 6 |
| Patient administration | | |
| Number of nurses | 8 | 4 |
| Number of observations | 9 | 8 |
| <i>Time observed, min</i> | | |
| Total | 41.9 | 46.2 |
| Range | 2.6–10.5 | 3.4–8.4 |
| Antineoplastic drug doses handled | 9 | 8 |

Table 2. Mean (SD) values of observations for the five most frequently touched surfaces in pharmacy areas, by urban vs. regional pharmacy type.

| Clinic | Urban | | | | Regional | | | |
|------------|-------------------------|------------------------|------------------------------------|---------------------------|-------------------------|------------------------|------------------------------------|---------------------------|
| | Number touches observed | Duration of touch, min | Touch frequency, min^{-1} | Average contact time, min | Number touches observed | Duration of touch, min | Touch frequency, min^{-1} | Average contact time, min |
| Vials | 13.7 (6.4) | 2.23 (1.24) | 1.69 (0.8) | 0.17 (0.04) | 9.5 (2.6) | 1.95 (0.64) | 0.98 (0.67) | 0.21 (0.05) |
| Syringes | 9.5 (5.1) | 3.79 (2.01) | 1.17 (0.44) | 0.42 (0.18) | 14.5 (15.7) | 6.21 (8.61) | 0.9 (0.26) | 0.35 (0.13) |
| IV lines | 4.9 (3.2) | 1.32 (1.05) | 0.73 (0.59) | 0.22 (0.15) | 9.8 (6.3) | 2.99 (2.22) | 0.75 (0.18) | 0.29 (0.10) |
| IV bags | 10.2 (7.1) | 0.98 (0.7) | 1.45 (1.03) | 0.10 (0.07) | 26 (13.8) | 4.68 (4.15) | 2.03 (0.50) | 0.15 (0.07) |
| Waste bags | 12.5 (4.7) | 0.50 (0.24) | 1.65 (0.77) | 0.04 (0.02) | 14 (7.4) | 0.58 (0.29) | 1.09 (0.25) | 0.04 (0.01) |

Discussion

Identifying factors potentially contributing to environmental contamination of AD is a critical first step towards reducing dermal exposure risks.^[10] Identifying potentially contaminated surfaces that are frequently touched and understanding how these differ by work process and work force will inform surveillance strategy development and future interventions aimed at reducing dermal exposure to AD.

Work practices among pharmacy staff in both clinics were relatively similar. No significant differences in the frequency and duration of touch to surfaces among pharmacy technicians were observed, suggesting AD compounding practices are very similar across the two clinics. In contrast, greater between-clinic variability in AD handling behavior among nurses indicated by differences in contact frequency and, to a lesser extent, contact duration. This may be due to differences in job/task training as well as differences in the physical layout of the facility (e.g., dedicated computer system in each patient bay at one site versus portable computer stations at the other), in addition to differences in patients' health status, with more vulnerable patients requiring more time and attention.

Previous studies have shown that AD surface contamination is widespread across oncology infusion clinics.^[11,12] Variability in work practices could potentially contribute to greater surface contamination of commonly touched areas and communal surfaces such as the computer workstations, shared work spaces, and supply cabinets.^[13] The higher variability in AD handling practices in patient administration areas compared with compounding practices in the pharmacy suggest that work practice guidance and training aimed at patient administration work practices may need to be revisited.^[14,15] Since administrative controls such as training and hazard communication and proper PPE use are primary exposure prevention strategies, training, and adherence to best practices is essential. Importantly, this study demonstrated that AD handling practices among nurses differ between

Table 3. Mean (SD) values for observations for the six most frequently touched surfaces in patient administration areas, by urban vs. regional pharmacy type.

| Clinic | Urban | | | Regional | | | | |
|----------------------|-------------------------|------------------------------------|---------------------------|-------------------------|------------------------|------------------------------------|---------------------------|-------------------------|
| | Duration of touch (min) | Touch frequency, min ⁻¹ | Average contact time, min | Number touches observed | Duration of touch, min | Touch frequency, min ⁻¹ | Average contact time, min | Number touches observed |
| Yellow bag | 4.0 (2.4) | 0.50 (0.22) | 0.87 (0.38) | 0.16 (0.12) | 3.8 (1.7) | 1.35 (0.87) | 0.70 (0.38) | 0.44 (0.38) |
| IV bag | 3.7 (2.7) | 1.26 (1.64) | 0.78 (0.3) | 0.29 (0.23) | 2.3 (1.4) | 0.48 (0.31) | 0.29 (0.20) | 0.25 (0.13) |
| IV line | 3.8 (3.1) | 1.52 (1.08) | 0.75 (0.37) | 0.42 (0.24) | 2.5 (0.9) | 2.04 (1.18) | 0.44 (0.12) | 0.86 (0.39) |
| IV pump | 4.0 (1.9) | 0.65 (0.37) | 0.99 (0.57) | 0.16 (1.07) | 3.4 (1.5) | 1.0 (0.18) | 0.58 (0.18) | 0.34 (0.11) |
| Patient port | 2.4 (2.4) | 0.99 (1.4) | 0.48 (0.21) | 0.34 (0.25) | 1.4 (0.5) | 0.42 (0.28) | 0.25 (0.08) | 0.30 (0.13) |
| Computer workstation | 5.1 (2.7) | 0.62 (0.42) | 1.19 (0.73) | 0.11 (0.06) | 3.5 (1.7) | 0.83 (0.44) | 0.66 (0.37) | 0.25 (0.14) |

Table 4. Two-way ANOVA of touch frequency and duration in patient administration areas.

| Surface | | Touch frequency | | | | | Duration | | | |
|-----------|-----------|-----------------|--------|---------|---------|--------------|----------|---------|---------|--------------|
| | | DF | Sum Sq | Mean Sq | F value | Pr(>F) | Sum Sq | Mean Sq | F value | Pr(>F) |
| IV | Clinic | 1 | 0.628 | 0.628 | 17.854 | 0.008 | 23.39 | 23.39 | 0.122 | 0.742 |
| | Employee | 10 | 0.821 | 0.082 | 2.336 | 0.181 | 1059.97 | 106.00 | 0.551 | 0.803 |
| | Residuals | 5 | 0.176 | 0.035 | | | 962.65 | 192.53 | | |
| IV line | Clinic | 1 | 0.401 | 0.401 | 6.782 | 0.048 | 2153.10 | 2153.05 | 2.545 | 0.186 |
| | Employee | 10 | 0.878 | 0.088 | 1.484 | 0.347 | 1302.00 | 130.20 | 0.154 | 0.992 |
| | Residuals | 5 | 0.296 | 0.059 | | | 3383.90 | 845.98 | | |
| IV pump | Clinic | 1 | 0.689 | 0.689 | 6.234 | 0.055 | 375.23 | 375.23 | 12.165 | 0.025 |
| | Employee | 10 | 2.292 | 0.229 | 2.074 | 0.218 | 402.74 | 40.27 | 1.306 | 0.429 |
| | Residuals | 5 | 0.553 | 0.111 | | | 123.38 | 30.84 | | |
| Computer | Clinic | 1 | 1.187 | 1.187 | 8.161 | 0.036 | 139.77 | 139.77 | 4.036 | 0.115 |
| | Employee | 10 | 4.543 | 0.454 | 3.122 | 0.110 | 159.78 | 15.98 | 0.461 | 0.854 |
| | Residuals | 5 | 0.727 | 0.145 | | | 138.52 | 34.63 | | |
| Port | Clinic | 1 | 0.224 | 0.224 | 17.858 | 0.008 | 14.77 | 14.77 | 0.059 | 0.818 |
| | Employee | 10 | 0.342 | 0.034 | 2.725 | 0.140 | 982.68 | 98.27 | 0.392 | 0.903 |
| | Residuals | 5 | 0.063 | 0.013 | | | 1253.25 | 250.65 | | |
| Waste bag | Clinic | 1 | 0.115 | 0.115 | 0.758 | 0.424 | 1167.00 | 1167.00 | 3.808 | 0.109 |
| | Employee | 10 | 1.364 | 0.136 | 0.896 | 0.589 | 2505.80 | 250.58 | 0.818 | 0.633 |
| | Residuals | 5 | 0.761 | 0.152 | | | 1532.10 | 306.43 | | |

clinics, resulting in differences in contact frequency and duration with potentially contaminated surfaces, despite rigorous handling guidelines and SOPs. Future interventions need to address this challenge. Further, when designing surveillance strategies involving wipe samples across multiple facilities, the strategies should account for between-clinic variability in work practices among nurses working in patient administration areas.

There are several limitations associated with this pilot study. Observational studies are prone to bias. While attempts were made to minimize the influence of the investigators' presence on work practice, it was apparent on several occasions that there was some likely deviation from typical work practices. The small sample size limits the generalizability of the results across other oncology centers, and any association between frequency of touch and probability of that surface being contamination was not tested in this

study. Despite these limitations, surfaces found to be most frequently touched in this study were frequently identified in other studies as being contaminated.^[9]

Conclusion

This study revealed trends in work practices and behaviors that can potentially contribute to environmental contamination of AD and lead to healthcare worker exposures. Work practice variability, as observed in the patient administration areas, can potentially contribute to surface contamination as hands, gloved or ungloved that previously touched contaminated surfaces, subsequently touch clean surfaces.

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- [1] **Connor, T.H., and M.A. McDiarmid:** Preventing occupational exposures to antineoplastic drugs in health care settings. *CA: Cancer J. Clinicians* 56(6):354–365 (2006).
- [2] **Hon, C.Y., K. Teschke, P.A. Demers, and S. Venners:** Antineoplastic drug contamination on the hands of employees working throughout the hospital medication system. *Ann Occup Hyg.* 58(6):761–770 (2014).
- [3] **Janes, A., C. Tanguay, N.J. Caron, and J.F. Bussières:** Environmental contamination with cyclophosphamide, ifosfamide, and methotrexate: A study of 51 Canadian Centres. *Can. J. Hosp. Pharm.* 68(4):279–289 (2015).
- [4] **McDiarmid, M.A., M.S. Oliver, T.S. Roth, B. Rogers, and C. Escalante:** Chromosome 5 and 7 abnormalities in oncology personnel handling anti-cancer drugs. *J. Occup. Environ. Med.* 52(10):1028–1034 (2010).
- [5] **Favier, B., L. Gilles, C. Ardiet, and J.F. Latour:** External contamination of vials containing cytotoxic agents supplied by pharmaceutical manufacturers. *J. Oncolo. Pharm. Pract.* 9(1):15–20 (2003).
- [6] **Fransman, W., R. Vermeulen, and H. Kromhout:** Dermal exposure to cyclophosphamide in hospitals during preparation, nursing and cleaning activities. *Int. Arch. Occup. Environ. Health* 78(5):403–412 (2005).
- [7] **Gabay, M.:** USP <800>: Handling Hazardous Drugs. *Hosp. Pharm.* 49(9):811–812 (2014).
- [8] **Convention, T.U.S.P.:** <800> Hazardous drugs-handling in healthcare settings. In *Revision Bulletin*, December 1, 2019: United States Pharmacopeial, 2019.
- [9] **Connor, T.H., D.G. DeBord, J.R. Pretty, et al.:** Evaluation of antineoplastic drug exposure of health care workers at three university-based US cancer centers. *J. Occup. Environ. Med.* 52(10):1019–1027 (2010).
- [10] **Yoshida, J., S. Koda, S. Nishida, H. Nakano, G. Tei, and S. Kumagai:** Association between occupational exposure and control measures for antineoplastic drugs in a pharmacy of a hospital. *Ann. Work Expos. Health* 57(2):251–260 (2012).
- [11] **Poupeau, C., C. Tanguay, N.J. Caron, and J.-F. Bussières:** Multicenter study of environmental contamination with cyclophosphamide, ifosfamide, and methotrexate in 48 Canadian hospitals. *J. Oncol. Pharm. Pract.* 24(1):9–17 (2018).
- [12] **Chauchat, L., C. Tanguay, N.J. Caron, S. Gagne, F. Labreche, and J.F. Bussieres:** Surface contamination with ten antineoplastic drugs in 83 Canadian centers. *J. Oncol. Pharm. Pract.* 25(5):1089–1098 (2019).
- [13] **Hon, C.-Y., K. Teschke, H. Shen, P.A. Demers, and S. Venners:** Antineoplastic drug contamination in the urine of Canadian healthcare workers. *Int. Arch. Occup. Environ. Health* 88(7):933–941 (2015).
- [14] **Boiano, J.M., A.L. Steege, and M.H. Sweeney:** Adherence to safe handling guidelines by health care workers who administer antineoplastic drugs. *J. Occup. Environ. Hyg.* 11(11):728–740 (2014).
- [15] **Boiano, J.M., A.L. Steege, and M.H. Sweeney:** Adherence to precautionary guidelines for compounding antineoplastic drugs: A survey of nurses and pharmacy practitioners. *J. Occup. Environ. Hyg.* 12(9):588–602 (2015).