

# Multicenter study of environmental contamination with ten antineoplastic drugs in 83 Canadian hospitals: a 2017 follow-up study

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## Purpose

- 75 000 Canadian workers are exposed to hazardous drugs  
(Hall, Ann Work Expo Health. 2017;61(6):6568).
- Environmental wipe sampling for hazardous drugs surface residues should be performed routinely (USP General Chapter <800> Hazardous Drugs).
- Our research groups have conducted annual Canadian wipe sampling studies since 2008.
- The aim of this study was to monitor environmental contamination with ten antineoplastic drugs in Canadian oncology pharmacy and patient care areas.
- The secondary objective was to explore the impact of factors that may explain contamination.

## Methods

- 12 standardized sites (600 cm<sup>2</sup>) sampled per center:
  - 6 in the pharmacy
  - 6 in patient care areas
- Samples collected February- June 2017
- Analysis conducted by the Institut National de Santé Publique du Québec by ultra-performance liquid chromatography-tandem mass spectrometry technology
- 7 drugs were quantified: cyclophosphamide, cytarabine, 5-fluorouracile, gemcitabine, ifosfamide, irinotecan, methotrexate
- 3 drugs were detected (present or absent): docetaxel, paclitaxel, vinorelbine
- Descriptive analyses were done
- Sub analyses were performed according to working practices and cyclophosphamide contamination (Kolmogorov-Smirnov test for independent samples).
- Limits of detection were, in ng/cm<sup>2</sup>: cyclophosphamide (0.001); cytarabine (0.040); docetaxel (0.090); 5-fluorouracile (0.040); gemcitabine (0.004); ifosfamide (0.006); irinotecan (0.003); methotrexate (0.002); paclitaxel (0.040) and vinorelbine (0.004).

## Results

- 83 centers across Canada
- 953 samples
- 45% (429/953) of the samples were positive to at least one antineoplastic drug
- The 3 most frequent drugs on surfaces were (Table I):
  - Cyclophosphamide;
  - Gemcitabine;
  - 5-fluorouracile
    - Both cyclophosphamide and gemcitabine are available in powder form which need more manipulations.
- The 3 most contaminated sites were: arm rest in administration area (82%), front grille inside the hood (78%) and floor in front of the hood (61%) (Table II)
- 3 factors associated with higher cyclophosphamide surface contamination:
  - size of oncology clinics (< or ≥ 15 outpatient beds) (p=0.000);
  - antineoplastic drug usage (< or ≥ 4000 preparations per year) (p<0.0001);
  - cyclophosphamide drug usage (< or ≥ 250g per year) (p<0.0001)
- Factors not associated with higher cyclophosphamide surface contamination: removal of outer packaging (p=0.204), cleaning of vials after reception (p=0.388), use of closed-system drug-transfer devices (p=0.971) and priming of antineoplastic IV tubing (p=0.577)
- 16/83 centers have participated in the 7 studies we conducted and the cyclophosphamide surface concentration is decreasing over the years (Figure 1).

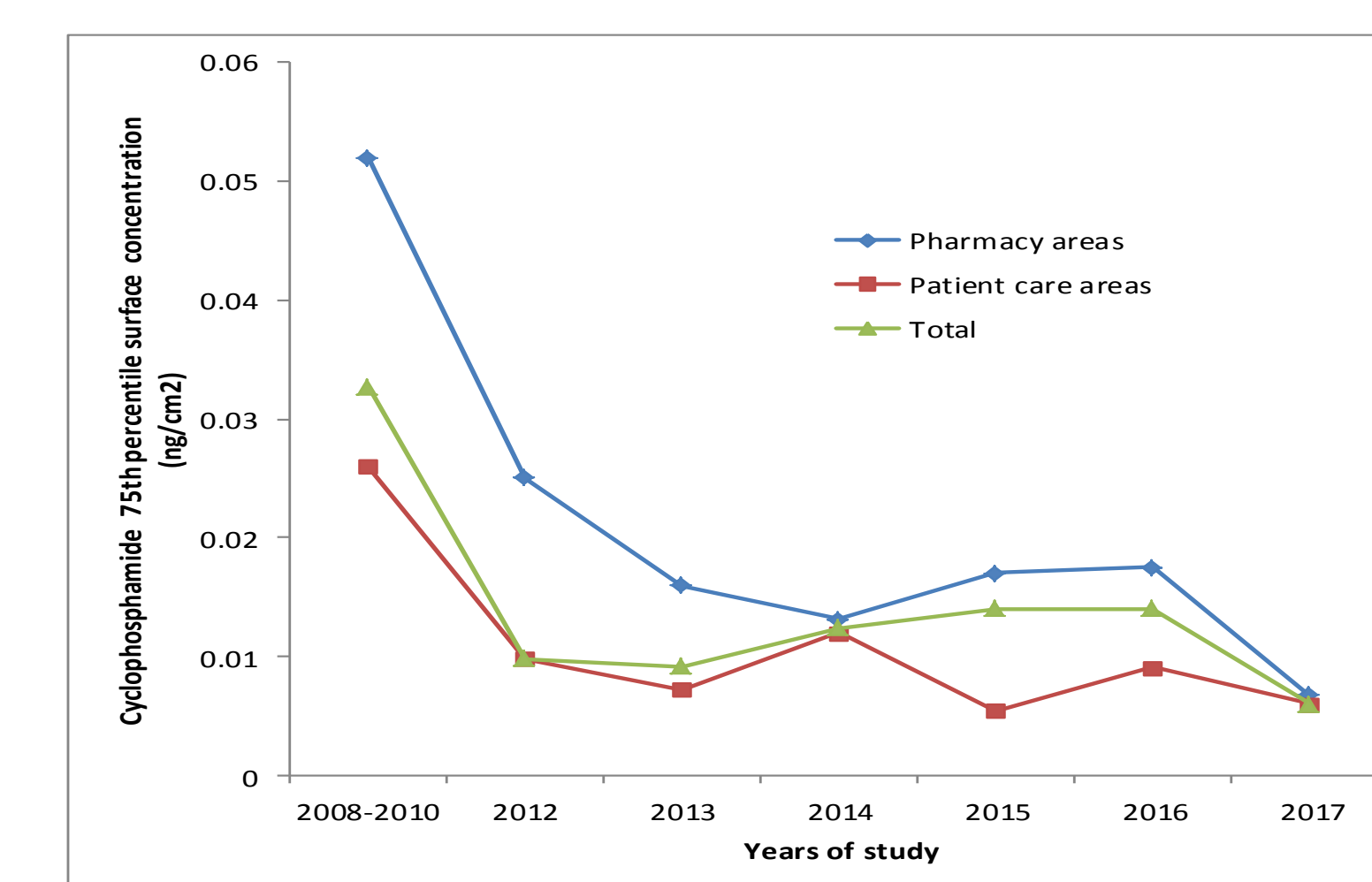
**Table I** Surface contamination and reported annual use of antineoplastic drugs

Antineoplastic drug n=953	Reported annual use (median in g)	Available forms in Canada	Surface contamination	
			Positive samples n (%)	75 <sup>th</sup> percentile (ng/cm <sup>2</sup> )
Cyclophosphamide	258	Powder	343 (36%)	0.0040
Gemcitabine	345	Powder and liquid	112 (12%)	<LOD
5-Fluorouracil	2275	Liquid	100 (11%)	<LOD
Methotrexate	4	Liquid	63 (7%)	<LOD
Ifosfamide	1	Powder	38 (4%)	<LOD
Irinotecan	59	Liquid	28 (3%)	<LOD
Cytarabine	1	Liquid	12 (1%)	<LOD
Paclitaxel	40	Powder and liquid	5 (1%)	NA
Vinorelbine	4	Liquid	4 (0%)	NA
Docetaxel	12	Liquid	1 (0%)	NA

LOD: Limit of detection; NA: Non applicable (qualitative analysis only)

**Table II** Cyclophosphamide surface contamination

Sample sites (n samples)	Positive samples n(%)	Concentration (ng/cm <sup>2</sup> )	
		75 <sup>th</sup> percentile	90 <sup>th</sup> percentile
<b>Pharmacy areas</b>			
Front grille inside the hood (83)	49(59%)	0.029	0.302
Floor in front of the hood (83)	48(57.8%)	0.022	0.0866
Storage shelf (82)	34(41.5%)	0.005	0.012
Trays used for drug delivery (83)	17(20.5%)	<LOD	0.004
Service hatch or preparation validation counter (83)	16(19.3%)	<LOD	0.0102
Shipment reception counter (81)	10 (12.3%)	<LOD	0.0017
<b>Total - pharmacy areas (495)</b>	<b>174(35.2%)</b>	<b>0.004</b>	<b>0.0286</b>
<b>Patient care areas</b>			
Arm rest (82)	65(79.3%)	0.065	0.12
Counter used for priming or validation (77)	30(39%)	0.0017	0.005
Exterior surface of container (e.g. bag/syringe) (79)	25(31.6%)	0.006	0.023
Patient room counter (66)	19(28.8%)	0.0017	0.0073
Outpatient clinic counter (74)	19(25.7%)	0.0017	0.0065
Storage shelf (80)	11(13.8%)	<LOD	0.0017
<b>Total - patient care areas (458)</b>	<b>169(36.9%)</b>	<b>0.004</b>	<b>0.0316</b>
<b>Total - pharmacy &amp; patient care areas (953)</b>	<b>343(36%)</b>	<b>0.004</b>	<b>0.0286</b>



**Figure 1** Cyclophosphamide 75<sup>th</sup> surface contamination for 16 centers 2008-2017

## Conclusions

- Despite growing awareness, healthcare centers' surfaces remain contaminated. The use of personal protective equipment remains undisputable. We were not able to identify specific working practices that were associated with reduced contamination, but "bigger" centers were prone to having higher concentration on their surfaces. Traces are hard to eradicate and this persistence may explain why having "zero" contamination is probably unattainable.
- Centers were provided with drug-specific goals corresponding to 75<sup>th</sup> and 90<sup>th</sup> percentiles.