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ANTINEOPLASTIC DRUGS IN HOSPITAL ADMINISTRATION UNITS: USE OF AUTOMATIC TOILET SEATS TO CONTAIN SURFACE CONTAMINATIONS IN WASHROOMS

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SUMMARY: The contamination of surfaces by antineoplastic drugs represents an increasing risk factor within healthcare environments. The primary causes are the rise in the number of prescriptions and patients treated in hospital oncology departments. Protective measures are implemented to safeguard workers involved in drug preparation within compounding units and administration units. The focus is on preventing contamination at the level of transfusion bags, while contamination from the biological fluids of treated patients, particularly urine, is significantly underestimated. Incorrect use of the toilet by patients due to ongoing intravenous therapy and poor personal hygiene is, at the time being, the most notable source of contamination inside administration units. In this context, the use of automatic toilet seats was tested in the departments of an Italian hospital to reduce the risk associated with the administration of antineoplastic drugs while simultaneously increasing the comfort of patients during day hospital treatments. The primary objective was to achieve a measurable reduction in surface contamination levels and thus assess improvements in patient and staff safety. Contamination levels of various surfaces inside the washrooms were monitored using UV lamps, focusing on the washroom floor, the surface of the toilet seat, and faucet. Samples were collected through wipe test sampling and then analysed using a UHPLC-MS/MS system. The results from the analyses and evaluations showed a promising reduction in contamination of the selected areas thanks to the use of the tested devices, accompanied by strong positive feedback from users.

Key words: *antineoplastic drugs, occupational exposure, automatic toilet seat, wipe test, surface contaminations*

INTRODUCTION

In 2022, the European Trade Union Institute (ETUI) released an updated list of Hazardous Medicinal Products (HMPs). In the same year, the European Union (EU) issued Directive 431 on the protection of workers from the risks related to exposure to carcinogens and mutagens by inserting Antineoplastic Drugs (ADs), later implemented in Italy by the Legislative Decree 135/2024, while in 2023 the European Agency for Safety and Health at Work (EU-OSHA) published a guide for the safe management of HMPs at work.

Despite their therapeutic benefits, the HMPs - including the ADs - constitute a source of risk for healthcare workers. Most ADs are included in the International Agency for Research on Cancer (IARC) classification as carcinogenic (group 1), probably (group 2A) or possibly carcinogenic

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(group 2B) for humans (List of classifications - World Health Organization). Long-term occupational exposure has been associated with various adverse effects including reproductive toxicity and the occurrence of malignancies. Acute adverse effects such as skin rash and hair loss have also been described.

Even though in 2019, the European Biosafety Network (EBN) proposed the limit value of 100 pg/cm^2 as safe for ADs surface contamination, the 'non-threshold' effects such as genotoxicity, the possible cumulative addition of multiple ADs and the correlations with adverse effects in workers are still poorly understood. On the other hand, there are certainly ways to reduce such exposure, and the common goal is to aim for the reduction according to the As Low As Reasonably Achievable (ALARA) principle.

So, contamination monitoring in the workplace is an important tool in the risk management of such hazardous compounds, and the most used approach in contamination detection is nowadays targeted sampling using wipe test. This type of monitoring allows identification of hot spots, major sources and release routes of ADs when they are handled, as well as comparison between different healthcare settings and improvements in prevention measures.

Recent studies *(Dugheri et al., 2022, Bláhová et al., 2023, Sottani et al., 2017, Mucci et al., 2020)* show markedly higher ADs positivity at the administration sites than at the preparation sites. During the cytostatic administration phase, attention must be paid to possible sources of contamination that can potentially expose workers and patients to unwanted and accidental absorption of these compounds. Sources of exposure during the administration phase might be dissemination from contaminated infusion bags, possible leaks at the infusion connections and - above all - contaminations inside of toilets, especially from the floor and WC surface, where urination occurs by patients administered with chemotherapy drugs. However, the centralization of the preparation of ADs in hospital pharmacies, the distribution of the infusion-bags equipped with close-circuit systems and the implementation of safe handling procedures, drastically reduced the accidental spills caused by the drug handling, leaving the biological fluids of the treated patients the principal source of contamination.

Table 1 presents a comprehensive analysis of various ADs contamination levels found in the literature on different surfaces within hospital environments. The data, expressed in pg/cm^2, includes measurements from multiple studies, highlighting the presence of specific ADs on washroom floors, WC surfaces, and washroom faucets.

Table 1. Summary of literature data ADs contamination levels (pg/cm^2) for washroom surfaces

Tablica 1. Sažetak podataka iz literature o razinama kontaminacije AD-a (pg/cm^2) za površine kupaonica

AD	Washroom Floor	WC	Washroom Faucet	Reference
CP	122.4 68 0.5 14176 30	1380.2 6 0.8 8414 -	25.9 - 0.3 4513 -	Dugheri et al. (2022) Sottani et al. (2022) Walton et al. (2020) Mucci et al. (2020) Bláhová et al. (2023)
GEM	281.8 721	421.8 323	<1.40 -	Dugheri et al. (2022) Sottani et al. (2022)
5-FU	4.9-23.2 1463	12.4-39.0 42	<0.75 -	Dugheri et al. (2022) Sottani et al. (2022)
CarboPt	7.9 1153 200	942.8 107 -	<13.65 - -	Dugheri et al. (2022) Sottani et al. (2022) Bláhová et al. (2023)
PTX	150.4 10	769.8 -	<0.92 -	Dugheri et al. (2022) Bláhová et al. (2023)
ETP	0.5	0.8	0.3	Walton et al. (2020)
IP	55462	19461	43172	Mucci et al. (2020)

Legend: Antineoplastic Drug (AD), Cyclophosphamide (CP), Gemcitabine (GEM), 5-FU, 5-Fluorouracil (5-FU), Carboplatin (CarboPt), Paclitaxel (PTX), Etoposide (ETP), Ifosfamide (IP).

A portion of each AD is excreted via the biliary and/or urinary tract either in an unmodified form or in the form of one or more metabolites, which may or may not retain some degree of biological activity and thus toxicity to those exposed to them. The sampling locations in patient care units showed that ADs residues were persistent even after the completion of the cleaning procedures *(Sottani et al., 2022)*. An important factor to be considered is also the half-life of such compounds, since an AD with a long half-life will more easily accumulate and thus overdose if the exposure is cumulative with a previous one, whether desired, as is the case for patients, or unwanted, as is the case for operators *(Hedmer et al., 2012)*.

As mentioned above, potential sites of hospital restrooms contamination and therefore a source of risk are floors, toilets, sinks, taps, handles, doors, and light switches, but there is no legislation obliging the use of automated devices, like touch-free automated doors, lights, and taps. However, their use seems at least desirable, considering the undeniable advantages they would bring in reducing surface contamination and contributing to an improvement in the consequent cleaning measures of the environments themselves. Since there is not existing regulatory about cleaning protocols nor about interior design, even though several international guidelines exist, the use of the so-called 'automatic hygienic seats' would make up for this shortcoming. They are a completely touch-free hygienic replacement for standard toilet seats, consisting of a covered area containing the driving mechanism and sanitary film rolls, while the toilet seat is enclosed in a sleeve-like wrap. As users utilize the fresh sanitary seat cover, it moves around the seat and is deposited on the opposite side of the covered area where it is cut so that it cannot be used a second time.

To reduce the exposure of workers and patients to these substances, which in turn can become vehicles of contamination, it is essential not only to identify the sources and quantify the exposure, but also to verify the usefulness of devices designed to reduce or eliminate such contact.

The use of automatic hygienic seats was thus tested on a trial basis within three wards an Italian hospital while concurrently monitoring the contamination of the surfaces of the wards to obtain an initial assessment of their effectiveness.

MATERIALS AND METHODS

Sample collection

Three wards with a patient turnout of about 50 to 70 patients per day were selected for the installation of the hygienic seat: Oncology Day Hospital, Radiotherapy Day Hospital, and Oncohematology Day Hospitals. For each department, during the sampling session, two washrooms with comparable patient flow were evaluated: one washroom was equipped with the NAVISANI hygienic seat developed by Xiamen Wing Technology Co., Ltd. (Xiamen, China), while the other with a standard hospital seat. Department staff were instructed on the operation of the seats, and simple usage instructions were posted near the restrooms to facilitate the use for the patients. Before starting the monitoring campaigns, each department was asked to arrange a thorough cleaning of the facilities to minimize any potential contamination prior to the start of measurements. The contamination monitoring was performed using wipe test sampling, consisting of the manual cleaning of 20x20 cm surface areas with 5x5 cm nonwoven wetted gauze pads. Sampling points were selected from surfaces considered to be at high risk of contamination and exposure.

- The sampled points were:
- floor at the patient room entrance,
- inside handle of the patient room door,
- floor at the washroom entrance,
- inside handle of the washroom door,
- WC surface,
- faucet.

Each point was sampled in the morning, before the start of drug administration (beginning of the work shift) and in the afternoon after the end of use (end of the work shift). Before each sampling, the areas were inspected with an ultraviolet light lamp to preliminarily assess the presence of macroscopic contamination. The lamps utilized were KL-440 LED rechargeable torch system (MADAtec Srl, Pessano con Bornago, Milano, Italy)

using UV-induced fluorescence (440 nm) detectable with the naked eye in darkened or semi-darkened environments.

Sample preparation

The samples were desorbed with 2 mL of a 50:50 water/methanol solution containing internal standards (10 ng/mL of trofosfamide and 40 ng/mL of 5-chlorouracil), filtered with a 0.2 µm filter into 2 mL vials, and analyzed using a Shimadzu Nexera X2 LCMS-8050 system.

Thirty-four antineoplastic drugs were monitored by analyzing each sample with two separated UHPLC-MS/MS methods *(Dugheri et al., 2021, 2022)*:

- Reverse-phase chromatography: Cyclophosphamide (CP), Dacarbazine (DC), Docetaxel (DTX), Daunorubicin (DNR), Doxorubicin (DXR), Epirubicin (EPI), Etoposide (ETP), Fotemustine (FTM), Idarubicin (IDC), Ifosfamide (IP), Irinotecan (IRT), Busulfan (BSF), Melphalan (MP), Methotrexate (MT), Mitomycin C (MITC), Paclitaxel (PTX), Pemetrexed (PMX), Raltitrexed (RTX), Tamoxifen (TMX), Topotecan (TPT), Vinblastine (VNB), Vincristine (VNC), Vindesine (VND), Vinorelbine (VNR), Thiotepa (THP), and Bendamustine (BDM) were analyzed with a Cortecs UPLC T3 1.6 µm 2.1 x 50 mm column (Waters SPA) using gradient elution. Eluent A was composed of water with 0.021% formic acid and 4 mM ammonium formate, and eluent B was a mixture of acetonitrile/methanol (90:10) with 0.021% formic acid.
- Direct-phase chromatography: Cytarabine (CTB), Gemcitabine (GEM), 5-Fluorouracil (5-FU), Carboplatin (CarboPt), Cisplatin (CisPt), Oxaliplatin (OxaliPt) and 5-Azacitidine (5-AZ) were detected with a POROSHELL 120 HILIC-Z, 2.1 x 100 mm, 2.7 µm column (Agilent Technologies, Inc.) using isocratic elution with a mobile phase composed of an acetonitrile/water mixture (90:10) with 20 mM ammonium formate.

Data analysis

The obtained contamination values, expressed for each of the 34 ADs in pg/cm^2, were converted in CP equivalents using the following equation:

$$CP(x)_{equiv} = \frac{C_x}{MW_x} \times MW_{CP} \quad [1]$$

where $CP(x)_{equiv}$ is the CP equivalent expressed in pg/cm^2 for the drug x, C_x is the contamination value of ADsx expressed in pg/cm^2, MWx is its molecular weight, and MW_{CP} is the molecular weight of CP. This conversion allowed the creation of the data set representing the total contamination measured as CP equivalents, which was used for data analysis *(Green et al., 2014)*.

The obtained values were thus divided into two groups: "Group A" included data from the washrooms where the standard toilet seats were installed, and "Group B" by data from the washrooms where the automatic ones were installed. The total daily amount of AD contamination was calculated for each sampling day, obtaining two sets of data, one for each group. The data were organized in Microsoft Excel worksheets and processed using RStudio Version 1.2.1335 ©2009–2019 RStudio, Inc., as GUI for R version 3.6.1 (2019-07-05) "Action of the Toes", ©2019 (RStudio PBC, Boston, MA, USA). The R Foundation for Statistical Computing.

RESULTS AND DISCUSSION

Determining ADs contamination in hospital bathrooms can often be a challenging task. The drug is usually processed by the body and excreted in the form of different metabolites, which may retain toxic activity. The study and development of quantification methods which involve active metabolites creates practical and economic issues, especially due to the need for tailor-made analytical standards. Yet, the study of the whole set of circumstances that lead to exposure provides a comprehensive understanding of the existing hazard. Table 2 summarizes the potential exposure caused by ADs excreted through urine. It reports the half-life, percentage of unmodified excreted drug, and recommended duration for protective precautions, based on literature data.

Table 2. Half-life, percentage of unmodified excreted ADs, and recommended duration for protective precautions for the ADs monitored in the present study

Tablica 2. Poluvrijeme eliminacije, postotak nemodificiranih izlučenih AD-ova i preporučeno trajanje zaštitnih mjera za AD-ove praćene u ovoj studiji

AD	t1/2 (time)	Urine excretion (%)	Urine protective precautions (time)	Reference
MITC	8-48 min	10	24 h	https://go.drugbank.com/ Dorr R. T. (1988)
DC	5 h	40	/	https://www.pfizermedicalinformation.com/
RTX	198 h	40-50	/	https://www.cancercareontario.ca/en
FTM	24 min	/	/	https://pubchem.ncbi.nlm.nih.gov/
DNR	18.5 h	25	48 h	https://go.drugbank.com/
VNB	19 h	/	4 days	https://go.drugbank.com/
MP	75 min	10	48 h	https://go.drugbank.com/
VNC	85 h	20	4 days	https://www.pfizermedicalinformation.com/ Awosika AO et al. (2023)
CP	3-12 h	10-20	72 h	https://go.drugbank.com/
PMX	3.5 h	70-90	/	https://go.drugbank.com/
TPT	2-3 h	49	/	https://www.pfizermedicalinformation.com/
EPI	30-40 h	10	6 days	Cersosimo R.J. et al. (1986)
DXR	20-48 h	5-12	6 days	https://go.drugbank.com/
IRT	6-12 h	17-25	/	https://www.pfizermedicalinformation.com/ Chabot et al. (1997)
PTX	13-52 h	14	/	Awosika AO et al. (2023) https://go.drugbank.com/
BSF	2.6 h	<2	12-24 h	https://go.drugbank.com/
CARBOPT	6 h	32	24-48 h	Ananya M. (2023)
CISPT	20-30 min	13.5-27	7 days	https://go.drugbank.com/ https://inchem.org/#/
DTX	11.1 h	6	/	https://go.drugbank.com/ Farha N.G. et al. (2024)
IDC	22 h	/	/	https://go.drugbank.com/
MT	3-10 h *(lower doses),* 8-15 h (higher doses)	80-90	24 h	https://go.drugbank.com/ https://www.pfizermedicalinformation.com/
5-FU	10-20 min	7-20	48 h	https://go.drugbank.com/
CTB	10 min	7-8	24 h	https://go.drugbank.com/ https://medsafe.govt.nz/
ETP	5.3-10.8 h	20-45	4 days	https://www.pfizermedicalinformation.com/ Slevin M.L. (1991)
OXALIPt	0.43-16.7 h	54	/	https://go.drugbank.com/
VNR	27.7- 43.6 h	<20	/	https://go.drugbank.com/
IP	7-15 h	12-18	48 h	https://go.drugbank.com/
GEM	0.7-1.6 h (70 min infusion), 4.1-10-6 h (70-285 min infusion)	9.2-9.8	/	https://go.drugbank.com/

Legend: t1/2 (AD half-life), urine excretion (urinary excretion percent of the unmodified drug), urine protective precaution (the recommended time for protective precautions).

Effective cleaning procedures have been demonstrated to protect workers from contamination by ADs through surface contact. Negri et al. *(2019)* showed that Marseille soap with hot water and Farmecol70® (a 70% hydroalcoholic solution) can be the optimal choice for decontamination from 5FU, CP, IP, and GEM because, in addition to being effective, they are economical and require a short time to act. This technique is complemented by the proposal of Adè et al. *(2017)*, who demonstrated the ability of a quaternary ammonium solution and a sodium hypochlorite solution (at concentrations of 0.02% and 2%) to remove about 95% of a quantity of 107 pg of cyclophosphamide after a single cleaning session. However, these cleaning systems do not solve the contamination problem, are not easily standardized, and cannot be applied after each use. For these reasons, it was decided to test a tool that prevents contamination in washrooms, the places with the highest risk of contamination from urine containing ADs. The product selected is an automatic toilet seat, "NAVISANI," short for Navigator of Sanity, developed by Xiamen Wing Technology Co., Ltd. (Xiamen, China), shown in Figure 1.

Figure 1. The NAVISANI automated toilet seats were installed inside the administration units

Slika 1. Automatske WC sjedalice NAVISANI ugrađene su unutar administrativnih jedinica

This system avoids direct contact thanks to a sensor with technology that automatically changes the hygienic film when activated, helping the patient to feel safe in its use and thus reducing the possibility of contamination. This brand was selected because it offers several models, is powered by both mains and battery, is economical, and is easily available in Italy. Urine stains are hard to be seen *(Virkler et al., 2009)*. They exhibit fluorescence when exposed to UV light, and the color of the stain may vary depending on the patient's condition or the presence of other substances on the surfaces, such as glycosuria *(Gaensslen, 1984)*. Vandenberg and Oorschot *(2006)* reported that urine is detectable by human eyes under 415 nm excitation wavelength with yellow goggles, 450 nm excitation wavelength with orange goggles, and 505 nm excitation wavelength with red goggles. Besides, Seidl et al. *(2008)* tested urine stains with excitation wavelength at 532 nm. For this ADs monitoring campaign, we adopted the KL-440 LED rechargeable torch system, which we believe is more manageable both in the field and economically compared to those offered on the market *(Lee et al., 2010)*.

The use of ultraviolet light lamps before each sampling allowed for the identification of macroscopic contamination near the sampling points, which guided the wipe tests. Additionally, it was possible to assess the cleanliness of surfaces that were sampled less frequently. For instance, on the first day of sampling in the Oncology Day Hospital, numerous macroscopic contaminations were identified using UV light, subsequently confirmed by significant levels of AD contamination (Figure 2). This was due to insufficient cleaning before sampling. The data from that day was thus excluded from the evaluation, as the considerable pre-existing contamination would compromise the validity of the study assessment.

Figure 2. Macroscopic contaminations were identified inside washrooms using UV light lamps

Slika 2. Makroskopske kontaminacije unutar kupaonica identificirane su pomoću UV lampi

Concerning the test results, the samplings were conducted for four days in the Oncology and Radiotherapy Day Hospital wards and for six days inside the Oncohematology one.

A total of 496 wipes were sampled, 223 of which resulted positive for at least one AD. The most commonly detected drugs were cyclophosphamide (41% of positivities), dacarbazine (17%), gemcitabine (14%), ifosfamide (7%) and paclitaxel (5%). Among the samples that tested positive, 143 presented multiple contaminations.

The data distributions of the two datasets, Group A (standard seat) and Group B (automated seat), were significantly non-normal (Group B, mean 1029, median 259, Shapiro-Wilk normality test: W = 0.73713, p-value 0.000921; Group A, mean 2314, median 1001, W = 0.68578, p-value = 0.0002643), and heteroscedastic (F-Test for two variances, F = 5.081, p-value 0.00308).

Therefore, the non-parametric Mann-Whitney-Wilcoxon test was used, which showed that the median of the "Group A" sample was larger than the median of the "Group B" sample at the 93.53% probability level (p-value 0.0647). The values obtained for the 28 measurements can be seen in the scatter plot reported in Figure 3.

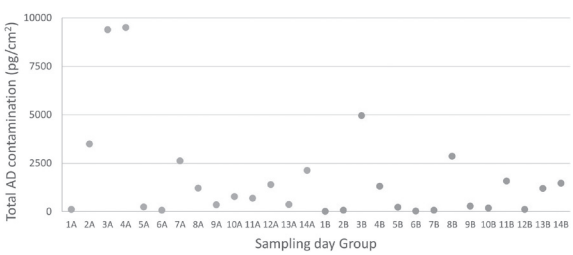

Figure 3. Time series of daily AD contamination values measured for the 14 days of sampling for Group A (standard seat) and B (automated seat)

Slika 3. Vremenski niz dnevnih vrijednosti kontaminacije AD izmjerenih tijekom 14 dana uzorkovanja za Grupu A (standardno sjedalo) i B (automatizirano sjedalo)

Figure 4 shows that the two data sets are not equivalent and that the "Group A" measures are more dispersed and characterized by slightly higher values than those in "Group B." Therefore, it can be concluded that in these experimental settings a reduction in total AD contamination on the surface is clear when the automatic toilet seat is installed.

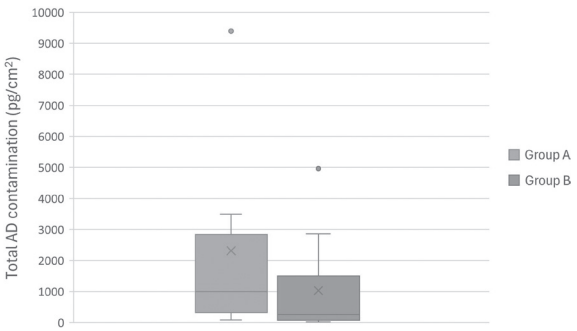

Figure 4. Box plot for total daily ADs contamination for the two data groups: Group A (standard seat) and B (automated seat). The "X" shows the Group mean AD contamination; the horizontal sides of the boxes show the first and third quartiles of the data sets of each sample, while the bold line inside the boxes shows the Group median AD contamination

Slika 4. Okvirni dijagram za ukupnu dnevnu kontaminaciju AD-om za dvije skupine podataka: Grupa A (standardno sjedalo) i B (automatizirano sjedalo). "X" prikazuje srednju kontaminaciju AD-om za Grupu; vodoravne stranice okvira prikazuju prvi i treći kvartil skupova podataka svakog uzorka, dok podebljana linija unutar okvira prikazuje medijan kontaminacije AD-om za Grupu.

The large variance carried by the non-exhaustive nature of the wipe test, affects the measurement precision and, thus, the validation of the different protective effects of the seat types against AD exposure. This issue does not allow further statistical analysis, which would be able to provide a result with higher significance level. However, since the wipe test is the most widely used sampling method, no other option was considered during the sampling campaign's design. The obtained results will be considered for further implementation in the design of future tests, which will be extended to larger numbers of wards and reach patients and operators.

Thanks to the interesting perspective and growing use of touch-free automated devices, an increasing number of companies is approaching the production in this sector, and this includes automated toilet seats. Generally, these types of devices cost from 119.32 to 326.55€ each, while the price of sanitary film rolls for 100 uses ranges from 3.72 to 6€. Table 3 shows a comparison between the main features of the devices currently available on the market.

Table 3. Comparison of the automatic hygienic seat devices currently available on the market

Tablica 3. Usporedba automatskih higijenskih sjedala trenutno dostupnih na tržištu

Producer	Model	Sensor	Power supply		Contact
			Grid	Power pack	
Clean4U	Clean4U	X	X	X	Rijeka, Croatia https://hygienic-seat.com/en
Hygolet	S3500	X		X	Wetzikon, Switzerland https://hygolet.eu/en/products/
North American Hygiene, Inc.	Sani-Seat	X	X	X	Ocean City, United States https://www.saniseat.com/
Xiamen Wing Technology Co.,Ltd	NAVISANI NS200C1	X	X	X	Xiamen, China https://www.navisani.com/
BRiLL Hygienic Products, Inc.	BRiLL™	X	X	X	Delray Beach, United States https://brillseat.com/
Save Srl	Hyprom			X	Mascalucia, Italy https://www.igienealtuoservizio.it/
RULOPAK	Rulopak®	X	N.R		Istanbul, Turkey www.rulopak.com
Trakmaş A.Ş	Tottolet®	X	X	X	Istanbul, Turkey https://www.tottolet.com/en/
Agrasen Global Pvt Ltd	Safe Seat		N.R.		Mumbai, India https://www.agrasenglobal.com/

CONCLUSION

This study presents the results obtained during the test of automatic toilet seats inside the wards of an Italian hospital. The aim of the test was to reduce AD surface contaminations and, thus, the risk associated with their use. Automatic toilet seats proved to be promising tools, decreasing the contamination of surfaces while increasing patient comfort during day hospital treatments. This pilot study lays the foundation for future tests, which will be extended to a higher number of wards and hopefully lead to a significant decrease in occupational exposure to ADs and higher hospital safety.

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ANTINEOPLASTIČNI LIJEKOVI U BOLNIČKIM PROSTORIMA: UPORABA AUTOMATSKIH TOALETNIH SJEDALA ZA SPREČAVANJE KONTAMINACIJE U TOALETIMA

SAŽETAK: Kontaminiranje površina antineoplastičnim lijekovima predstavlja sve veći čimbenik rizika u zdravstvenom okruženju. Primarni je uzrok povećanje broja recepata i bolesnika na onkološkom bolničkom tretmanu. Uvode se mjere kako bi se zaštitili zaposlenici koji pripremaju lijekove u bolničkim i uredskim jedinicima. U fokusu je sprečavanje kontaminacije pri primjeni transfuzijskih vrećica, dok je kontaminacija izazvana biološkim tekućinama tretiranih bolesnika, naročito mokraće, znatno podcijenjena. Pogrešna upotreba toaleta od strane bolesnika pri intravenskoj terapiji i slaba osobna higijena trenutno su najveći izvor kontaminacije u bolničkim prostorima. S tim u vezi, testirana su automatska toaletna sjedala na odjelima jedne talijanske bolnice kako bi se smanjio rizik od antineoplastičnih lijekova i povećala udobnost bolesnika tijekom dnevnih bolničkih tretmana. Primarni je cilj bio postizanje mjerljivog smanjenja površinske kontaminacije i procjena poboljšanja sigurnosti bolesnika i osoblja. Razina kontaminacije različitih površina u toaletima praćena je pomoću UV svjetiljki, s fokusom na pod, te na površinu toaletnog sjedala i slavinu. Uzorci su prikupljeni pomoću brisova koji su zatim analizirani sustavom UHPLC-MS/MS. Rezultati analiza i evaluacija pokazuju obećavajuće smanjenje kontaminacije u izabranim prostorima zahvaljujući korištenju testiranih naprava a i povratne informacije od korisnika bile su vrlo pozitivne.

Ključne riječi: *antineoplastični lijekovi, profesionalna izloženost, automatsko toaletno sjedalo, test brisom, površinska kontaminacija*

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