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Preface

Injury prevention is a common thread throughout every workplace, yet keeping employee safety and health knowledge consistently is a continual challenge for all employers. The discipline of Safety Management and Human Factors is cross-disciplinary concerning safety, health and welfare of the people engaged in work or employment. The book offers a platform to showcase research and for the exchange of information in safety management and human factors. Mastering safety management and human factors concepts is fundamental to both the creation of products and systems that people use and the design of work systems to avoid stresses and minimize the risk for accidents.

This book focuses on the advances in the safety management and its relationship with human factors, which are critical in the design of any human-centered technological system. The ideas and practical solutions described in the book are the outcome of dedicated research by academics and practitioners aiming to advance theory and practice in this dynamic and all-encompassing discipline.

A total of six sections are presented in this book. Each section contains research papers that have been reviewed by members of the International Editorial Board. Our sincere thanks and appreciation to the following Board members:

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Cytotoxic Drug Manipulation and Its Impact on Occupational Safety of Hospital Workers

João Silva, Pedro M. Arezes, Rudolf Schierl and Nélson Costa

Abstract In order to study environmental contamination by cytostatic drugs in a Portuguese hospital two wipe sampling campaigns were conducted in 2010 (12 samples) and 2015 (44 samples). Platinum containing drugs and fluorouracil were chosen because both were administered in high amounts. The detection limit was 0.01 pg/cm^2 for platinum and 0.1 pg/cm^2 for fluorouracil. The detected contamination on specific locations in the pharmacy and in the day hospital was higher in 2010. More detailed sampling in 2015 confirmed that optimization of working procedures and introduction of closed transfer system resulted in lower contamination by platinum drugs and fluorouracil. But there is still a need for continuing those processes.

Keywords Occupational safety · Hospitals · Cytostatic agents · Hospital workers · Environmental contamination

1 Introduction

Improving working conditions has been the object of study of many experts in various fields. In hospitals, occupational environment is a concerning for factor risk management, not to ensure the fulfilment of all legal obligations but also because health care professionals, who manipulate cytostatic agents, are exposed to chemical risks that can contribute to their health deterioration, due to everyday contact and exposure time [1].

Cytostatic agents are substances capable of inhibiting or preventing neoplastic cell evolution, reducing malignant cells proliferation and acting on specific stages

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of cellular cycle, particularly on those involved in cell division processes. They feature distinct physical–chemical tasks and act through very different means [2].

Health care professionals who manipulate cytostatic agents may be exposed to chemical risk through several routes, among which stand out the following [3]: Inhalation, cutaneous route, ingestion and accidental injection. Contaminations by these products can be taken up and may generate genotoxic effects. However, due to the implementing of current safety regulations, there have been records of improvements in various countries [4]. This improvement occurred after NIOSH had proposed risk control measures for professionals who manipulate cytostatic agents [5].

Platinum and 5-fluorouracil are the selected for the study, due to their broad application in various neoplasia types, being used to treat many of the most frequent cancers. They can be used in combination with other anticancerogenic medicines [6, 7].

This is a topic which is not very much considered in Portugal, probably due to the inexistence of quantifying laboratory equipment and absence of a specific legal context for the problem that is contamination risk by contact with cytostatic agents. Thus, it is pertinent to study the real impact caused on the occupational environment in Portuguese hospital units where cytostatic agents are regularly manipulated, since the present bibliography consists on exposures in international hospital units and points out various risk situations, mainly in places of cytostatic agents manipulation/preparation and administration (hospital pharmacies and ambulatory care) [8–11].

The number of new cancer cases are increasing every day, and therefore also the number of patients and preparations [12], which is reflected on a greater need for hospitals preparing and administering cytostatic agents and subsequently, involving a larger number of employees. The importance for the professionals' health in these types of services, associated to the fact of the present study having been performed on a single health unit [1], adds relevance to this subject.

2 Methods

Performing this research implied a set of previous actions for its achievement. Thus, written contact was established with the hospital unit's administration in the sense of obtaining authorization for developing the project in its facilities. After receiving affirmative reply, the process of contacting headship and for meeting scheduling with collaborators was carried out. These meetings took place with the headship and employees of the intervening services, i.e., hospital pharmacy, day hospital and control group, for presenting the research project to be carried out and their involvement level. The project was disseminated to collaborators by headship through an institutional email message.

2.1 Observing and Procedures Recording

The project's presentation was followed afterwards by the performing at the hospital pharmacy and day hospital of four observation sessions of procedures and practices, their respective recording and procedures guidelines consultation at the health unit. The first session was aimed at observing procedures and equipment at the hospital pharmacy and day hospital in medical oncology. The second session was aimed at recording procedures and practices in different functions. The third observation session consisted on concluding the procedures and practices recording in different functions. Lastly, the fourth observation served in verifying workplaces in loco to thereby determine sampling points in hospital pharmacies and oncological medicine hospitals.

2.2 Sample Collection Technique

Samples were collected at the hospital pharmacy and day hospital in medical oncology from the hospital unit located in northern Portugal region.

The applied technique for sample collection was the "*wipe sampling*" technique method, used by [8] in studies developed for 5-fluorouracil (5FU) and platinum (Pt) purposes.

"*Wipe sampling*" was applied in this research at the selected hospital B. Sampling purposes and places were determined in accordance with the risk management official. Among the several places, it was defined a set of these at the hospital pharmacy and oncological medicine day hospital (Table 1).

The basis for choosing these sampling spots was the fact of them being susceptible to a high chemical contamination, [13], leaving these organisations' health care professionals exposed to risk and eventual damage.

The research of platinum (Pt) surface contaminations as a marker for platinum-drugs (Cis-, Carbo-, Oxaliplatin) was carried out using paper filters and sample containers along with hydrogen chloride (HCl) in suited percentage of 0,1% as moistening agent, which is included in the "wipe-kit". The same procedure was used for investigations of 5-fluorouracil surface contaminating area, except with methanol (MeOH) as moistening agent.

After the sample collection, they were properly sealed, equipped with cool bags and sent to the "*Institute for Occupational and Environmental Medicine*", University Hospital of Munich for analysing the contamination level at the hospital pharmacy and day hospital in medical oncology of Hospital Unit B, located in Northern Portugal region. Using this technique implies a good logistical planning, to the extent that time between collecting and reaching the laboratory cannot exceed 48 h.

Table 1 Hospital B sampling places

Place reference	Section	Specific place or equipment	Wipe characteristics
1	Hospital Pharmacy	Laminar flow hood (inside with gutter)	30 × 20 cm^2
2	Hospital Pharmacy	Floor in front of LFH	(40 × 40) cm^2
3	Hospital Pharmacy	Transfer chamber	(20 × 20) cm^2
4	Hospital Pharmacy	3 stainless trays	(30 × 30) cm^2
5	Hospital Pharmacy	Reception table	(20 × 20) cm^2
6	Hospital Pharmacy	Packing table	(20 × 20) cm^2
7	Hospital Pharmacy	Transport bag	(30 × 30) cm^2 + (70 × 23) × 2 cm^2
8	Hospital Pharmacy	Waste trolley bin	(28 × 28) × 2 cm^2 + (128 × 4) cm^2
9	Hospital Pharmacy	Storage location (Carbo/Platinum/5-FU)	(30 × 20) cm^2
10	Hospital Pharmacy	Computers Area	(20 × 20) cm^2
11	Hospital Pharmacy	Floor next to computers	(30 × 30) cm^2
12	Hospital Pharmacy	Laminar flow hood–inside–T=Ø	(30 × 20) cm^2
13	Hospital Pharmacy	Laminar flow hood–inside–T=finish	(30 × 20) cm^2
14	Hospital Pharmacy	Storage	(30 × 20) cm^2
15	Day Hospital	Reception table	30 × 20 cm^2
16	Day Hospital	Stainless steel tablet	(30 × 30) cm^2
17	Day Hospital	Transport cart	(30 × 30) cm^2
18	Day Hospital	Waste trolley bin	(28 × 28) × 2 cm^2 + (128 × 4) cm^2
19	Day Hospital	Support treatments	(11 × 13) × 2 cm^2 + (30 × 20) cm^2
20	Day Hospital	Armchair	(42 × 7) × 2 cm^2 + (30 × 30) cm^2
21	Day Hospital	Bathroom door handle (outside)	(15 × 30) cm^2
22	Day Hospital	Bathroom floor	(20 × 20) cm^2

3 Results and Discussion

Samples from 2010 were collected from six points for platinum and 5-fluorouracil, whereas samples from 2015 were collected from 22 points for each of the drugs. Thus, there is a difference in the number of sampling points between the second and the first collection, although two points of the first collection (laminar flow hood support table and patient support table) were not sampled in the second collection since they were inexistent within the current work context. The results of the samples collected in March 2010 and September 2015 at the hospital pharmacy are shown in Table 2 for both drugs being studied.

The results of the samples collected in March 2010 and September 2015 at the day hospital are shown in Table 3 for both drugs being studied.

The TLV proposed by [8] were derived on a statistical basis from a large dataset. Values below TLV-1 (Pt: 0.6 pg/cm^2, 5-FU: 5.0 pg/cm^2) got a "green" traffic light, which means they are in a normal range. Values above TLV-2 (Pt: 4.0 pg/cm^2, 5-FU: 30.0 pg/cm^2) got a "red" traffic light, which means they are too high and there is a need for action. Values between TLV-1 and TLV-2 got a "yellow" traffic light and are suspicious. The sampling results from the year 2010 with many "red" values confirmed the intervention priority at the workplace. Thus, for platinum (Pt), there are four critical points (**) and important to know: inside the laminar flow hood (LFH), floor in front of the laminar flow hood, transfer chamber and patient support table.

Table 2 Platinum and 5-Fluorouracil (5-FU) contamination in Hospital B Pharmacy according to threshold limit values (TLV) as defined by [8]

Cytostatic drug	2010		2015	
	Platinum	5-FU	Platinum	5-FU
Location of sampling	pg/cm^2	pg/cm^2	pg/cm^2	pg/cm^2
Laminar flow hood, inside	292.5	4375.0	0.1	14.2
Laminar flow hood support table	4.0*	5.0		
Laminar flow hood–inside–T=Ø			0.3	4.5
Laminar flow hood–inside–T=finish			0.3	179.3**
Floor in front of LFH (left side)	1457.5**	193.0**	0.2	10.1*
Transfer chamber (left side)	13**	199.3**	0.2	17.0*
3 stainless trays (30 × 30) cm^2			3.0*	12.0*
Reception table (left side)			0.5	3.8
Packing table (left side)			0.3	0.8
Transport bag (30 × 30) cm^2			0.0	1.1
Waste trolley bin			0.0	1.7
Storage location (platinum/5-FU)			0.8*	48.7**
Computers Area			0.1	1.0
Floor next to computers (30 × 30) cm^2			0.1	nn

* >TLV-1, ** >TLV-2; nn < 0,1 ng FU/sample

Table 3 Platinum and 5-Fluorouracil (5-FU) contamination in Day Hospital B according to threshold limit values (TLV) as defined by [8]

Cytostatic drug	2010		2015	
	Platinum	5-FU	Platinum	5-FU
Location of sampling	pg/cm^2	pg/cm^2	pg/cm^2	pg/cm^2
Reception Table (30 × 20) cm^2	3.5*	8.0*	0.1	nn
Patient table	15.8**	10.3*		
Stainless steel tablet (30 × 30) cm^2			0.1	nn
Transport cart (30 × 30) cm^2			0.2	0.8
Waste trolley bin (28 × 28) × 2 cm^2			0	3.1
Support treatments			38.5**	162.2**
Armchair			1.9*	9.4*
Bathroom door handle			7.3**	6.2*
Bathroom floor (left)			750**	146.8**
Storage (30 × 20) cm^2			0.1	nn

* >TLV-1, ** >TLV-2. nn <0,1 ng FU/sample

The remaining points (LFH support table and administration room work desk), are less critical (*), nonetheless, they should also be intervened since they exceed admissible values.

Also 5-fluorouracil FU shows three critical points which are inside the laminar flow hood (LFH), floor in front of the laminar flow hood and transfer chamber.

It should be noted that the existence of two less critical points (administration room work desk and patient support table should also be intervened, since there were detected values higher than admissible ones.

In the study performed in 2015 for platinum at the hospital pharmacy there are two observed places with one star (stainless trays and carbo/platinum shelves). The day hospital in oncology shows three critical places marked by two stars (bathroom floor, bathroom door inside handle and treatment support) and one place marked by a single star (armchair). These places require priority intervention in a sequential manner from two to one star.

5-fluorouracil analysis shows a larger number of places with concentrations in need of intervention since they exceed admissible values. Thus, at the hospital pharmacy there are two critical places marked by two stars (shelves and laminar flow hood, after performing of functions) and four places marked by one star (laminar flow hood with gutter, floor in front of laminar flow hood, transfer chamber and stainless trays). At the day hospital in medical oncology there are two places marked by two stars (treatment support and bathroom floor) and two places marked by one star (armchair and bathroom door outside handle).

Comparing results from the 2015 study with the ones from the 2010 study, we verify that regarding platinum (Pt), all common places were not marked, whereas the 5-fluorouracil (FU) results were marked by one star. It is important to note that the results gathered from the 2015 study show much lower concentrations when

compared with the previous study, whether in the hospital pharmacy or in the day hospital in medical oncology. These values should be associated to various factors among which stand out the following:

Improve procedures in the hospital pharmacy and day hospital in medical oncology, such as using protection equipment and using drug transferring closed system apparatus and centralised preparation.

There have also occurred changes at the physical facilities, especially because it is new, as well as all equipment installed in the preparation room and at the day hospital in medical oncology.

At the hospital pharmacy, there have occurred changes at the preparation professional's level, with the replacing of nurses by pharmacists and pharmacy technicians.

In the day hospital in medical oncology there have also been changes with the use of the drug transferring closed system apparatus [14, 15] and the fact that nursing staff who participated in the 2010 study continue performing their duties in 2015, reveals that they are professionals with experience in manipulating cytostatic agents [12], which can significantly reduce the probability of occurring errors.

4 Conclusion

The problem focus is due to the fact that for the first time in Portugal there have been two studies performed in the same hospital unit, allowing for a comparison. The first study was performed in May 2010 and the second one was performed in September 2015. Comparing both studies resulted in significant improvements in reducing cytostatic agents' contamination, preparation and administration.

Thus, these values should be associated with procedures improvement, greater awareness for this problem and changes made in hospital pharmacy by replacing nursing staff with pharmacists and pharmacy technicians. For the nursing stuff at the day hospital in medical oncology which uses the drug transferring closed system apparatus, it is revealed that they are professionals with experience in manipulating cytostatic agents, as they participated in the 2010 study, as well as in the 2015 study.

However, there are still high concentrations for 5-FU and platinum on the hospital pharmacy's shelves and in treatment support, bathroom door handles and bathroom floor of the oncological medicine day hospital.

As intervention measures to reduce these concentrations, there must be a change of gloves for contacting with the hospital pharmacy's shelves. In the same manner, the cleaning of door handles and bathroom floors at the oncological medicine day hospital must be performed with greater frequency. In treatment support, the use of gloves must be mandatory as well as their frequent exchange.

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