ORIGINAL ARTICLE

The status of drug wastage in the pediatric emergency department of a tertiary hospital

Ibrahim Hakan Bucak[1], Habip Almis[1], Cagla Nur Dogan[2], Mehmet Turgut[1]

[1]Department of Pediatrics, Adiyaman University School of Medicine, Adiyaman, Turkey, [2]Department of Pediatrics, Çukurova University School Medicine, Adana, Turkey

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ABSTRACT

Background: The aim of this study was to evaluate surplus drugs left over from medications used via the intravenous and intramuscular routes in a pediatric emergency unit of a tertiary hospital in Turkey and to determine the financial burden imposed by drug wastage. **Materials and Methods:** The study was planned prospectively on patients presenting to the pediatric emergency department of a tertiary university hospital between January 1 and April 30, 2017, on weekdays and between 08:00 and 16:00, for any reason, and receiving intravenous and/or intramuscular drug administration resulting in drug wastage after treatment. **Results:** The number of patients enrolled in the clinical trial was 1620 (35.9%). Twenty-one different medications were administered via the intravenous or intramuscular (IM) routes during the study. The proportion of total medication wastage at the end of trial was estimated to be 0.425. The drug with the highest proportion of mean wastage to drug form was paracetamol (1000 mg vial) at 0.79. The total cost of the drugs used for the patients in the study was US$580.98, and the overall burden of drug wastage was US$288.09. The three medications involving the highest wastage costs were methylprednisolone, ondansetron, and dexamethasone. The total wastage cost/total drug cost ratio was 0.495. **Conclusion:** If commercial drugs with intravenous and IM formulations are used by the pediatric age group, then dosage formulations appropriate for pediatric age group use also need to be produced. The development by manufacturers of ampoules and similar products suitable for multiple use will also reduce drug wastage. Reducing levels of drug wastage will inevitably reduce the drug expenditure.

Key words: Cost, drug, formulations, pediatric emergency department, wastage

INTRODUCTION

Global expenditure on healthcare is increasing every year. According to the Organisation for Economic Co-operation and Development (OECD), per capita health spending in Turkey was US$1088 in 2016, US$863 of this representing obligatory state health spending.[1] According to the Turkish Institute of Statistics (TIS), health spending in Turkey increased by 15.5% in 2016 as compared to the previous year, reaching a total of US$33.9 billion (3.7% of gross national product). Of these, US$17.02 billion was reported to consist of hospital costs.[2,3] Drug costs represent a significant part of costs incurred in hospitals, whereas the exact proportion of drug costs to total hospital spending in Turkey is unknown.

Although health services specifically aimed at children are available, such as children's hospitals for the pediatric age group, subbranch polyclinics, child development specialist health services, child physiotherapy units, and child oncology centers, no pediatric formulations are available for some drugs used by the IM and intravenous (IV) routes.

Address for correspondence: Dr. Ibrahim Hakan Bucak, Department of Pediatrics, Adiyaman University School of Medicine, Altinşehir Neighborhood, Uygur Site, G-Block No: 32, Adiyaman 02040, Turkey.
E-mail: ihbucak@hotmail.com

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Most drugs in children are dosed according to their body weight.[4] When dosages are calculated based on pediatric patients' body weights using the adult formulations of these drugs, the remaining part of the drug has to be discarded. Several studies of drug wastage have revealed the economic dimension of the effect of waste on the health system.[5-7]

The aim of this study was to assess wastage of drugs used IV and IM in the pediatric emergency department of a tertiary hospital in Turkey and to determine the financial burden imposed by such wastage.

MATERIALS AND METHODS

The study was planned prospectively on patients presenting to the pediatric emergency department of a tertiary university hospital between January 1 and April 30, 2017, on weekdays and between 08:00 and 16:00, for any reason, and receiving IV and/or IM drug administration resulting in drug wastage after treatment.

The active ingredients of the drugs administered, their forms (ampoule, vial) and quantities, the amount of drug administered (milligram = mg), and the amount of drug remaining after the administration dose (drug wastage) (mg) were recorded. If the active ingredients were the same but different dosages of the same drugs were available, this was also taken into account, and those data were recorded (e.g., methylprednisolone 20-mg and 40-mg ampoules). When more than one IV or IM medication was given to a patient, the quantity of the drugs used was recorded and examined separately. Total prices paid for drugs were calculated based on prices paid for medications used by the hospital, and the proportional cost of drug wastage was also measured. Payments by the hospital for drugs were made in Turkish Lira (TL), and were converted into US dollars (US$1 = 3.65 TL) using the exchange rate applied by the Turkish Central Bank at the time of the study (April 2017). Patients presenting to hospital during the study dates but receiving no medication, and patients receiving drugs other than by the IM or IV routes (e.g., oral or rectal administration), and drug formulations other than ampoule or vial (e.g., suspension, syrup, tablet, or capsule) were excluded from the analysis. Data were analyzed by using Statistical Package for the Social Sciences software version 21.0(IBM, Chicago, IL). The study was approved by the local research ethics committee (Protocol no: 2017/2–19).

RESULTS

The total number of presentations to the pediatric emergency department during the study dates and hours was 4512. Of these, 2892 patients, who received no treatment in the pediatric emergency department, who received treatment but no IM or IV administration, or who received IM or IV administration but in whose cases no drug wastage ($n = 135$) was incurred, were excluded from the study. The study was thus performed with 1620 (35.9%) patients. Twenty-one different drugs were administered, either IV or IM, during the study. The total drug quantity used for patients was 194,382.8 mg, and the amount unused (wastage) was 144,213.2 mg. The proportion of wastage to the total drug quantity was 0.425 (42.5%). The drug with the highest proportion of mean wastage per drug form was paracetamol (1000 mg vial) at 0.79, followed by dimenhydrinate (50-mg ampoule) at 0.73 and midazolam (5-mg ampoule) at 0.63. The amount of drug wasted exceeded the amount used in 10 of the 21 drugs.

Our analysis of costs incurred for wasted drugs showed that a mean 9.9 mg per 20-mg ampoule of methylprednisolone was used, whereas 10.1 mg was wasted; a total of US$121.11 was paid for this medication. The total sum paid for ondansetron (4-mg ampoule) was US$57.75 and the total sum paid for dexamethasone (8-mg ampoule) was US$21.31. The total cost of drugs used IM and IV for the patients in the study was US$580.98, whereas the total cost of wasted drugs was US$288.09. The proportion of cost of drug wastage to total drug cost was 0.494. The study data are shown in Table 1.

DISCUSSION

The following countries devote a larger share of their health budget on drug expenditure: the drug costs represent 27.2% of the total health spending in Mexico,[8] in Hungary 29.2%, in Lithuania 26.8%, and in Greece 25.9%.[8] The health spending in the USA was US$3.9 trillion in 2017 . The drug costs represent 10% (US$333.4 billion) of total health spending in the USA.[9] Among these countries, Mexico, with per capita medication spending of US$1080, is the closest country to Turkey in terms of per capita health spending.[1] The proportion of health spending represented by drug costs in Turkey and the budget that hospitals devote to that purpose are unclear.[1,2] However, health spending in Turkey is increasing every year. The measures that reduce health costs will make a substantial contribution to the national budget. The USA represents the largest market for the pharmaceutical industry, followed by the European Union. The per capita drug expenditure in the USA was US$1200 in 2016, whereas in Sweden it is US$350. The most main factor behind this is the high drug prices in the USA. The U.S. government does not directly allow the firms to charge such a high price and intervene to regulate the price of drug as compared with several European countries.[10]

Table 1: Data obtained in the study

Drug name	Drug quantity (mg)- form	Mean quantity of drug used (mg)	Mean quantity of drug unused (mg)	Mean quantity of drug unused /drug quantity form	Cost of unused drugs (US$)	Total cost (US$)
Ondansetron	4-mg ampoule	1.56	2.44	0.61	57.75	94.52
Methylprednisolone	20-mg ampoule	9.9	10.1	0.5	121.11	242.22
	40-mg ampoule	30	10	0.25	1.01	4.05
Pheniramine maleate	45.5-mg ampoule	22.5	23	0.5	7.12	14.24
Dexamethasone	8-mg ampoule	4.67	3.33	0.42	21.31	50.77
Ampicillin-sulbactam	1000-mg vial	689.62	310.38	0.31	13.84	44.67
Midazolam	5-mg vial	1.84	3.16	0.63	10.43	16.56
	15-mg vial	8	7	0.47	0.29	0.62
Ranitidine	50-mg ampoule	34.26	15.74	0.31	1.48	4.78
Metamizole	1000-mg ampoule	462.77	537.23	0.54	2.43	4.51
Ceftriaxone	1000-mg vial	692.85	307.15	0.3	6.31	21.04
Diclofenac	75-mg ampoule	40	35	0.47	0.97	2.08
Paracetamol	1000-mg vial	207.14	792.86	0.79	17.99	22.78
Levetiracetam	500-mg vial	262.85	237.15	0.47	4.97	10.58
Cefazolin	1000-mg vial	575	425	0.42	3.83	9.13
Phenytoin	250-mg ampoule	174	76	0.3	3.43	11.45
Metoclopramide	10-mg ampoule	4	6	0.6	0.52	0.87
Vitamin K1	2-mg ampoule	1	1	0.5	2.07	4.14
Dimenhydrinate	50-mg ampoule	13.3	36.7	0.73	0.9	1.24
Omeprazole	40-mg vial	17	23	0.57	7.13	12.51
Cefuroxime	750-mg vial	600	150	0.2	0.33	1.67
Valproate Sodium	400-mg ampoule	200	200	0.5	2.95	5.91
Diazepam	10-mg ampoule	8	2	0.2	0.12	0.64
					280.09	580.98

Studies concerning drug wastage have reported wastage levels of between 16.6% and 28.7%, depending on types of hospitals and patients.[4,5] Our study shows that the three drugs incurring the greatest financial losses in the pediatric emergency department are methylprednisolone, ondansetron, and dexamethasone. A mean 9.9-mg methylprednisolone was used. As the smallest form available on the market is a 20-mg ampoule, the production of a 10-mg ampoule would reduce the level of drug wastage and the costs incurred. The mean quantity of ondansetron used was 1.56 mg; the smallest form available on the market is a 4-mg ampoule, indicating that the production of a 2-mg ampoule would again reduce the level of drug wastage and the costs incurred. The mean quantity of dexamethasone used was 4.67 mg. However, the smallest form available on the market is an 8-mg ampoule, and we think that wastage and costs could also be reduced by the manufacture of a smaller form. Karamikhah *et al.*[5] reported an 18.05% level of drug wastage in an Obstetric and Children's Hospital in Iran. The level in our study, 42.5%, was considerably higher. The levels of drug wastage and cost analyses in our study reflected only data for weekday and working hours, and the scale of the financial losses incurred will be very much higher when the total numbers of hospitals and patients in Turkey are taken into account.

The high cost of cancer medications means that these constitute 6% of total drug spending in Europe.[11] In a study by Fasola *et al.* [12,13] on cancer drug waste minimization, it was observed that wastage could be reduced by giving patients with the same diagnosis appointments on the same day, inviting patients due to use of the same medication for treatment on the same day, and by calculating dosages before the treatment. The fact that should not be forgotten here is that these are chronic patients and can be invited to hospital by appointment. Appropriate quantities of the drugs that will be administered can therefore be placed in stock beforehand. The establishment of dedicated units in the preparation of chemotherapeutic drugs, and the drugs to be used being prepared in vials permitting re-use, facilitated anti-waste measures. Pollock *et al.*[14] showed that the amount and costs of drugs wasted can be reduced by establishing a new model in growth hormone preparate dose adjustment. Jacobson *et al.*[15] showed that carrying out some vaccinations on the same day within a pediatric vaccination program will have wastage- and cost-reducing effects. Nava-Ocampo *et al.*[16] revealed that the undocumented use of drugs during anesthesia for pediatric patients and drug wastage occurring during anesthesia increased total costs. Mackay *et al.*[17] developed a computer program for prescription for children requiring total parenteral nutrition and showed that drug wastage levels decreased by 90% with the use of this program.

Children presenting to the pediatric emergency department do not do so by appointment, and drugs are not prepared and kept in stock, because patients with the same diagnosis do not present at the same time. Medications are prepared

Table 2: Storage times and conditions after opening of the vials and ampoule forms of the drugs used in the study

Drug name	Shelf life after opening
Ondansetron	Use immediately.[22]
Methylprednisolone	Can be kept for 24 h at 2–8 °C when prepared under appropriate conditions.[22]
Pheniramine maleate	Use immediately.[22]
Dexamethasone	Can be kept for 24 h at 2–8 °C when prepared under appropriate conditions.[22]
Ampicillin-sulbactam	Use immediately.[23]
Midazolam	Can be kept for 24 h at 2–8 °C when prepared under appropriate conditions.[22]
Ranitidine	–
Metamizole	Can be kept for 24 h at 2–8 °C when prepared under appropriate conditions 24.[22]
Ceftriaxone	Can be kept for 24 h at 25 °C or for 4 days at 2–8 °C when prepared under appropriate conditions
Diclofenac	–
Paracetamol	Use immediately.[18] Must be used within 6 h after opening.[19]
Levetiracetam	Can be kept for 24 h at 2–8 °C when prepared under appropriate conditions.[22]
Cefazolin	Can be kept for 8 h at 25 °C or for 24 h at 2–8 °C when prepared under appropriate conditions.[24]
Phenytoin	–
Metoclopramide	–
Vitamin K1	–
Dimenhydrinate	The effective agent has been shown to remain stable after opening for 72 h at 15–25 °C.[25]
Omeprazole	Can be kept for 12 h at 25 °C or for 24 h at 2–8 °C when prepared under appropriate conditions.[22]
Cefuroxime	Can be kept for 24 h at 2–8 °C when prepared under appropriate conditions.[22]
Valproate Sodium	Although the effective substance remains stable for seven days at 20–22 °C when prepared under appropriate conditions, in microbiological terms it can be kept for 24 h at 2–8 °C.[22]
Diazepam	–

and used separately for every patient, and wastage levels are therefore high. The solution is for drugs to be manufactured in pediatric dose formulations. The only paracetamol IV form on the market is a 1000-mg vial, and our findings show that 79% of paracetamol was wasted. On the basis of our findings, the mean quantity of paracetamol used is 207.14 mg. If paracetamol were to be available in 250-mg, 500-mg, and 750-mg formulations, these would be very much preferable for pediatric patients. Similar formulations for paracetamol (1 mL:50 mg; 50 mL:500 mg; 100 mL:1000 mg) are available in the United Kingdom, but not in Turkey. This would reduce paracetamol wastage and financial losses. There is no information in Turkey concerning the use of paracetamol from the moment the vial is opened in the instructions for use, whereas the instructions in the United Kingdom state that consumption should be rapid because of the risk of microbial contamination.[18] Some publications state that paracetamol should be used within 6 h after the vial is opened; otherwise, it should be discarded.[19] As these different statements show, in the most satisfactory manner, the shelf life once the vial has been opened has not been definitively reported. One study concerning whether single-use paracetamol vials are suitable for multiple use stated that there may be a risk of infection in multiple use due to the absence of protective preservatives in vials intended for single use. The manufacturing company also recommends that the product should not be frozen or kept in a fridge, although it is unclear under what conditions opened vials should be stored during the storage period.[20] Kwiatkowski *et al.*[21] reported that the manufacturing company emphasized a 6-h shelf life for paracetamol, whereas other studies have reported that the effective agent remains stable for 48 h after the vial has been opened. The maximum recommended shelf life after the vial has been opened, and the recommended storage conditions must be specified by the manufacturer. The storage times and conditions for the ampoule and flask forms of the drugs used in this study were evaluated together with the relevant literature [Table 2]. As can be seen from Table 2, several flask and ampoule forms can be kept for some time under appropriate conditions after opening. The storage conditions for opened drugs in our emergency department need to be revised. We think that drug wastage can be reduced following such revision.

Karamikhah *et al.*[5] showed that drug wastage is greater in pediatric departments than in adult departments. They also reported in the same study that antibiotics, analgesics, and anticonvulsants had the highest wastage levels, and that ampoules and vials represented 78.6% of all wastages. In agreement with our own findings, Karamikhah *et al.*[5] also recommended the production of pediatric dose drug formulations in order to reduce waste and unnecessary costs.

The limitation of our research is that it is a single-center study that only examines the pediatric emergency department. In our pediatric emergency department, we consider it a limitation not to pay attention to the maximum waiting times for the use of the drugs after opening.

CONCLUSION

Our study reveals that if drugs available in IM and IV formulations are used in the pediatric age group, then these

should also be produced in dose formulations appropriate to that age group. Hospitals should also demand drug dose formulations prepared for the pediatric drug group during the purchasing procedures. The development by manufacturers of ampoules and similar products suitable for multiple use will also reduce drug wastage. We recommend that emergency departments' drug application areas be designed with the storage of opened vials and ampoules in mind. Reducing levels of drug wastage will inevitably reduce drug expenditure.

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Conflicts of interest
There are no conflicts of interest.

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