

Department of Hospital Pharmacy¹, Hospital of the University of Occupational and Environmental Health; Department of Respiratory Medicine², School of Medicine, University of Occupational and Environmental Health; Second Department of Surgery³, School of Medicine, University of Occupational and Environmental Health, Japan

Changes in the impact of high-priced medications on medication wastage in a university hospital

T. Ueki^{1,*}, E. SANEMATSU¹, S. KAWANO¹, T. KISHIMOTO¹, N. KAWAMICHI¹, Y. SHINOHARA¹, K. YATERA², F. TANAKA³

Received August 4, 2022, accepted September 3, 2022

*Corresponding author: Tetsuya Ueki, Department of Hospital Pharmacy, Hospital of the University of Occupational and Environmental Health, 1-1, Iseigaoka, Yahatanishi-ku, Kitakyushu, Fukuoka 807-8556, Japan
uekit@clnc.uoeh-u.ac.jp

Pharmazie 77:343-347 (2022)

doi: 10.1691/ph.2022.2480

Medication wastage is a global issue. This study aimed to clarify changes in the impact of high-priced medications on medication wastage in our university hospital. We investigated the total number and total cost of medication wastage, and the involvement of high-priced medications in each fiscal year (FY) from FY 2013 to FY 2020. During the eight years, total medication wastage did not increase, but total cost increased steadily from 3,959,779 JPY (36,079 USD) in FY 2013 to 12,157,129 JPY (110,767 USD) in FY 2020. Medication wastage of 50,000 JPY (456 USD) or more and 100,000 JPY (911 USD) or more per case were 11 cases and two cases in FY 2013, respectively; however, this increased to 42 cases and 23 cases in FY 2020, respectively. Furthermore, the costs of medication wastage of 50,000 JPY or more and 100,000 JPY or more per case were 1,018,111 JPY (9,276 USD) and 471,731 JPY (4,298 USD) in FY 2013, respectively, but increased significantly to 8,812,954 JPY (80,297 USD) and 7,510,415 JPY (68,430 USD) in FY 2020, respectively. The most common medication type among medication wastage of high-priced medications was antineoplastic agents such as protein kinase inhibitors and monoclonal antibodies. These findings indicate that high-priced medications have the largest impact on the cost of medication wastage and suggest the need for efforts on medication management focusing on antineoplastic agents.

1. Introduction

Medication wastage, also referred to as pharmaceutical waste, is generated by healthcare activities. The definition of medication wastage by the World Health Organization (WHO) is expired, unused, spilt, and contaminated pharmaceutical products, prescribed and proprietary drugs, vaccines, and sera that are no longer required (WHO 2017). Medication wastage is a global issue, and its economic cost is a serious social concern. At the national level, the United Kingdom's National Health Service estimated the annual losses by wasted prescription medications at 300 million GBP in 2009 (Hazell and Robson 2015). Most previous studies of medication wastage have focused on prescribed medications in the possession of patients (Abou-Auda 2003; Law et al. 2015; Monga et al. 2019; Vogler and de Rooij 2018; West et al. 2014); however, medication wastage also occurs in hospitals managed by healthcare professionals (Al-Dhawailie 2011; AlSamanhodi et al. 2017; Ebrahim et al. 2019; Peltoniemi and Suomi 2019; Ueki et al. 2022), and research in this area is limited (West et al. 2014).

Prescription medication costs are steadily increasing due to rising prices for new medications (Burns et al. 2020; Chen et al. 2017; Gronde et al. 2017; Prasad et al. 2017; Shibata et al. 2018). In Japan, nivolumab, an immune checkpoint inhibitor, was approved for health insurance for the first time in 2014 and its high medication costs have sparked social debate about the sustainability of the health insurance system (Niki 2020). After that, many extremely high-priced medications have been released such as ipilimumab (Suzuki et al. 2016) and onasemnogene abeparvovec (Kotulska et al. 2021). Currently, high-priced medications are commonly used for treatment in hospitals that provide advanced medical care, and the wastage of these medications is a burden on hospital management. However, little is known about the changes

in the impact of high-priced medications on medication wastage in recent years.

In the present study, we investigated the changes in medication wastage of high-priced medications in our university hospital during an eight-year study period.

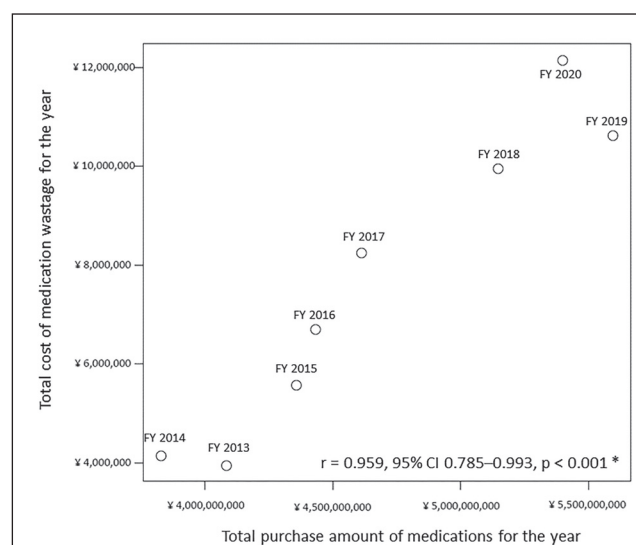


Fig. 1: Correlation between total purchase amounts of medications and total costs of medication wastage
Abbreviations: FY, fiscal year; CI, confidence interval.
* Pearson's correlation coefficient analysis

2. Investigations and results

2.1. Changes in total number and total cost of medication wastage

We counted the numbers and costs of medication wastage in the hospital of the University of Occupational and Environmental Health, Japan. Changes in total number and total cost of medication wastage between fiscal year (FY) 2013 and FY 2020 are shown in Table 1. Although total medication wastage did not tend to increase, the total cost steadily increased every FY. Total cost of medication wastage and the total purchase amount of medications for each FY are shown in the Fig. A significant positive correlation was found for these variables ($r = 0.959$, 95% confidence interval 0.785–0.993, $p < 0.001$). The proportions of the total cost of medication wastage to the total purchase amount of medications for each FY were: 0.10% in FY 2013, 0.11% in FY 2014, 0.13% in FY 2015, 0.15% in FY 2016, 0.18% in FY 2017, 0.19% in FY 2018, 0.19% in FY 2019, and 0.23% in FY 2020.

Table 1: Changes in total numbers and total costs of medication wastage

| | | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 | FY 2018 | FY 2019 | FY 2020 |
|---|-----|------------|------------|------------|------------|------------|------------|------------|-------------|
| Total number of medication wastage for the year | | 3,480 | 3,426 | 3,977 | 3,815 | 3,810 | 3,766 | 3,762 | 2,968 |
| Total cost of medication wastage for the year | JPY | ¥3,959,779 | ¥4,150,314 | ¥5,577,899 | ¥6,703,240 | ¥8,252,473 | ¥9,958,100 | ¥0,624,899 | ¥12,157,129 |
| | USD | \$36,079 | \$37,815 | \$50,822 | \$61,075 | \$75,191 | \$90,731 | \$96,806 | \$110,767 |

The cost calculated in JPY was converted to USD using the currency exchange rate of 2021 announced by the Organisation for Economic Co-operation and Development (1 USD = 109.754 JPY). Abbreviation: FY, fiscal year.

Table 2: Changes in numbers and costs of medication wastage in high-priced medications of 50,000 JPY (456 USD) or more per case and 100,000 JPY (911 USD) or more per case

| | | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 | FY 2018 | FY 2019 | FY 2020 |
|--|-----|------------|------------|------------|------------|------------|------------|------------|------------|
| Number of medication wastage of 50,000 JPY (456 USD) or more per case | | 11 | 15 | 16 | 24 | 38 | 33 | 45 | 42 |
| Proportion of the total number | | 0.32% | 0.44% | 0.40% | 0.63% | 1.00% | 0.88% | 1.20% | 1.42% |
| Cost of medication wastage of 50,000 JPY (456 USD) or more per case | JPY | ¥1,018,111 | ¥1,391,257 | ¥2,625,943 | ¥3,435,443 | ¥4,978,543 | ¥6,319,345 | ¥7,301,558 | ¥8,812,954 |
| | USD | \$9,276 | \$12,676 | \$23,926 | \$31,301 | \$45,361 | \$57,577 | \$66,527 | \$80,297 |
| Proportion of the total cost | | 25.7% | 33.5% | 47.1% | 51.3% | 60.3% | 63.5% | 68.7% | 72.5% |
| Number of medication wastage of 100,000 JPY (911 USD) or more per case | | 2 | 5 | 6 | 11 | 16 | 22 | 25 | 23 |
| Proportion of the total number | | 0.06% | 0.15% | 0.15% | 0.29% | 0.42% | 0.58% | 0.66% | 0.77% |
| Cost of medication wastage of 100,000 JPY (911 USD) or more per case | JPY | ¥471,731 | ¥750,713 | ¥1,945,316 | ¥2,506,535 | ¥3,350,108 | ¥5,568,697 | ¥5,833,271 | ¥7,510,415 |
| | USD | \$4,298 | \$6,840 | \$17,724 | \$22,838 | \$30,524 | \$50,738 | \$53,149 | \$68,430 |
| Proportion of the total cost | | 11.9% | 18.1% | 34.9% | 37.4% | 40.6% | 55.9% | 54.9% | 61.8% |

The numbers and costs of medication wastage of 50,000 JPY (456 USD) or more per case includes those of 100,000 JPY (911 USD) or more per case. The cost calculated in JPY was converted to USD using the currency exchange rate of 2021 announced by the Organisation for Economic Co-operation and Development (1 USD = 109.754 JPY). Abbreviation: FY, fiscal year.

2.3. Reasons for medication wastage of high-priced medications

The reasons for medication wastage of 50,000 JPY or more per case and 100,000 JPY or more per case for every FY are shown in Table 3. During the eight-year study period, expired medications and change or discontinuation of medication after preparation increased as reasons for medication wastage of high-priced medications.

2.4. Medication types for medication wastage in high-priced medications

The medication types of medication wastage of 50,000 JPY or more per case and 100,000 JPY or more per case for every FY are shown in Table 4. During the eight-year study period, medication wastage of high-priced antineoplastic agents (Anatomical Therapeutic Chemical [ATC] code second level L01), especially protein kinase inhibitors (ATC code third level L01E), monoclonal antibodies, and antibody drug conjugates (ATC code third level L01F), increased.

2.2. Changes in numbers and costs of medication wastage of high-priced medications

The numbers and costs of medication wastage of 50,000 JPY (456 USD) or more per case and 100,000 JPY (911 USD) or more per case, and their proportions of the total numbers and the total costs every FY are shown in Table 2. The numbers of medication wastage of 50,000 JPY or more and 100,000 JPY or more per case were 11 cases (0.32% of the total number) and two cases (0.06%), respectively, in FY 2013; however, these increased to 42 cases (1.42%) and 23 cases (0.77%), respectively, in FY 2020. Furthermore, the costs of medication wastage of 50,000 JPY or more and 100,000 JPY or more per case were 1,018,111 JPY (9,276 USD) (25.7% of the total cost) and 471,731 JPY (4,298 USD) (11.9%), respectively, in FY 2013, but these increased significantly to 8,812,954 JPY (80,297 USD) (72.5%) and 7,510,415 JPY (68,430 USD) (61.8%), respectively, in FY 2020.

3. Discussion

The aim of this study was to clarify changes in medication wastage of high-priced medications in our hospital. Our results showed that the numbers and costs of medication wastage of high-priced medications increased over the study period. Moreover, the wastage of high-priced medications had a significant impact on the total medication wastage cost. Expired medications and change or discontinuation of medication after preparation increased among the reasons for the medication wastage of high-priced medications. The most common medication type in the medication wastage of high-priced medications was antineoplastic agents such as protein kinase inhibitors and monoclonal antibodies.

The increase in total purchase amount of medications was correlated with an increase in the total cost of medication wastage. In addition, the proportion of the total cost of medication wastage to the total purchase amount of medications gradually increased. One explanation for this may be the increasing frequency of high-priced medications used for rare diseases (Luzzatto et al. 2018; McCabe et al. 2010) and personalized cancer chemotherapy (Chen et al. 2017). Although these medications were only used in a few

Table 3: Reasons for medication wastage of high-priced medications

| | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 | FY 2018 | FY 2019 | FY 2020 |
|---|---------|---------|---------|---------|---------|---------|---------|---------|
| Change or discontinuation of medication after preparation | 4 (1) | 7 (2) | 6 (3) | 12 (7) | 17 (9) | 18 (12) | 17 (9) | 8 (8) |
| Breakage or contamination due to dropping | 3 | 1 | 1 | 1 (1) | 1 | | 1 (1) | 2 (1) |
| Preparation error | 3 | | 3 (1) | 2 | 3 (1) | 4 (2) | 1 (1) | 3 (1) |
| Expired medications | 1 (1) | 5 (3) | 3 | 7 (1) | 10 (5) | 7 (5) | 23 (14) | 26 (11) |
| Discontinuation due to adverse reactions such as allergic reactions | | | | 1 (1) | 4 (1) | 3 (3) | | 2 (2) |
| Damage due to mishandling | | 2 | | 1 (1) | | | | 1 |
| Medication administration error | | | 2 (2) | | 1 | | 1 | |
| Other | | | 1 | | 2 | 1 | 2 | |

Values are numbers of medication wastage of 50,000 JPY (456 USD) or more per case, and in the parentheses are medication wastage of 100,000 JPY (911 USD) or more per case. The numbers of medication wastage of 50,000 JPY (456 USD) or more per case includes those of 100,000 JPY (911 USD) or more per case. Abbreviation: FY, fiscal year.

patients, they were unlikely to be reused by other patients and, if discontinued, were wasted due to expiration. Furthermore, we found that expired medication was the most common reason for medication wastage in high-priced medications. A particular focus should be placed on the management of infrequently used high-priced medications to reduce the total cost of medication wastage, such as optimizing orders and inventory, at hospital pharmacy departments (American Society of Health-System Pharmacists 2008).

In the present study, the most wasted high-priced medication type was antineoplastic agents. A previous study reported that the purchase costs of antineoplastic agents have a significant positive correlation with the total purchase amount of medications and account for a large proportion of the total purchase cost (Sakurada et al. 2022). Thus, hospitals offering active cancer chemotherapy, such as our hospital, have higher medication purchase costs. Attention should be paid to their management to reduce the cost of medication wastage.

In the practice of cancer chemotherapy in hospitals, antineoplastic agents are often dose-reduced, medication-changed, or discontinued because of adverse effects or disease progression (Ang et al. 2020; Layton et al. 2019; Monga et al. 2019). As a result, unused antineoplastic agents eventually expire if they cannot be reused by other patients. Although these patient factors are unavoidable, it is difficult to promote the use of leftover antineoplastic agents.

On the other hand, one of the major reasons for the medication wastage of high-priced medications was change or discontinuation of medication after preparation. Specifically, on the day of administration, if blood examination results, such as neutropenia, or changes to a patient's condition, such as fever, require dose reduction or discontinuation of injectable antineoplastic agents after their preparation, the mixed antineoplastic agents are wasted. This medication wastage can be reduced by healthcare professionals carefully checking the results of blood examinations and the patient's condition on the day of administration. For example, checking medical orders prior to the preparation of antineoplastic agents by hospital pharmacists is expected to reduce medication wastage (Yamada et al. 2020); thus, we should be proactive in addressing preventable medication wastage.

Our study had some limitations. First, this study was conducted in a single advanced treatment hospital; therefore, our results may not be transferable to other hospitals. Second, specific plans that are currently feasible within the hospital to minimize medication wastage were not examined in this study. Further research is needed to establish an effective strategy.

In conclusion, our study found that the number and cost of medication wastage in high-priced medications has increased in recent years, with a large impact on cost. Antineoplastic agents, such as protein kinase inhibitors and monoclonal antibodies, were the most common medication type among medication wastage of high-priced medications, which suggests the need for medication management efforts to reduce waste due to expired medications and change or discontinue drugs after preparation of those medications.

4. Experimental

4.1. Study setting

This study was conducted at the hospital of the University of Occupational and Environmental Health (Kitakyushu, Japan), which is an advanced treatment hospital and a designated regional cancer care hospital with 678 beds.

4.2. Data source

As a routine workflow in our hospital, information on the medications that could not be used or completely administered (excluding reusable and/or re-dispensable medications) was reported by healthcare professionals in each department as a "Medication Disposal Report", and these reports were submitted to the hospital pharmacy department. The reports submitted in the period from April 2013 to March 2021 were used for analysis. The submitted reports during the eight-year study period were evaluated by hospital pharmacists and were aggregated for each medication type by the quantity of each report. For example, if one report described that an injection consisting of two medication vials and one infusion solution bottle were wasted, these were each aggregated into one case. The submitted reports were aggregated for each FY from April of that year to March of the following year (for example, FY 2013 was from April 2013 to March 2014).

4.3. Definition

The definition of medication wastage of high-priced medication in our hospital was 50,000 JPY or more per case (Ueki et al. 2022).

4.4. Cost calculation

Medication costs were calculated based on the purchase prices at our hospital. The cost calculated in JPY was converted to USD using the currency exchange rate of 2021 (1 USD = 109.754 JPY) (Organisation for Economic Co-operation and Development 2022).

4.5. Medication classification

The medication types were categorized based on the ATC classification system (WHO Collaborating Centre for Drug Statistics Methodology 2021), and ATC codes up to the third level (pharmacological subgroup level) were investigated in this study.

4.6. Statistical analysis

The correlation between total purchase amounts of medications and total costs of medication wastage was assessed by Pearson's correlation coefficient analysis after testing the normality of each data. The level of significance was set at $p < 0.05$. Statistical analyses were performed with EZR software (version 1.35), which is a graphical user interface for R (Kanda 2013).

4.7. Ethical approval

Ethical approval by the Ethics Committee of Medical Research of our university was not applicable as this study did not include any human subjects.

Conflicts of interest: None declared

References

- Abou-Auda HS (2003) An economic assessment of the extent of medication use and wastage among families in Saudi Arabia and Arabian Gulf countries. *Clin Ther* 25: 1276–1292.
- Al-Dhawali AA (2011) Control of intravenous medication wastage at a teaching hospital in Saudi Arabia. *Saudi Med J* 32: 62–65.

Table 4: Medication types for medication wastage in high-priced medications

| First level (Anatomical main group) | Second level (Therapeutic subgroup) | Third level (Pharmacological subgroup) | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 | FY 2018 | FY 2019 | FY 2020 |
|---|---|---|---------|---------|---------|---------|---------|---------|---------|---------|
| A: Alimentary tract and metabolism | A16: Other alimentary tract and metabolism products | A16A: Other alimentary tract and metabolism products | | | | | | | | 1 (1) |
| | B01: Antithrombotic agents | B01A: Antithrombotic agents | | 3 | 2 | 4 | 4 | 5 (1) | 6 (1) | 3 (1) |
| B: Blood and blood-forming organs | B02: Antihemorrhagics | B02B: Vitamin K and other hemostatics | 6 | 1 | 2 | | 1 | | 2 (2) | 4 (3) |
| | B06: Other hematological agents | B06A: Other hematological agents | | | | | | | | 1 |
| D: Dermatologicals | D11: Other dermatological preparations | D11A: Other dermatological preparations | | | | | | | 1 | 1 |
| H: Systemic hormonal preparations, excl. sex hormones and insulins | H01: Pituitary and hypothalamic hormones and analogues | H01A: Anterior pituitary lobe hormones and analogues | | 1 | | | | | | 2 |
| | J01: Antibacterials for systemic use | J01X: Other antibacterials | | | | | | | 1 | |
| | J02: Antimycotics for systemic use | J02A: Antimycotics for systemic use | | | | | 1 | | 1 (1) | |
| | J04: Antimycobacterials | J04A: Drugs for treatment of tuberculosis | | | | | | | | 1 |
| J: Antiinfectives for systemic use | J05: Antivirals for systemic use | J05A: Direct acting antivirals | | 2 (1) | | 2 | 3 (2) | | 7 (4) | 1 |
| | J06: Immune sera and immunoglobulins | J06B: Immunoglobulins | | | 1 | 1 | 2 | | 1 | 1 |
| | J07: Vaccines | J07B: Viral vaccines | | | | | | | 1 (1) | 1 |
| | | L01A: Alkylating agents | | | 1 | | 3 (3) | | 1 | 2 (1) |
| | | L01B: Antimetabolites | 1 (1) | | 3 (2) | 3 (3) | | 2 (2) | 1 | |
| | | L01C: Plant alkaloids and other natural products | 1 | | 1 (1) | | 1 | 3 (1) | 1 | |
| | L01: Antineoplastic agents | L01D: Cytotoxic antibiotics and related substances | | | 1 | | 1 | | | |
| | | L01E: Protein kinase inhibitors | | 1 | 1 | 2 (1) | | 2 (1) | 4 (3) | 10 (5) |
| L: Antineoplastic and immunomodulating agents | | L01F: Monoclonal antibodies and antibody drug conjugates | 1 (1) | | 3 (2) | 6 (5) | 14 (9) | 13 (11) | 7 (7) | 7 (7) |
| | | L01X: Other antineoplastic agents | 1 | 3 (1) | | | 2 (1) | 2 | 5 (3) | |
| | | L02A: Hormones and related agents | | 1 | | | 2 | | | |
| | L02: Endocrine therapy | L02B: Hormone antagonists and related agents | | | | | | 1 (1) | | |
| | L03: Immunostimulants | L03A: Immunostimulants | | | | 1 | 3 | | 1 | |
| | L04: Immunosuppressants | L04A: Immunosuppressants | 1 | | | 3 (2) | 1 (1) | 1 (1) | 4 (2) | 4 (2) |
| | N02: Analgesics | N02A: Opioids | | 2 (2) | | | | 1 (1) | | |
| N: Nervous system | N04: Anti-parkinson drugs | N04B: Dopaminergic agents | | | | 1 | | | | |
| | N05: Psycholeptics | N05A: Antipsychotics | | | | 1 | | | | |
| R: Respiratory system | R03: Drugs for obstructive airway diseases | R03D: Other systemic drugs for obstructive airway diseases | | 1 (1) | | | | | | |
| S: Sensory organs | S01: Ophthalmologicals | S01L: Ocular vascular disorder agents | | | 1 (1) | | | 2 (2) | | 2 (2) |
| V: Various | V03: All other therapeutic products | V03A: All other therapeutic products | | | | | | 1 (1) | 1 (1) | 1 (1) |

Values are numbers of medication wastage of 50,000 JPY (456 USD) or more per case, and in the parentheses are medication wastage of 100,000 JPY (911 USD) or more per case. The numbers of medication wastage of 50,000 JPY (456 USD) or more per case includes those of 100,000 JPY (911 USD) or more per case. Medication types were categorized based on the Anatomical Therapeutic Chemical (ATC) classification system. Abbreviation: FY, fiscal year.

AlSamanhodi H, Almeshary M, Amoh K, Aldekhail S, Alkatheri A, Alharbi S, AlAmari M, AbuRuz S, Albekairy A (2017) Evaluation of the causes and cost impact of returned intravenous medications at a tertiary care hospital in Riyadh, Saudi Arabia. *Trop J Pharm Res* 16: 231–237.

American Society of Health-System Pharmacists; ASHP Expert Panel on Medication Cost Management (2008) ASHP guidelines on medication cost management strategies for hospitals and health systems. *Am J Health Syst Pharm* 65: 1368–1384.

Ang ZY, Cheah KY, Abdullah NB, Samsuri SB, Lee SH, Yem AW, Sriraman MA (2020) Parenteral cytotoxic drug wastage at a tertiary hospital in Kuala Lumpur: how much and why? *J Oncol Pharm Pract* 26: 1306–1317.

Burns TM, Crowell JL, Smith AG (2020) A crisis in US drug pricing: Consequences for patients with neuromuscular diseases, physicians and society, part 1. *Muscle Nerve* 62: 567–572.

- Chen Q, Jain N, Ayer T, Wierda WG, Flowers CR, O'Brien SM, Keating MJ, Kantarjian HM, Chhatwal J (2017) Economic burden of chronic lymphocytic leukemia in the era of oral targeted therapies in the United States. *J Clin Oncol* 35: 166–174.
- Ebrahim AJ, Teni FS, Yimenu DK (2019) Unused and expired medications: are they a threat? A facility-based cross-sectional study. *J Prim Care Community Health* 10: 2150132719847857.
- Gronde TV, Uyl-de Groot CA, Pieters T (2017) Addressing the challenge of high-priced prescription drugs in the era of precision medicine: A systematic review of drug life cycles, therapeutic drug markets and regulatory frameworks. *PLoS One* 12: e0182613.
- Hazell B, Robson R (The National Health Service Business Services Authority: NHS BSA) (2015) Pharmaceutical waste reduction in the NHS: A best practice compilation paper. < <https://www.england.nhs.uk/wp-content/uploads/2015/06/pharmaceutical-waste-reduction.pdf> > accessed 14 May 2022.
- Kanda Y (2013) Investigation of the freely available easy-to-use software 'EZR' for medical statistics. *Bone Marrow Transplant* 48: 452–458.
- Kotulska K, Fattal-Valevski A, Haberlova J (2021) Recombinant adeno-associated virus serotype 9 gene therapy in spinal muscular atrophy. *Front Neurol* 12: 726468.
- Law AV, Sakharkar P, Zargarzadeh A, Tai BW, Hess K, Hata M, Mireles R, Ha C, Park TJ (2015) Taking stock of medication wastage: Unused medications in US households. *Res Social Adm Pharm* 11: 571–578.
- Layton JL, Lewis B, Ryan C, Beer TM, Sartor O (2019) Recycling discarded drugs: Improving access to oral antineoplastic drugs. *Oncologist* 24: 291–292.
- Luzzatto L, Hyry HI, Schieppati A, Costa E, Simoens S, Schaefer F, Roos JCP, Merlini G, Käähriäinen H, Garattini S, Hollak CE, Remuzzi G; Second Workshop on Orphan Drugs participants (2018) Outrageous prices of orphan drugs: a call for collaboration. *Lancet* 392: 791–794.
- McCabe C, Edlin R, Round J (2010) Economic considerations in the provision of treatments for rare diseases. *Adv Exp Med Biol* 686: 211–222.
- Monga V, Meyer C, Vakiner B, Clamon G (2019) Financial impact of oral chemotherapy wastage on society and the patient. *J Oncol Pharm Pract* 25: 824–830.
- Niki R (2020) Recent debate over how to tackle rapid increases in pharmaceutical expenditure in Japan. *JMA J* 3: 146–148.
- Organisation for Economic Co-operation and Development (2022) OECD data: Exchange rates < <https://data.oecd.org/conversion/exchange-rates.htm> > accessed 16 July 2022.
- Peltoniemi T, Suomi R (2019) Eliminating medicine waste in a Finnish university hospital – a qualitative study. *J Pharm Policy Pract* 12: 27.
- Prasad V, De Jesús K, Mailankody S (2017) The high price of anticancer drugs: origins, implications, barriers, solutions. *Nat Rev Clin Oncol* 14: 381–390.
- Sakurada H, Naito K, Teramachi H (2022) Research on the ratio of anti-cancer drug purchase costs at municipal hospitals in the Aichi Prefecture. *Gan To Kagaku Ryoho* 49: 53–57.
- Shibata S, Matsushita M, Saito Y, Suzuki T (2018) Anticancer drug prescription patterns in Japan: Future directions in cancer therapy. *Ther Innov Regul Sci* 52: 718–723.
- Suzuki S, Ishida T, Yoshikawa K, Ueda R. Current status of immunotherapy (2016) *Jpn J Clin Oncol* 46: 191–203.
- Ueki T, Sanematsu E, Kawano S, Nakamura Y, Kawamichi N, Shinohara Y, Yatera K, Tanaka F (2022) Medication wastage in a university hospital in Japan. *Biol Pharm Bull* 45: 118–123.
- Vogler S, de Rooij RHPF (2018) Medication wasted – Contents and costs of medicines ending up in household garbage. *Res Social Adm Pharm* 14: 1140–1146.
- West LM, Diack L, Cordina M, Stewart D (2014) A systematic review of the literature on 'medication wastage': an exploration of causative factors and effect of interventions. *Int J Clin Pharm* 36: 873–881.
- World Health Organization (2017) Safe management of wastes from health-care activities: A summary. < <https://www.who.int/publications/i/item/WHO-FWC-WSH-17.05> > accessed 14 May 2022.
- WHO Collaborating Centre for Drug Statistics Methodology (2021) Guidelines for ATC classification and DDD assignment 2022. < https://www.whocc.no/filearchive/publications/2022_guidelines_web.pdf > accessed 14 May 2022.
- Yamada H, Kobayashi R, Shimizu S, Yamada Y, Ishida M, Shimoda H, Kato-Hayashi H, Fujii H, Iihara H, Tanaka H, Suzuki A (2020) Implementation of a standardised pharmacist check of medical orders prior to preparation of anticancer drugs to reduce drug wastage. *Int J Clin Pract* 74: e13464.