TANZANIA MEDICAL JOURNAL
Maganda et al. TMJ V 35 No. 1. March 2024

Original Research Open Access

Effectiveness of Drug Dispensing Systems at a Tertiary Hospital in Tanzania: A Comparative Study

Betty A. Maganda[1], Suzana A. Majule[2], David T. Myemba[1]*

[1]Department of Pharmaceutics and Pharmacy Practice, School of Pharmacy, Muhimbili University of Health and Allied Sciences, Dar es Salaam, Tanzania
[2]Medical Stores Department, Headquarters, Dar es Salaam, Tanzania

***Corresponding author:**

David T. Myemba

Muhimbili University of Health and Allied Sciences

P. O. Box 65001

Dar es Salaam, Tanzania

Email: dmyemba09@gmail.com

Original Research Open Access

Abstract

Introduction

The quality of pharmaceutical care is affected by the nature of the drug dispensing system in a facility. This study evaluated the effectiveness and operational labor costs between traditional drug dispensing systems (TDDS) and Unit Dose Drug Dispensing Systems (UDDS) at a tertiary hospital in Tanzania.

Methods

A comparative mixed-method cross-sectional study was conducted at Muhimbili National Hospital involving patients and healthcare professionals (HCPs). Data for medication errors, missed doses, dispensing times, and operational labor costs were collected in standardized collection forms. Qualitative data was collected through in-depth interviews. Thematic analysis was used for qualitative data, while descriptive statistics were used for quantitative data. Comparisons were done by using a t-test, X^2 test, and Odds Ratio (OR), a p-value <0.05 was considered for statistical significance.

Results

The study enrolled 243 patients, finding that patients using TDDS were 16.6 times more likely to miss a dose. Labour costs were statistically significantly higher in UDDS than in TDDS (p=0.003). Also, UDDS had a higher number of patients with medication errors (54.7%) compared to TDDS (45.3%). The average dispensing time was longer (96 minutes) in UDDS compared to 72 minutes in TDDS. HCPs perceived UDDS as a more effective dispensing system than TDDS through improving inter-professional relationships and drug availability to patients.

Conclusion

The unit-dose dispensing system effectively reduces missed doses and enhances drug availability to patients and inter-professional relationships but incurs higher labor costs than the traditional dose dispensing system. Its use in other healthcare settings is recommended after operational cost improvement.

Keywords: *Effectiveness, Drug dispensing systems, Tertiary hospital, Tanzania.*

Introduction

Worldwide, traditional dose dispensing systems (TDDS) and unit-dose dispensing systems (UDDS) are among the most employed hospital-based drug dispensing systems (DDS) (1). The TDDS has been the major operating DDS in healthcare settings for decades (2). In TDDS, nurses manage and administer medicines to patients whereas, the pharmacy is the key supplier (3,4). However, the system had several challenges such as poor management, wastage, and pilferage of medicine within hospital wards (5). In UDDS, medicines are dispensed in a unit dose that fulfils patient needs for 24 hours (3,6),[3] The UDDS was developed in the 1960s and aimed to support nurses and pharmacists in improving the medication administration procedure (1,6). The UDDS enables pharmacists to be more involved in-patient care by expanding their roles in counselling and treatment monitoring (2,7). Advantages of the UDDS include but are not limited to reduction of medication errors and healthcare costs, efficient usage of pharmacy and nursing personnel, improved overall drug control and use monitoring, and accurate patient drug billings (1,2,4,6).

Globally, the UDDS is adopted by many healthcare settings, especially in developed countries (7,8). However, most healthcare settings in developing countries such as Tanzania still use the TDDS since the UDDS is associated with increased operational and technology costs (9,10). In Tanzania, most public health facilities employ mixed DDS such as TDDS and UDDS (11). In 2019, the UDDS was introduced in a few wards of the Tanzanian tertiary referral hospital under the one-time taking program. Irrational medicine use, pilferage, poor management of medicines within the hospital wards, and increased medical costs to patients and the hospital (unpublished hospital data) were influencers of this change. Thus, in this study, the effectiveness of UDDS and TDDS was evaluated regarding patient medication safety, dose coverage, dispensing time, and operational labour costs.

Methods

Study design and setting

A comparative mixed-method cross-sectional study employing both quantitative and qualitative methods was conducted at Muhimbili National Hospital, (MNH) a tertiary hospital in Dar es Salaam, Tanzania, between May and June 2021. Two wards that employ UDDS and TDDS with a daily admission of about 180 patients with similar medical conditions were involved in the study.

Study population

The quantitative study included all in-patients aged 18 years and older, admitted to the two wards, and with new prescriptions on the survey day. The study excluded terminally ill patients who couldn't provide informed consent or patients who were already discharged on the survey day. The qualitative study involved all nurses, pharmacists, and medical doctors working in the two wards, while the limit of recruitment was determined by data saturation.

Sample size calculation and sampling techniques

Quantitative: This study utilized a census approach to enroll patients admitted in two selected wards using either UDDS or TDDS and meeting inclusion criteria like new prescription, not terminally ill, or discharged on the study day. A purposive sampling method was used to obtain the sample size. Thus, a total of 243 patients were enrolled in this study, as shown in the flow diagram for study participant enrolment (Figure 1).

Qualitative: Experts' opinions were used to obtain the least number of study participants, whereby, according to Creswell (1998), 5–25 participants are sufficient to address the required phenomenon (12). Hence, this study included 9 pharmacists, 7 nurses, and 6 doctors. Sampling stopped when saturation of information was obtained.

Data collection

For the quantitative study, standardized checklists were used to collect data for medication errors, average dispensing time, and missed doses. A data abstraction form was used to collect data for operational labour costs. Individual patient information such as age, weight, religion, gender, and financing status were obtained from the patient's medical files and filled in the checklist. Each patient was assigned a unique study identity (ID). All patients were followed up for 24 hours.

Medication errors

Patients' prescriptions were screened and then the patients were followed up for 24 hours to identify medication error (s). A medication error (s) was identified when one or more of the following five conditions of rational use of medicines (RUM) was or were not fulfilled (7,9,12,13).

The Five rights (5Rs) of medication safety;

- Right medicine
- Right patient
- Right dose
- Right route of administration
- Right time

Average dispensing time

The time spent by the pharmacist to verify and record prescriptions in an electronic system and pack, label, and dispense medicine for each patient was observed and recorded.

Missed doses

The patient's dosing information was collected from treatment charts. For each dose to be administered, the time was noted and followed up to confirm whether the patient had received the prescribed dose.

Operational labour cost

The cost of labour was computed for the twelve months of the year 2021. Labor costs included salaries and financial incentives.

Perceptions of healthcare professionals toward the drug dispensing systems

For the qualitative study, a semi-structured questionnaire (topic guide) was utilized in the in-depth interviews with the HCPs to explore their perceptions of UDDS and TDDS. The guided interviews comprised two parts. Part I consisted of participants' social-demographic information, and Part II consisted of ten guiding interview questions. The guided interviews were recorded using digital audio recorders.

Ethical considerations

The study received ethical clearance from the Muhimbili University of Health and Allied Sciences, Research Ethical Committee and Institutional Review Board (Ref. No. DA.282/298/01.C/ MUHAS-REC-05-2021-601). Informed consent was obtained from all participants before the interview. To ensure confidentiality, only numbers were used to identify study participants.

Data management and analysis

Quantitative data analysis

The Statistical Package for Social Sciences (SPSS) version 23 was used for quantitative data analysis. Descriptive statistics were used to summarise the data. The number of patients with medication errors and missed doses from each ward was determined. Comparison of medication errors was done by using a Chi-square test, while the likelihood of patients missing a dose was compared by using an odds ratio (OR). The average dispensing time was presented using mean (SD) and compared using t-tests. Labor costs for UDDS and TDDS were directly calculated from the hospital's accounts department. Currency

conversions were done according to the OANDA rates at the time.[14] A p <0.05 was considered statistically significant at a 95% confidence level.

Qualitative data analysis

The NVivo 11 plus software was used for qualitative data analysis. The recorded interviews were transcribed verbatim and then a thematic analysis approach was used for analysis. The specific objectives of the study were used to obtain the domains and predetermined codes, whereas the transcribed data was analyzed to develop in-vivo codes. Results were presented as themes, sub-themes, and quotes.

Results

Socio-demographic characteristics of patients

About 376 patients were admitted in two wards on the survey day where 243 (64.6%) met the inclusion criteria and were enrolled in the study. Of these, 129 (53.1%) and 114 (46.9%) were admitted to the UDDS and TDDS-based wards, respectively. The majority, 225 (92.6%), of the enrolled patients completed the 24-hour follow-up period. In-patients that did not complete follow-up were either instantly discharged, 15 (6.2%), or died, 3 (1.2%) (Figure 1). About 142 (58.4%) patients from both wards were male, aged between 41 and 60 years. More than 50% of the participants were under a self (private) financing scheme (Table 1).

Table 1: Socio-demographic characteristics of patients involved

Variable	UDDS (n=119) n (%)	TDDS (n=106) n (%)	P value
Gender			
Male	81 (68)	61 (57.55)	0.109
Female	38 (32)	45 (42.45)	
Age (years)			
≥ 18 - 40	21 (17.65)	15 (14.15)	0.235
41 - 60	52 (43.69)	69 (65.09)	
61 - 80	30 (25.21)	18 (16.98)	
≥ 81	16 (13.45)	4 (3.78)	
Financing category			
Self-financing	83 (69.75)	69 (65.1)	0.003
NHIF	32 (26.89)	33 (31.1)	
Exempted	3 (2.52)	4 (3.8)	
NSSF	1 (0.84)	0 (0)	

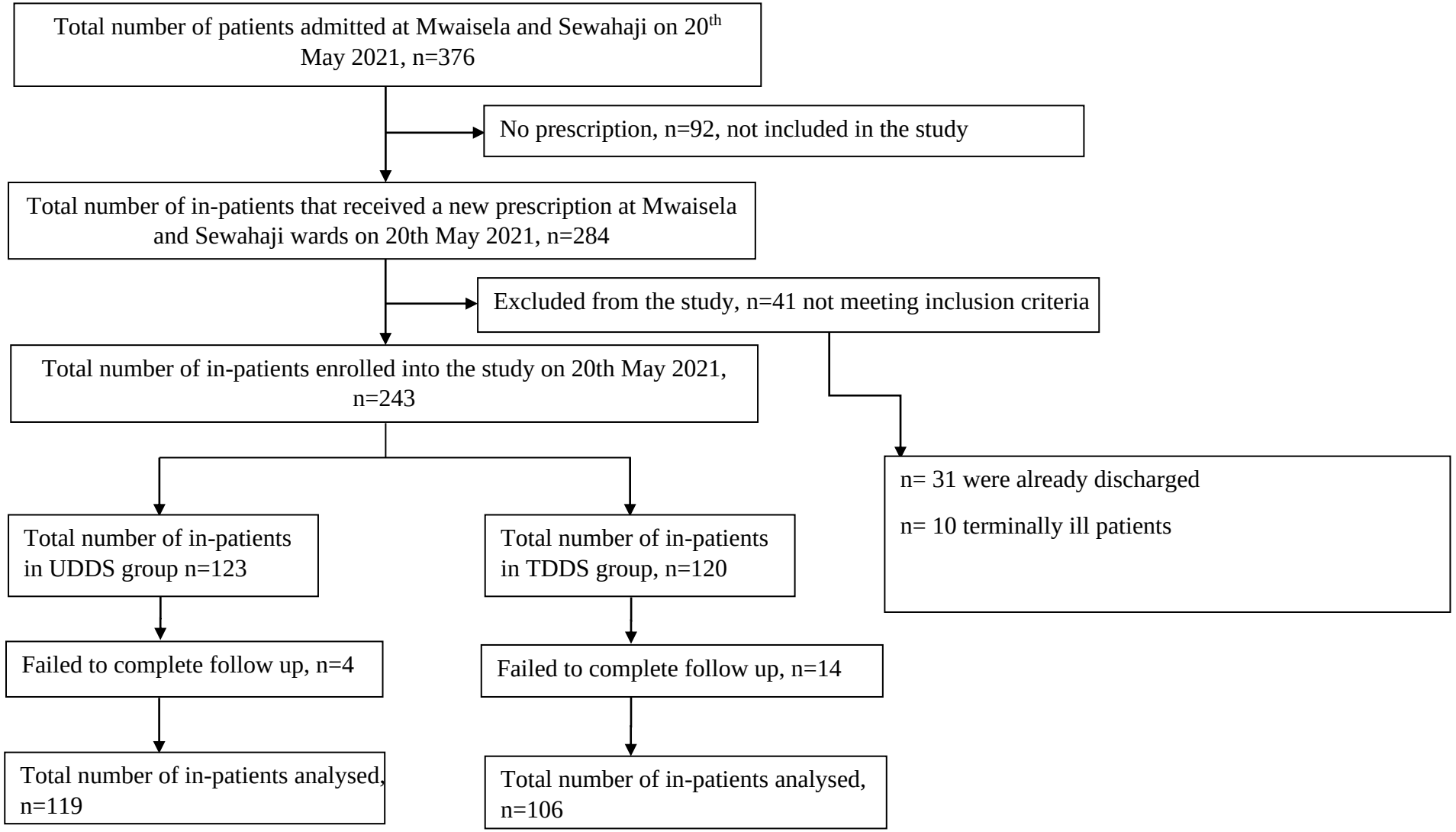

Figure 1. Flow diagram for enrolment of study participants

Medication errors

The total number of patients with medication errors during the follow-up period was 84 (37.3%). There was a higher proportion of patients with medication errors in the UDDS group, 46 (38.7%) compared to the TDDS group, 38 (35.8%), although the difference was not statistically significant, p = 0.664 (Table 2).

Table 2: Number of medication errors between the UDDS and TDDS wards

Drug Dispensing System	Number of medication Errors		Total	P value
	Error	No Error		
UDDS	46 (38.7%)	73 (61.3%)	119 (100%)	0.664
TDDS	38 (35.8%)	68 (64.2%)	106 (100%)	
Total	**84 (37.3%)**	**141 (62.7%)**	**225 (100%)**	

Average dispensing time

On average, pharmacists in the UDDS ward spent a longer time (96 minutes) verifying prescriptions, entering data in electronic records, and packing and labeling medications than those in the TDDS ward (72 minutes), although the differences were not statistically significant (p=0.107) (Table 3).

Table 3: Average dispensing times between the UDDS and TDDS wards

Activity	UDDS (Minutes)	TDDS (Minutes)	P-value
Verifying prescriptions	23.375 ±6.6319	18.625±8.7003	0.240
Electronic recording	25.750±15.1445	13.285±8.6739	0.060
Packing and labelling	47.250±12.8368	39.250±22.9455	0.404
Total	**96.375±21.1250**	**72.125±33.8206**	**0.107**

Missed doses

The total number of patients from both wards who missed drug doses was 74 (32.9%). Patients admitted in the TDDS-based ward were 16.6 times more likely to miss their daily drug dose compared to those admitted in the UDDS-based ward (OR= 16.6, CI= 7.8022 – 35.3590, p < 0.0001) (Table 4).

Table 4: Number of missed doses between the UDDS and TDDS wards

Drug Dispensing System	Missed Doses		Total	OR	CI	P-value
	Missed	Not Missed				
TDDS	64 (60.4%)	42 (39.6%)	106 (100%)	16.6	7.8022 – 35.3590	<0.0001
UDDS	10 (8.4%)	109 (91.6%)	119 (100%)			
Total	**74 (32.9%)**	**151 (67.1%)**	**225 (100%)**			

Operational labour cost

The operational monthly labour cost was significantly higher in the ward using UDDS compared to the TDDS ward (p=0.003). The hospital spent more money (total= 25,927,000 TZS) on salaries (19,877,000 TZS), allowances (4,250,000 TZS) and incentives (1,800,000 TZS) to run the UDDS in a month than for the TDDS, total (13,853,000 TZS), salaries (10,283,000 TZS), allowances (2,850,000 TZS) and incentives (260,000 TZS).

Perceptions of healthcare professionals towards the drug dispensing systems

In total, twenty-two (22) HCPs were interviewed, including 9 pharmacists, 7 nurses, and 6 medical doctors. The majority of the participants, 19 (86.3%), were aged between 18 and 45 years. The number of males and females was equal, and the majority of the participants, 13 (59.1%), had experience of less than 5 years. Upon thematic analysis, the following themes, sub-themes, and quotes were obtained.

Perceived benefits of UDDS over TDDS

Reduction in medical costs to hospital management

Participants stated that the UDDS reduced excess medicine costs incurred by the hospital management due to a significant reduction in medicine wastage through irrational use of medicine, pilferage, and expiration.

> "*UDDS has minimized cost to the hospital management...unit dose system saves a lot of wasted medicines through irrational use, pilferage and expiring. Wasted medicines are not only a cost burden to patients but also to the hospital pharmacy. In addition, we are spending fewer costs to procure healthcare commodities than we did in the past". (Pharmacist 2, UDDS ward).*

Shortened hospital stay

Participants highlighted that the length of hospital stay for patients admitted to UDDS-based was shortened hence, healthcare cost reduction. Also, patients admitted to the UDDS-based ward's recovery time was shortened compared to those in the TDDS-based ward.

> "*If a patient receives his/her prescribed dose(s) on time, he/she improves faster and is discharged on time" (Nurse 2, UDDS ward).*

Improved medicine supply and management within the wards

Participants also viewed that UDDS has improved medicine supply and patient management within the wards. The time for the availability of medicines in the UDDS-based ward was shortened and traceable compared to TDDS.

> *Compared with the ordinary dispensing system, we can easily trace the supply of medicines with their uses to each patient in each ward. Medicines are less wasted". (Pharmacist 4, UDDS ward).*

Improved medicine administration practices

Participants acknowledged that UDDS has managed to improve medication administration practice. Therefore, over and under-dosing and wrong-dosing practices have been well managed and minimized.

> "*This new system (UDDS ward) enables us to administer doses accurately without confusing the dose. All unit doses are supplied to us from a pharmacy with the patient's name and administration details. Also, we make verification and check on whether the patient has taken medication". (Nurse 2, UDDS ward).*

Reduction in the number of missed doses to patients

Participants reported that UDDS has resulted in a few missed doses and linked this to fixed medicines administration times for all patients regardless of their dosing intervals. UDDS has made the dose administration process more transparent and accountable.

> *“Currently, here (UDDS), a large proportion of patients take their medication on time as prescribed except in a few cases. All medicines here are administered at a fixed time.” (Nurse 1, UDDS ward).*

Improved inter-professional relationship

Participants stated that UDDS has improved inter-professional relationships among medical doctors, nurses, and pharmacists.

"A pharmacist is always present during ward rounds. They provide advice on medication, on whether to use or not... Sometimes we may fail to reconstitute powders for injection due to multiple calculations but once you call a pharmacist, the matter is solved". (Nurse 3, UDDS ward).

Perceived barriers to the effectiveness of drug dispensing systems

Resource consuming

Participants acknowledged that UDDS is more resource consuming than TDDS despite its positive treatment outcomes. The HCPs reported that the UDDS requires more pharmacists to prepare and dispense medicines.

"There is a challenge at the UDDS ward. UDDS requires several pharmacists to prepare unit doses than here (TDDS ward) …I think operational labour cost is high" (Doctor 6, TDDS ward).

Time-consuming during drug dispensing

Participants highlighted that the pharmacists spent more time verifying, entering prescriptions on the computer, and packing unit doses before administration in the based ward than in the based ward.

"My biggest challenge was time, one time-taking program (OTT-UDDS) requires a lot of time and manpower to prepare unit doses for each patient compared to bulky doses "(Pharmacist 2, UDDS ward).

Staff shortage and less effective in providing quality pharmaceutical services

Participants stated that staff shortage in UDDS-based wards results in overwhelming duties for pharmacists. Thus, pharmacists become less efficient in providing quality pharmaceutical services to patients.

"In short (UDDS) requires several pharmacists. If we are few, we spend a lot of energy and become tired, our effectiveness decreases". (Pharmacist 2, UDDS ward.)

Discussion

This study evaluated patient medication safety, dispensing time, dose administration, and operational labour costs to compare the effectiveness of UDDs and TDDS. Additionally, the perception of healthcare workers (HCWs) on the effectiveness of the two DDS was explored.

This study found that UDDS was perceived to be a more effective drug dispensing system than TDDS in terms of improved medicine availability to patients, inter-professional relationships, and reduction of hospital and patient healthcare costs at large. However, the UDDS was more expensive in terms of labor costs and time spent by pharmacists verifying prescriptions and packing and labelling medications before dispensing them to patients.

The study also found more prescriptions with medication errors in the UDDS-based ward than in the TDDS-based ward, but the difference was not statistically significant. In contrast, reports from other studies have shown a reduction in medication errors among patients in healthcare settings using UDDS (3,10). Additionally, other findings have shown that UDDS has the potential to save about 80% of preventable harm related to diagnosis, prescription, and the use of medicines in patients (14,15). The high rate of medication errors observed in this study could be attributed mainly to wrong prescribing and dispensing practices. Most prescribers used non-standard abbreviations for medicine names and dose strength that were not familiar to dispensers. In addition, dispensers provided either double or half-strength unit doses since most were pre-packed doses in definite strength irrespective of the actual prescribed dose strength.

Pharmacists spent longer time proofing and recording prescriptions in the electronic system and packing unit doses for each patient before administration in the UDDS-based ward than in TDDS. Even so, most patients admitted to the UDDS-based ward received their prescribed doses on time compared to those in the TDDS ward. This result is comparable to previous findings which showed that the presence of a pharmacist within a ward using UDDS enables most of the prescribed medicines to be prepared and dispensed to in-patients on time, regardless of the time spent during packing unit doses (9,16).

Patients admitted to the UDDS-based ward had significantly fewer missed doses than those in the TDDS ward. Effectively pharmacists collaborating with nurses monitored the dispensing and administration process to patients, which could account for the reduction in the number of missed doses in the ward using UDDS. This finding is in line with results from previous studies that indicated fewer missed doses in patients admitted to healthcare settings using UDDS (4,6).

The operational labour cost was significantly higher in the UDDS ward than in the TDDS ward. To effectively manage the entire drug dispensing process such as the packaging of unit doses per patient and the administration of the medicines in the UDDS-based ward, more pharmaceutical personnel were required as the whole process is manual. Hence, this explains increased operational labour costs in the UDDS-based ward. Net increases in the

healthcare cost per patient are reported in healthcare settings using UDDS (14,15,17,18). The incremental cost was related to pharmaceutical personnel and equipment costs (14,15,17,18).

In this study, the HCWs perceived UDDS as more effective than TDDS. According to the HCWs, reduction in medicine expiration and wastage through irrational medicine use and pilferage in the UDDS-based ward contributed to the decrease in healthcare costs to patients and hospital management. These findings are ascertained in previous studies that using UDDS promotes optimal use of medicines within wards hence, reducing general healthcare costs to healthcare facilities and patients (6,19). Dispensing unit doses for the intended period in the UDDS increases control over irrational use, misuse, pilferage, and wastage (6). Furthermore, the HCWs reported that UDDS reduced healthcare costs to patients that could otherwise be caused by prolonged hospital stays and extravagant prescribing practices. Similar findings are reported in other studies revealing that decentralized automated UDDS positively reduces patient drug costs by shortening hospital stays (6,10,19,20).

Furthermore, the HCWs indicated that the UDDS improved medicine availability to patients through optimal management and use of medicines within the wards. Again, other studies have reported similar findings (2,3). Most of the HCWs admitted that the use of UDDS has reduced the number of patients missing their doses and was linked to fixed-time dose administration regardless of dosing intervals.

Significantly, pharmacists, nurses, and medical doctors' inter-professional relationship was improved in the UDDS-based ward than in TDDS. The role of pharmacists in patient care services through medicine monitoring and counselling services was improved in UDDS. Previous studies have reported on improving teamwork between nurses, medical doctors, and pharmacists in healthcare settings using UDDS (19). Nevertheless, the HCWs indicated that UDDS is more resource-consuming in terms of time and labour costs despite the positive outcome. The time spent by pharmacists in verifying, reconciling, and packing unit doses for each patient in the UDDS-based ward was longer than in the TDDS-based ward. This aligns with other reports that centralized UDDS increases the workload of pharmacists, pharmacy technicians, and medical doctors (2,3,6).

Conclusion and recommendations

The unit dose dispensing system was found to be a more effective drug dispensing system than the traditional dose dispensing system. The UDDS improved drug availability, and inter-

professional relationships, and reduced healthcare costs for patients and the hospital at large. However, it was more expensive in labour and time spent by pharmacists to prepare unit doses and dispense them to patients. Operational cost improvements are recommended for adoption in other healthcare settings to benefit from the reported positive outcomes.

Acknowledgment

We would like to sincerely thank Mr. Shilla Chiumbo of Muhimbili National Hospital (MNH) for his valuable contribution during data collection. Also, patients are highly acknowledged for participating in this study.

Authors' contributions

BAM and ZM contributed to study conception and design, data collection, analysis, and manuscript writing. DM contributed to data analysis, and manuscript writing. All authors participated in reading and approving the final manuscript.

References

1. Hersberger KE, Boni F, Arnet I. Dose Dispensing Service: An Intervention to Improve Adherence to Polymedication.Expert Rev Clin Pharmacol. 2013;6(4):413-421.
2. Kingsley DB. An Analysis of The Unit Dose Pharmacy System in Small Hospital. 1975 .https://www.semanticscholar.org/paper/An-analysis-of-the-unit-dose-pharmacy-system-in-Kingsley/864c8b6b86cce1469ef56414ac106e694aff1b28. Accessed 20 January 2022.
3. Al-Anazi M, Al-Dhawailie A, Al-Arifi MN, Wajid S, Babelghaith SD. Missing of Unit Dose Medications at King Khalid University Hospital Saudi Arabia: A Cross-Sectional Study. Lat Am J Pharm. 2016;35(6):1434-1437.
4. Aguwa CN. Unit Dose Dispensing as a Tool for Effective Drug Management. Bull Entomol Soc Am. 1999;7(4):259-259.
5. Fontan J-E, Maneglier V, Nguyen VX, Loirat C, Brion F. Medication Errors in Hospitals: Computerized Unit Dose Drug Dispensing System Versus Ward Stock Distribution System. Int J Clin Pharm. 2003;25(3):112-117.
6. Carvalho MF de, Marques JM, Marta CB, Peregrino AA de F, Schutz V, Silva RCL. Effectiveness of the automated drug dispensing system: systematic review and meta-analysis. Rev Bras Enferm. 2020;73(5):e20180942.
7. Donaldson JL, Kelley TE, Kumar DN, Kieny MP, Sheikh A. Medication Without

Harm: WHO's Third Global Patient Safety Challenge. The Lancet. 2017; 389 (10080):1680-1

8. Anacleto TA, Perini E, Rosa MB, César CC. Medication errors and drug-dispensing systems in a hospital pharmacy. Clinics (Sao Paulo). 2005;60(4):325-32.
9. Mambile G, Konje E, Kidenya BR, Katabalo D, Marwa KJ. Quality of drug prescription in primary health care facilities in Mwanza, North-Western Tanzania. Tanzan J Health Res. 2016;18(4):1-11.
10. Viprey M, Burgos D, G A. The Effect of a Robotic Unit Dose Drug Dispensing System on Medicines Administration Errors and the Cost of Drug Dispensing. Eur J Hosp Pharm. 2013;20 (1): A1–238.
11. Leshabari MT, Mwangu M, Mbembati N, Ezekiel MJ, Hospital MN. **P**atient Satisfaction at A tertiary Hospital in Dar Es Salaam, Tanzania. J Public Health (Bangkok). 2008;5(2):67-73.
12. Creswell JW. Qualitative Inquiry and Research Design: Choosing among Five Traditions. 2007, Second edition. Sage Publications, Inc, Thousand Oaks, Califonia-USA. file:///C:/Users/hp/Downloads/Second_Edition_Qualitative_Inquiry_and_R%20(1).pdf. Accessed 15 April 2020.
13. World Health Organization. Patient Safety: Making Health care Safer. 2017. https://apps.who.int/iris/bitstream/handle/10665/255507/WHO-HIS-SDS-2017.11-eng.pdf?sequence=1&isAllowed=y. Accessed 26 June 2020
14. OANDA, Olsen and Associates Currency Converter. 2021. https://www1.oanda.com/currency/converter/. Accessed 20 July 2020
15. Dib JG, Abdulmohsin SA, Farouki MU, Mohammed K, Iqbal M, Khan JA. Effects of an automated drug dispensing system on medication adverse event occurrences and cost containment at SAMSO. Hosp Pharm.2006; 41(12):1180-1184.
16. Ahtiainen HK, Kallio MM, Airaksinen M, Holmström AR. Safety, Time and Cost Evaluation of Automated and Semi-Automated Drug Distribution Systems in Hospitals: A Systematic Review**.** Eur J Hosp Pharm. 2020; 27(5):253-262.
17. Management Science for Health. Managing Access to Medicines and Health Technologies. 2014. https://msh.org/resources/mds-3-managing-access-to-medicines-and-health-technologies/ Accessed 18 August 2021
18. Lepinski P, Thielke T, Collins M, Hanson A. Cost Comparison of Unit Dose and Traditional Distribution System in a Long Termed Care Facility**.** Am J Hosp Pharm.

1986; 43(11):1-7.

19. Noparatayaporn P, Sakulbumrungsil R, Thaweethamcharoen T, Sangseenil W. Comparison of Human Resource Requirement between Manual and Automated Dispensing Systems. Value Health Reg Issues. 2017; 12:107-111.

20. Noparatayaporn P, Sakulbumrungsil R, Thaweethamcharoen T. Cost Comparison between the Manual System and Automated Dispensing Systems; How to Use Effective Health Technology at a Large Academic Hospital in Thailand. Value in Health. 2016; 19: A1-A318