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Cost Savings and Waste Reduction Through Redispensing Unused Oral Anticancer Drugs
The ROAD Study

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IMPORTANCE New strategies targeting waste are required to improve financial and ecologic sustainability of expensive therapies, such as oral anticancer drugs, that frequently remain unused by patients. Redispensing unused oral anticancer drugs seems to be a promising strategy when drug quality is guaranteed.

OBJECTIVES To determine the waste reduction and net cost savings attained by redispensing oral anticancer drugs that go unused by patients compared with the standard practice of disposal.

DESIGN, SETTINGS, AND PARTICIPANTS The ROAD study was a prospective single-group intervention conducted in the outpatient pharmacies of 4 hospitals in the Netherlands from February 1, 2021, to February 1, 2023, with 12-month follow-up of each patient. Patients with cancer and who had a prescription for an oral anticancer drug that could be stored at room temperature were included. Of 2426 eligible patients, 602 did not consent and 601 did not respond. Data analyses were performed from August 25, 2022, to April 19, 2023.

INTERVENTION Participants received oral anticancer drugs for use at home in special packaging (ie, sealed packaging with time-temperature indicator), to be returned to the pharmacy should these remain unused. The pharmacy ensured quality of returned drugs based on authenticity, appearance, remaining shelf life and adequate storage temperature. Drugs fulfilling quality requirements were redispensed to other patients.

MAIN OUTCOME AND MEASURE Total waste reduction and mean net annual cost savings per patient compared with the standard practice of disposal. Optimization of cost savings was explored by introducing variations in the quality assurance procedure and patient population. All analyses used the average exchange rate for 2021 €1 = US $1.18.

RESULTS Of 1223 patients with cancer who consented, 1071 participated (median [IQR] age, 70 [62-75] years; 622 [58.1%] were male). In all, 171 patients (16.0%; 95% CI, 13.8%-18.3%) returned 335 unused oral anticancer drug packages. Of the returned drugs, 228 packages were redispensed, which reduced waste by 68.1% (95% CI, 67.7%-68.5%) compared with the standard practice (disposal). Redispensing unused oral anticancer drugs comprised 2.4% (95% CI, 2.2%-2.5%) of total drug costs, providing mean net annual cost savings of US $680 (95% CI, $524-$837) up to $1591 (95% CI, $1226-$2002) per participant.

CONCLUSIONS AND RELEVANCE The findings of this multicenter intervention study indicate that redispensing unused oral anticancer drugs is associated with waste reduction and cost savings, which in turn may improve the affordability and sustainability of cancer treatment.

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Supplemental content

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Sustainable and affordable access to drugs is increasingly at stake, even in high-resource countries. Drug shortages and high prices, particularly for novel drugs, are major contributors to this challenge.[1] Concurrently, health care faces environmental challenges because climate change contributes to disease burden, while paradoxically health care itself contributes to climate change through its substantial carbon footprint.[2,3] Drugs have an important effect on the environment, generating a waste stream of valuable resources when disposed of after remaining unused by patients.[4] Waste reduction is needed to sustain affordable access to novel drugs while simultaneously minimizing environmental repercussions.[5]

To reduce waste, drugs unused by patients at home could be collected by the pharmacy and redispensed to other patients. This idea is supported by patients, health care professionals, and policymakers because it could prevent the disposal of millions of unused drugs, saving costs and reducing environmental pollution by drugs. Nevertheless, uncertainties regarding drug quality due to storage of drugs at patients' homes challenges the implementation of this possible solution.[6-11]

Sensing technologies and sealed packaging could be used to ensure that only unopened and intact drugs that meet all pharmaceutical quality standards are redispensed.[6-13] This requires an investment; thus, the benefits of waste reduction must outweigh the costs to contribute to affordability of drugs.

Oral anticancer drugs (OADs) are potentially suitable candidates for redispensing. Previous studies have demonstrated that (1) approximately one-third of patients discontinue OAD treatment early,[14-17] (2) half of the patients that discontinue treatment have unused OAD packages,[18] and (3) (originator) OADs are very expensive drugs, thus wasting these produces substantial financial losses.[19] With the high and increasing budget implications of OADs, waste reduction appears to be a convenient cost-containment strategy because it does not compromise therapeutic value to patients.[20,21] Redispensing unused OADs appears to be feasible given the substantial quantity and cost of the waste[22]; however, economic benefits must be elicited to promote uptake as standard practice. Therefore, this study aimed to quantify the waste reduction and net cost savings attained by redispensing OADs that remain unused by patients compared with the standard practice of disposing unused drugs.

Key Points

Question What are the waste reduction and net cost savings attained by redispensing oral anticancer drugs that remained unused by patients compared with the standard practice of disposing of unused drugs as waste?

Findings This multicenter intervention study including 1071 patients with cancer treated with oral anticancer drugs at home demonstrated a 68% waste reduction (comprising 2.4% of total dispensed drug costs in the study) and a mean net annual cost savings of at least €576 (2021 US $682) per participant.

Meaning The findings of this multicenter intervention study indicate that redispensing unused oral anticancer drugs was associated with reduced waste and substantial cost savings, improving the affordability and sustainability of cancer treatment.

Methods

Ethical review was waived by the local medical research ethics committee of the Radboud University Medical Center (METC Oost Nederland, protocol No. 2020-7049), based on all study documents. The trial complies with the Declaration of Helsinki and all the study participants provided written informed consent. The trial was registered in the World Health Organization International Clinical Trials Registry Platform. Castor Electronic Data Capture was used to manage data according to the Good Clinical Practice guidelines. The Consolidated Standards of Reporting Trials (CONSORT) reporting guidelines were followed in reporting this trial, adjusted for reporting nonrandomized studies,[23] and supplemented with Consolidated Health Economic Evaluation Reporting Standards (CHEERS) reporting guidelines for economic evaluations (Supplement 1).

Study Design and Setting

A prospective, single-group multicenter intervention study was conducted to evaluate the effect of redispensing unused OADs on waste reduction and net cost savings. The study was conducted in the outpatient pharmacies of 4 hospitals in the Netherlands, 2 academic medical centers (Radboud University Medical Center in Nijmegen and University Medical Center in Utrecht), and 2 teaching hospitals (Jeroen Bosch Hospital in Hertogenbosch and Saint Antonius Hospital in Utrecht, Nieuwegein, and Woerden), from February 1, 2021, to February 1, 2023. In the Netherlands, cancer treatment (including OADs) is covered by standard health insurance; the outpatient pharmacies had the exclusive right to dispense OADs to outpatients due to reimbursement regulations. Data on currency were collected and reported in 2021 Euros (€1 = $1.18).

Intervention Procedure

The redispensing procedure was developed based on previous work, which consisted of qualitative intervention design and pilot testing[8,10,24] as well as input from 2 patient representatives to ensure drug quality when redispensed (eMethods in Supplement 2). OADs were protected against influences of light and humidity by the original drug packaging, while drug intactness and adequate storage were monitored by additional sealed packaging (Transposafe; Brady Co) and a time-temperature indicator (LIBERO ITS [customer configuration]; Elpro-Buchs AG). Patients were instructed to store drugs in the packaging provided until OAD was used and to return any unused OADs. To prevent additional burden and costs to patients for visiting the pharmacy more often, patients were instructed to return unused OADs during planned hospital visits. Patients were also requested to return the time-temperature indicators to the outpatient pharmacy for reuse.

Pharmacy employees assessed the quality of returned OADs, using 4 criteria: (1) unopened sealed bag; (2) undamaged outer packaging; (3) shelf life of 6 months or longer; and

(4) drug storage per the Summary of Product Characteristics, measured by a time-temperature indicator (eTable 1 in Supplement 2). OADs that fulfilled all 4 criteria were restocked and redispensed to participants who had a prescription for the same OAD. When an OAD was redispensed, the pharmacy refunded the initial payer (eg, hospital department).

Study Participants

Adult patients (aged ≥18 years) with a clinical diagnosis of cancer and a current prescription for any OAD that could be stored at room temperature were eligible to participate (eTable 1 in Supplement 2). Pharmacy employees screened and recruited eligible participants by mail. Potential participants who were not able to communicate in Dutch were excluded.

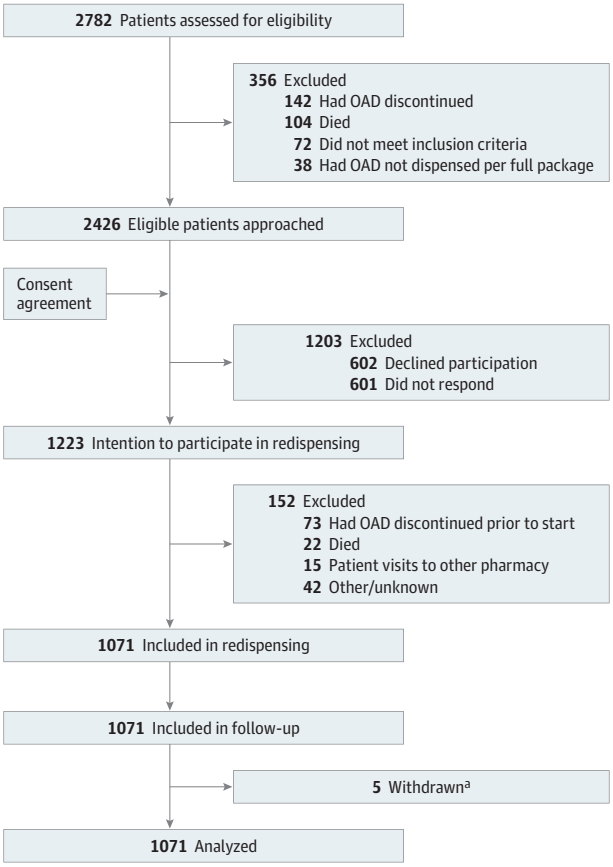
After receiving study information, eligible participants provided written informed consent or could opt to report their reason for declining to participate. Patients were encouraged to address questions and concerns with their pharmacist, oncologist, or hematologist. Reminders were sent by mail and telephone. Inclusion was defined as the first dispensing after the intervention procedure, with exclusion at treatment discontinuation or after a maximum follow-up of 12 months. Patient characteristics, including demographic information (age and sex), index OAD information (drug name, strength, dosage regimen, and duration of use), and disease information (topographic region), were collected. According to the laws of the Netherlands, race and ethnicity were not collected for analysis.

A total of 2782 patients were screened from February 1, 2021, to January 31, 2022, and 2426 potentially eligible patients were approached (**Figure**). Of these, 1203 did not provide consent due to a lack of response (n = 601) or they declined to consent (n = 602) because they lacked unused drugs (n = 200) or interest (n = 102), perceived the study to be too demanding (n = 99), were concerned about their health status (n = 78) or quality and safety (n = 64), or other reason (n = 59). The remaining 1071 eligible patients participated in the intervention and analyses.

Waste Reduction and Cost Savings

Primary outcomes were waste reduction and mean net annual cost savings per participant attained by redispensing unused OADs compared with standard practice (ie, disposal). Waste reduction was the percentage of returned OAD packages being redispensed, and the number of participants needed to prevent waste for 1 patient. Net cost savings was the economic value of redispensed OADs according to Dutch drug prices in 2021,[25] corrected for operational costs. Cost savings were analyzed from both the health care and the societal perspectives. These perspectives included equal costs for patients; they were explicitly instructed to return any unused OADs during a planned hospital visit to avoid any additional visits and related costs. Operational costs included materials (ie, time-temperature indicator, sealed bag, information leaflet), labor, and overhead costs; 60% of the time-temperature indicators were reused. Labor time was based on a previous microcosting study[26] (eTable 2 in Supplement 2), modified for the current process and converted into a cost by using 2021 salary rates based on 1558 working hours and 39% taxes.[27] Overhead costs were valued at 44% of labor costs.[27] Secondary outcomes were the proportion of returned OADs, including the rates and reasons for returning OADs, and the quality of returned OADs.

Figure. Flow Diagram of Participants Modified for Single-Group Trial Design



OAD refers to oral anticancer drug.

[a] Data included in analysis up to exclusion.

Scenario Analysis

Scenarios were explored to adjust for parameter uncertainty and to optimize the effect of redispensing unused OADs by introducing variations in the quality assurance procedure and patient population. Three scenarios on the quality assurance procedure were composed: (1) current quality procedure but with single use of time-temperature indicators (eg, no reuse); (2) optimized quality procedure, sealed packaging is eliminated, shelf life criterium is reduced to 2 months, and temperature indicators are only supplied to OADs with a maximum storage temperature of 25 °C (eTable 1 in Supplement 2); and (3) quality checked only visually and requiring no additional materials (eg, no sealed packaging or temperature indicators). Furthermore, mean net annual cost savings were explored for identified subsets of the patient population associated with having positive cost savings.

Table 1. Baseline Participant Characteristics (N = 1071)

Characteristic	No. of participants, (%)
Female	449 (41.9)
Male	622 (58.1)
Median (IQR) age, y	70 (62-75)
Center	
Academic hospital	655 (61.2)
Teaching hospital	416 (38.8)
Morbidity/condition	
Solid cancer	548 (51.2)
Prostate cancer	170 (15.9)
Breast cancer	85 (7.9)
Lung cancer	57 (5.3)
Kidney cell cancer	53 (4.9)
Sarcoma	43 (4.0)
Gynecologic cancer	37 (3.5)
Brain tumor	30 (2.8)
Melanoma	26 (2.4)
Thyroid cancer	22 (2.1)
Gastrointestinal cancer	19 (1.8)
Other	6 (0.6)
Hematologic cancer	523 (48.8)
MPN	254 (23.7)
Leukemia	136 (12.7)
Multiple myeloma	102 (9.5)
Lymphoma	17 (1.6)
Other	14 (1.3)
OAD treatment at study entry[a]	1153 (107.7)
Targeted therapies	655 (56.8)
Cytotoxic agents	255 (22.1)
Endocrine therapy	152 (13.2)
Immunosuppressants	91 (7.9)
Onset OAD treatment[b]	
≤6 mo	347 (32.4)
7-24 mo	338 (31.6)
>24 mo	386 (36.0)
Median (IQR) participation time, mo[c]	12 (7-12)

Abbreviations: OAD, oral anticancer drug; MPN, myeloproliferative neoplasms.

[a] Multiple OADs could be used simultaneously (n = 1153); all OADs included in the study are summarized in eTable 1 in Supplement 2.

[b] 60 patients (5.6%) initiated a new OAD treatment during the study period.

[c] 305 patients (28.5%) discontinued OAD treatment during the study period.

Statistical Analyses

Descriptive analyses were used to describe population characteristics, with categorical variables reported as percentages and numeric variables as mean (SD) or as median (IQR). Proportions were described with 95% CIs. Mean costs per patient and corresponding CIs were determined using bootstrapping (n = 2000). Multiple logistic regression analysis was used to identify patient characteristics associated with having positive cost savings in an explorative association model. Given the relatively large population size and limited number of variables, a full regression model was used, including patient characteristics (age and sex) and treatment characteristics (indication, medication type used, and duration of treatment). The medical center was identified as a confounder because it would affect type of treatment and cost savings; it was corrected for in the analysis. Statistical tests were 2-tailed and *P* values < .05 were considered statistically significant. Data analyses were performed from August 25, 2022, to April 19, 2023, using SPSS, version 25 (IBM Corp).

Results

Study Population

Of the 1071 participants (median [IQR] age, 70 [62-75] years), 449 (41.9%) were female and 622 (58.1%) were male according to their medical health records (**Table 1**). The types of prescribed OAD treatments at study entry among the participants were 14 targeted therapies (655 patients [56.8%]), cytotoxic agents (255 patients; 22.1%), endocrine therapy (152 patients [13.2%]), and/or immunosuppressants (91 patients [7.9%]). At inclusion, treatment onset had been 6 or fewer months for 347 patients (32.4%), 7 to 24 months for 338 patients (31.6%), and more than 24 months for 386 patients (36.0%) at inclusion. Median (IQR) participation duration was 12 (7-12) months, with 305 patients (28.5%; 95% CI, 25.8%-31.3%) discontinuing OAD treatment during the study period. Mean (95% CI) annual OAD treatment costs were €41 421 (95% CI, €39 231-€43 451) per patient, ranging from €23 051 (95% CI, €19 896-€26 387) in teaching hospitals to €52 158 (95% CI, €47 867-€56 617) in academic medical centers, due to differences in treatment type (Table 1).

Waste Reduction and Net Cost Savings

In total, 13 069 OAD packages were dispensed during the study, containing an average of 27 daily doses per package. In all, 171 patients (16.0%; 95% CI, 13.8%-18.3%) returned 335 unused OAD packages (2.6%; 95% CI, 2.4%-2.7%).

After quality assurance, 228 OAD packages from 128 patients were redispensed, reducing waste by 68.1% (95% CI, 67.7%-68.5%). Thus, for every 8 patients receiving OAD treatment, waste of OAD for 1 patient was avoided. Waste reduction comprised 2.4% (95% CI, 2.2%-2.5%) of the total OAD treatment costs. Redispensing unused OADs provided a mean net annual cost savings of €576 (95% CI, €444-€709) per participant compared with disposal of unused OADs (**Table 2**); the savings ranged from €134 (95% CI, €29-€263) to €1070 (95% CI, €890-€1250) per patient among the 4 medical centers. Mean annual benefits were €613 (95% CI, €580-€746) per participant vs mean annual operational costs of €37 (95% CI, €35-€38) per participant, primarily associated with time-temperature indicators and sealed packaging, which had mean costs of €23 (95% CI, €22-€24) and €5 (95% CI, €5-€5) per participant, respectively. Mean annual labor was 12 (95% CI, 11-13) minutes per participant (eTable 2 in Supplement 2), equivalent to a mean cost of €9 (95% CI, €8-€9) including overhead costs.

OAD Returns and Drug Quality

Returned OAD packages primarily consisted of targeted therapies (68.0%; 95% CI, 65.5%-70.5%), followed by endocrine therapy (18.0%; 95% CI, 15.9%-20.1%), immunosuppressants

Table 2. Mean Net Annual Cost Savings Attained Per Patient Associated With Redispensing Oral Anticancer Drugs vs Standard Practice (eg, Disposal of Unused Drugs) and Influence of Quality Assurance Procedure

	Redispensed OADs		Patients with redispensed OAD(s)		Annual mean per patient vs standard practice, (95% CI)[a]		
Quality procedure	No.	% (95% CI)	No.	% (95% CI)	Costs; €	Benefits; €	Net cost savings; €
Base case[b]	228	1.7 (1.6-1.9)	128	12.0 (11.0-12.9)	37 (35-38)	613 (481-746)	576 (444-709)
Single-use TTI[c]	228	1.7 (1.6-1.9)	128	12.0 (11.0-12.9)	70 (67-73)	613 (481-746)	543 (411-676)
Optimized quality procedure[d]	250	1.9 (1.8-2.0)	141	13.2 (12.1-14.2)	9 (8-9)	663 (527-800)	655 (518-791)
Visual check only[e]	335	2.6 (2.4-2.7)	171	16.0 (14.8-17.1)	1 (1-1)	816 (664-968)	814 (663-967)

Abbreviations: OAD, oral anticancer drug; TTI, time-temperature indicator.

[a] Data on currency were collected and reported in 2021 Euros (€1 = $1.18).

[b] Quality assurance consisted of: (1) sealed packaging; (2) undamaged outer packaging; (3) shelf life ≤6 months; and (4) storage according to product label claim, measured with a TTI (60% was reused).

[c] Quality assurance as in base case, with single use of TTI.

[d] Quality assurance consists of: (1) undamaged outer packaging; (2) shelf life ≤2 months; and (3) TTI is only dispensed for drugs with a maximum storage temperature of 25 °C according to product label claim (60% was reused).

[e] Pharmacy collected and redispensed unused OAD packages with visual quality assurance procedure.

Table 3. Targeting Strategies for Redispensing Unused Oral Anticancer Drugs and Associated Mean Net Annual Cost Savings Per Patient vs Standard Practice (ie, Disposal)

		No. (%) (95% CI)		Annual mean per patient vs standard practice (95% CI)[a]		
Treatment type	Patients, No.	Redispensed OADs	Patients with redispensed OADs	Costs; €	Benefits; €	Net cost savings; €
Base case	1071	228 (1.7) (1.6-1.9)	128 (12.0) (11.0-12.9)	37 (35-38)	613 (481-746)	576 (444-709)
OAD treatment						
Targeted therapies	611	163 (1.2) (1.2-1.3)	86 (8.0) (7.2-8.9)	43 (41-45)	751 (600-901)	708 (558-858)
Study onset OAD treatment						
≤24 mo	685	188 (1.4) (1.3-1.5)	102 (9.5) (8.6-10.4)	38 (36-40)	793 (641-945)	755 (604-906)
Combined						
Targeted therapies; ≤24 mo	401	138 (1.1) (1.0-1.1)	71 (6.6) (5.9-7.4)	43 (41-45)	976 (803-1149)	934 (761-1106)

Abbreviation: OAD, oral anticancer drug.

[a] Data on currency were collected and reported in 2021 Euros (€1 = $1.18).

(7.5%; 95% CI, 6.1%-8.9), and cytotoxic agents (6.6%; 95% CI, 5.2%-8.0). OADs were returned due to disease progression (47.4%; 95% CI, 44.5%-50.3%) and toxic effects (29.4%; 95% CI, 26.8%-32.0%), association with a drug switch (44.8%; 95% CI, 41.9%-47.7%), discontinuation (34.0%; 95% CI, 31.2%-36.8%), or dose adjustments (18.0%; 95% CI, 15.8%-20.2%).

The quality of most (73.4%; 95% CI, 73.0%-73.8%) of the 246 returned OAD packages was approved; disapproval was due to opened packaging (77.5%; 95% CI, 75.2%-79.8%), damaged outer packaging (60.7%; 95% CI, 58.0%-63.4%), shelf life (21.3%; 95% CI, 19.1%-23.5%), lack of a time-temperature indicator (31.5%; 95% CI, 29.0%-34.0%), and/or a temperature breach (10.1%; 95% CI, 8.5%-11.7%). Temperature breaches ranged from 25 to 30 °C; no other breaches nor technical issues were encountered. Additionally, 18 OAD packages of approved quality were not redispensed because no other patient required that particular drug (83.3%; 95% CI, 74.5%-92.1%) or there was a change of stock (16.7%; 95% CI, 7.9%-25.5%), ie, after introduction of a generic drug. During the study period, there were no concerns reported regarding product quality by patients nor their prescribers or pharmacists.

Scenario Analyses

Scenario analysis on quality assurance demonstrated a mean net annual cost savings of €543 (95% CI, €411-€676) per participant for single use of time-temperature indicators to €655 (95% CI, €518-€791) per participant in an optimized quality procedure scenario (Table 2). The optimized quality assurance procedure improved waste reduction from 68.1% to 74.6% (95% CI, 73.3%-76.0%) given the quality approval of an additional 12 packages that had an opened seal and 11 packages with a remaining shelf life of 2 to 6 months. When eliminating quality assurance materials, a mean net annual cost savings of up to €814 (95% CI, €663-€967) per participant could be attained.

Statistically significant associations with positive cost savings due to redispensing unused OADs were identified by OAD type; targeted therapies compared with cytotoxic agents (odds ratio [OR], 2.1; 95% CI, 1.0-4.3); and treatment duration ≥6 months (OR, 3.0; 95% CI, 1.7-5.1) and ≥24 months (OR, 2.1; 95% CI, 1.2-3.7) (eTable 3 in Supplement 2). Focusing on patients using targeted therapies up to 24 months increased mean net annual cost savings to €934 (95% CI, €761-€1106) per participant with the current quality procedure (**Table 3**) or up to €1348 (95% CI, €1039-€1697) per participant with only a visual quality check.

Discussion

This study demonstrated a two-thirds waste reduction through redispensing unused OADs with a mean net annual cost savings

of €576 (95% CI, €444-€709) per participant compared with disposal, the standard practice. Net cost savings could be further optimized through the quality assurance procedure, minimizing the required materials (lower costs) while increasing redispensing rates (higher benefits). Patients undergoing targeted therapies and using OADs for up to 24 months had a greater cost savings associated with the redispensing of OADs. Therefore, focusing on these subgroups of patients could further improve cost savings attained per patient.

Redispensing unused drugs is increasingly suggested to constrain the cost of expensive drugs, specifically OADs; however, few studies have quantified the economic effects of this change in standard practice (disposal).[28,29] Redispensing of postexposure prophylaxis therapy among medical students going abroad showed cost savings of 74%[24] because these drugs were prescribed prophylactically, meaning that most of them remained unused. Clearly, return rates are another important factor affecting the benefits of redispensing unused drugs.[26] Therefore, focusing on patient subgroups (eg, prescribed targeted therapies and ≤24-months use) that were associated with positive cost savings could maximize the amount saved by redispensing OADs.

Quality assurance is another factor affecting the net cost savings of redispensing unused drugs. Quality assurance facilitated alignment with pharmaceutical guidelines and patient participation by ensuring drug quality and safety when redispensing; however, because of the additional quality measures, waste was reduced to a lesser extent.[10,30] The debate on quality assurance is ongoing. Our study did not encounter temperature breaches exceeding 30 °C. Therefore, using time-temperature indicators could potentially be limited to drugs with a maximum storage temperature of 25 °C, raising the cost savings by 10%.

Although environmental implications of redispensing unused OADs must still be evaluated by future analyses, it could be hypothesized that reducing quality assurance materials avoids environmental consequences.[31] Accordingly, the use of sensing technologies should be carefully considered to guarantee drug quality and safety when redispensing OADs (eg, the current study), while optimizing economic and environmental implications of redispensing unused OADs.

Drug waste is a "wicked" problem,[32,33] having multivariable causes in which various stakeholders with competing interests are involved. A set of waste-minimizing strategies throughout the pharmaceutical supply and use chain is therefore required to address drug waste,[4] starting with waste prevention.[34] Dispensing reduced quantities of OADs (eg, split filling or individualizing dispensing) prevented about one-third of OAD waste.[35-38] However, it has several limitations, including the burden of frequent pharmacy visits on patients and a considerable proportion of drug waste being unforeseen.[38] Complementing strategies, including the redispensing of unused drugs, could be required. Although these measures attain a substantial waste reduction, they may benefit from extended stakeholder cooperation. Drug manufacturers could provide more variable package sizes and stability data or incorporate quality indicators in the original packaging.[39] Wholesalers and pharmacies could support easy exchange of returned OAD packages to facilitate the redispensing of all OADs of approved quality. Lastly, waste minimization should be legislated to empower health authorities and financially incentivized by health insurance providers to ensure the commitment of all stakeholders to sustainability.[4]

This study contributes to the mission of sustainable cancer care by providing the same value care at reduced costs,[40,41] while improving sustainability by protecting environmental resources.[42] To our knowledge, this is the first study to bring the idea of redispensing unused drugs into clinical practice by introducing an extensive quality assurance process. The findings of this study show an economic advantage to redispensing drugs in the context of a large study population treated in different medical centers. These findings will serve as evidence to supporting legislation and incorporation of redispensation into clinical guidelines. Accordingly, these findings provide a waste-minimizing strategy to contribute to sustainable and affordable access to drugs, which could also be applied to other drugs exceeding a price of €100 per package.[26]

Limitations

This study needs to be placed in the context of its limitations. First, as is common with economic evaluations, setting-specific assumptions complicate generalizability. For instance, novel drugs are 377% more expensive in the US compared with the Netherlands, so the Dutch context might underestimate cost savings.[43,44] Second, patients were requested to return unused OADs, prompted through reminders in the pharmacy, but potentially not all unused OADs were returned despite the current population being motivated to participate. Moreover, it is possible that, regardless of explicit instructions, patients did visit the pharmacy more often to return the unused OADs, adding possible costs hat we did not consider. Therefore, redispensing initiatives may benefit from offering (financial) incentives for patients. Third, this study was a prospective intervention study, lacking a comparative (randomized) cohort; however, because standard practice does not consist of redispensing, the benefits of redispensing are reflected in the difference with standard practice (disposal of OADs). Still, we observed considerable differences among medical centers, potentially associated with population differences and treatment types offered as well as variations in dispensing policies. Although research has shown OAD waste despite conservative dispensing policies,[38] abundant research needs to elicit the effects of concurrent waste-minimizing strategies. All of the scenarios considered by this study showed positive cost savings; so despite uncertainty regarding underlying factors, redispensing unused OADs was associated with reduced waste and cost savings for cancer therapies.

Conclusions

This multicenter intervention study demonstrated substantial waste reduction associated with redispensing of quality-approved OADs unused by patients, which generated substantial cost savings compared with the standard practice of

disposal. In addition, these cost savings could be increased through minimization of quality assurance and/or by focusing on subgroups of the patient population. Nevertheless, these findings indicate that redispensing unused drugs has the potential to improve sustainability and affordability in cancer treatment.

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