Exploratory Research in Clinical and Social Pharmacy 20 (2025) 100639

Contents lists available at ScienceDirect

Exploratory Research in Clinical and Social Pharmacy

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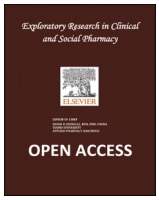

Prevalence and determinants of unused medicines among households in Ethiopia: A systematic review and meta-analysis

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ARTICLE INFO

Keywords:
Unused medicines
Prevalence
Determinants
Ethiopia
Systematic review
Meta-analysis

ABSTRACT

Background: Unused medicines present significant public health, environmental risks and economic challenges. Understanding their prevalence and determinants is crucial for designing appropriate interventions. This systematic review and meta-analysis aimed to estimate the pooled prevalence and determinants of unused medicines among households in Ethiopia.

Method: A comprehensive search was conducted across major databases, including Scopus, Science Direct, Embase, PubMed/MEDLINE, Google Scholar, and Research Gate, to identify relevant studies published up to January 10, 2025. Eligible studies reporting the prevalence and determinants of unused medicines in Ethiopian households were included. Data were extracted via a Microsoft Excel spreadsheet and analyzed using STATA version 11.0, applying a random-effects model to estimate the pooled prevalence and account for heterogeneity. Subgroup and sensitivity analyses were performed to explore variations across studies.

Result: A total of 12 studies involving 6123 households were included. The pooled prevalence of unused medicines was estimated at 44.34 % (95 % CI: 32.83, 55.84), with substantial heterogeneity among studies ($I^2 = 99.0$ %, p value =0.000). Subgroup analyses revealed higher prevalence rates in urban households at 47.8 % compared to rural households at 26.89 % and regional disparities. Antibiotics were the most frequently unused class of medications, accounting for 31.49 % of all unused medicines in households, followed by analgesics at 26.14 %, while antacids constituted 8.7 %. The primary reasons for the accumulation of unused medicines included self-discontinuation upon symptom relief at 34.21 %, while anticipation of future use constitute 20.47 %. Factors such as self-medication with NSAIDs, acquisition of medications without prescriptions, and higher household income were significantly associated with the prevalence of unused medicines among households in Ethiopia.

Conclusion: This systematic review and meta-analysis revealed that unused medicines among households in Ethiopian was prevalent, with significant regional variations. Antibiotics were the most commonly unused

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https://doi.org/10.1016/j.rcsop.2025.100639
Received 20 February 2025; Received in revised form 10 June 2025; Accepted 29 July 2025
Available online 31 July 2025

medications, followed by analgesics, while cardiovascular medicines and dietary supplements were the least reported. The primary reasons for the accumulation of unused medicines included self-discontinuation upon symptom relief, and anticipation of future use. Key determinants such as self-medication with NSAIDs, acquisition of medications without prescriptions, and higher household income were significantly associated with the prevalence of unused medicines. These findings underscore the need for context specific interventions to address the high prevalence of unused medicines in Ethiopia, particularly in urban settings and regions with higher rates.

1. Background

Access to medicines is a cornerstone of a well-functioning healthcare system, playing a critical role in improving health outcomes and ensuring the well-being of populations.[1,2] However, the availability of medicines often comes with challenges, including improper use, storage, and wastage.[3] One significant issue is the accumulation of unused medicines in households, which has emerged as a global public health concern. Unused medicines are those that are prescribed, dispensed, or purchased but remain unused due to various reasons such as patient non-adherence, changes in treatment regimens, adverse effects, or expiration.[4]

Globally, more than half of all medicines are prescribed, dispensed, or sold improperly, and 50 % of patients fail to take them correctly, which causes unnecessary accumulation at home.[5] Studies revealed that the magnitude of unused medicines in households varies widely across different regions and populations. In the United States, up to 67 % of prescribed medicines were reported as unused, with the main reasons for nonuse being improved health conditions, forgetfulness, and side effects.[6] Studies from low- and middle-income countries (LMICs) have reported higher prevalence rates. Studies conducted in Malaysia and Pakistan found that 84 % of participants in Malaysia,[7] and 87 % in Pakistan reported having unused medicines.[8] Similarly, another a study conducted in Tanzania revealed that 70.19 % of participants had unused medications stored in their homes. The primary reason for keeping unused medications at home was an early discontinuation of treatment, often due to patients believing they had recovered from their illness.[9]

Like in other low- and middle-income countries (LMICs), in Ethiopia, individual studies suggest that the prevalence of unused medicines is similarly high, but comprehensive data are lacking. In Ethiopia, the prevalence of unused medicines among households suggests that up to 13.8–55 % of medicines remain unused.[10–12] The determinants of unused medicines are multifaceted, encompassing individual, household, and healthcare system factors. These may include limited patient counseling and poor monitoring of medication use, over prescription, and limited access to proper disposal mechanisms. In addition to this, in Ethiopia, the Ethiopian Food and Drug Authority (EFDA) regulates safety, efficacy, and quality of medicines. While regulatory frameworks exist, enforcement and monitoring at the community level is weak. Medicines are available through public and private health facilities, but in some private pharmacies, drugs are accessed without prescriptions, which influence medication availability, leading to misuse and accumulation of unused medicines. Furthermore, in Ethiopia, where healthcare infrastructure is underdeveloped, the presence of chronic disease, having health insurance coverage, self-medicating with NSAIDs, may exacerbate the problem of unused medicines.[11–13]

Unused medication presents significant challenges from both economic and environmental perspectives. Economically, it undermines the cost-effectiveness of the drug supply chain. Despite the extensive processes involved in the preparation, storage, and delivery of medications, a substantial portion of these efforts goes to waste when the products remain unused.[14] For instance, households in Saudi Arabia incurred a total expenditure of US $150 million on medications that ultimately went unused.[15] Environmentally, improper disposal of unused medications poses risks to human health, wildlife, and plant ecosystems, leading to potentially harmful consequences.[16,17] Furthermore, the presence of unused medicines in households poses several risks, such as the potential for inappropriate self-medication, accidental poisoning, and the development of antimicrobial resistance.[18] In spite of the implementation of various interventions such as mobilizing health extension workers to educate households about managing unused medicines,[19] implementing stricter controls on over-the-counter (OTC) medications to reduce unnecessary purchases, and training healthcare providers to counsel patients on proper medication use and storage,[20] unused medicines among households remains an evolving public health problem.

Despite its public health implications, the issue of unused and expired medicines at the community level in Ethiopia has not received adequate policy attention. Existing pharmaceutical waste management policies and guidelines primarily focus on institutional practices, such as those at health facility level, with limited consideration of community behaviors and household-level medicine disposal. There are no structured national programs or public awareness campaigns aimed at reducing medicine wastage at the household level, and reverse logistics systems for the safe return of unused or expired medications are notably absent. Moreover, structured policy discussions on the root causes of medicine wastage are scarce. This lack of attention suggests a potential underestimation of the magnitude of the problem and underscores the urgent need for evidence-based research to guide national policy development. Furthermore, there is a significant shortage of precise and up-to-date data on the prevalence and determinants of unused medicines at the household level in Ethiopia. Existing studies are often geographically limited, and lack a comprehensive analysis of both the pooled prevalence and the factors contributing to the issue. Reliable and context-specific data are crucial for designing effective interventions, raising public awareness, and informing policy development. Without such data, policymakers may continue to overlook the scope of the problem, resulting in insufficient or misdirected responses. Therefore, this systematic review and meta-analysis aims to synthesize available evidence, estimate the pooled prevalence of unused medicines, and identify key determinants among households in Ethiopia.

2. Method

2.1. Study protocol

The protocol for this systematic review and meta-analysis has been registered with the International Prospective Register of Systematic Reviews (PROSPERO) under the registration ID CRD42024563052. This review adheres to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, ensuring a rigorous and transparent methodology for literature search, study selection, data extraction, and reporting of findings (Supplementary File 1).[21]

2.2. Search strategy

A systematic review and meta-analysis were conducted to determine the pooled prevalence and determinants of unused medicines among households in Ethiopian. The search for relevant research articles was conducted via databases such as HINARI, Science Direct, Embase, Thesis Bank, PubMed/MEDLINE, Google Scholar, and Research Gate for English-language publications. The reference lists of the identified studies were also reviewed for additional relevant research. The search was conducted between December 19, 2024, and January 10, 2025, and

all published articles available online until the day of data collection were considered. The search terms used included "prevalence," "magnitude," "burden," "extent", "unused medicines," "leftover medicines," "expired medicines," "associated factors," "predictors," "determinant,""causes," "households," "home," "community," and "Ethiopia." These terms were used in combination with "AND" and "OR" to identify relevant articles. After data were retrieved from the articles, we attempted to contact the primary or corresponding authors via email to obtain any missing information.

2.3. Study selection

Following the identification of relevant articles through comprehensive database searches across several platforms, duplicate publications were eliminated to ensure that each article was unique, and the remaining articles were imported into EndNote X20. Five investigators, TTA, GWG, TM, EDG, and TBA, separately screened the titles and abstracts of the articles to assess their eligibility based on predefined criteria. Finally, the authors (TTA, GWG, TM, EDG, and TBA) then conducted an independent evaluation of the full-text articles, applying the established inclusion and exclusion criteria. Disagreements among the investigators regarding article selection were settled by discussion before beginning the analysis.

2.4. Eligibility criteria

2.4.1. Inclusion criteria

Observational studies (cohort, cross-sectional, and case–control studies), which were reported as original articles, theses, and abstracts from scientific events and meetings, published in English at any time, addressing the prevalence of unused medicines among households in Ethiopia were included.

2.4.2. Exclusion criteria

Based on the consensus of the authors, we decide to exclude a) articles were excluded if they did not report the prevalence of unused medicines, did not provide sufficient data to calculate the prevalence either in the original text or upon request, and/or only provided descriptive information about unused medicines without quantifiable estimates. However, studies that reported the prevalence of unused medicines were included in the analysis of pooled prevalence, even if they did not assess or report factors associated with unused medicine. Only studies that specifically reported or examined associated factors were included in the analysis of determinants. b) Articles reporting interventions for unused medicines but not their prevalence before intervention. c) Articles not published in peer-reviewed journals. Additionally, studies with incomplete data, even after the authors were contacted, were also excluded. If there were doubts about the eligibility of a study, the decision was made by involving five additional reviewers (MT, RBA, MDM, MAE, and AEF).

2.4.3. Data extraction

A standardized piloted data extraction form was developed and key variables were extracted, including study characteristics such as (the first author's name, publication year, region where the study was conducted, sample size, study design), the common class of unused medicines, and reason for the presence of unused medicines. Additionally, the outcome of interest (prevalence of unused medicines, and determinants of unused medicines, as well as measures of effect (odds ratios (ORs)), lower confidence intervals, and upper confidence intervals, were also extracted (Supplementary Data). After the articles were selected and final decisions were made, TTA, MDM, MJT, EDG, TM, GWG, ZWB, and TBA individually extracted all relevant data from the selected articles. In cases where the authors had different opinions during the data extraction process, a decision to extract was made by consulting and discussing with second groups of authors (ATG, AEF, MT, RBA, and TKZ). At this point, the data were double-extracted with other authors. To compare the observed and expected agreements across authors, we used kappa statistics to illustrate any differences. The calculated kappa value of $\geq$0.6, indicating substantial agreement, was considered acceptable. To determine the reliability of the meta-analytic results, a sensitivity analysis was also performed. Once all data were verified and discrepancies were resolved, the finalized dataset was compiled for analysis.

2.5. Outcome measurements

The primary aim of the current systematic review and meta-analysis was to assess the pooled prevalence of unused medicines, as well as determinants associated with unused medicines among households in Ethiopia. This study also has two secondary outcomes: i) to identify the most commonly retained unused medications. ii) To identify the primary reason cited for the accumulation of unused medicines.

2.6. Quality assessment

The methodological quality of the selected studies was evaluated using a modified version of the quality assessment checklist for household surveys, originally developed by West et al.[22] This checklist consists of 17 items, each scored as follows: 2 points for "yes," 1 point for "partial," and 0 points for "unclear" or "no." The total quality score for each study was calculated using the formula:

$$(\text{Number of "yes" x2}) + (\text{number of "partial" x1})$$

$$34 - (\text{Number of "N/A" x2})$$

Based on the total score, studies were ranked and categorized into three risk-of-bias levels: high ($\leq$ 50 %), moderate (50–75 %), and low ($\geq$ 75 %). TTA, TBA, GWG, TM, MDM, and EDG conducted the quality assessment. Any disagreements between these reviewers were resolved through consensus, and the opinion of another reviewer (TKZ, MT, ATG, RBA and AEF) was sought if necessary. The quality assessment process was completed on January 25, 2025.

2.7. Statistical procedure

Following data extraction, the information was organized in Microsoft Excel and subsequently analyzed using STATA 11.0. The findings from the present study were systematically presented through descriptive text, comprehensive tables, and forest plots to ensure clarity and facilitate interpretation. For each original article included in the analysis, the standard error of prevalence was calculated using the binomial distribution. To ensure the robustness of our findings and assess the potential influence of small study effects, we investigated the presence of publication bias, via two complementary methods. First, a funnel plot was constructed to visually evaluate the symmetry of the distribution, which indicated an absence of significant publication bias. Additionally, Egger's correlation and Begg's regression intercept tests were conducted at a 5 % significance level to statistically confirm these findings. In cases where evidence of publication bias was detected, the analysis incorporated funnel plot formalization, estimation of the number and outcomes of potentially missing articles, and adjustment for hypothetical absent studies using the nonparametric "trim and fill" method developed by Duval and Tweedie.[23]

2.8. Heterogeneity assessment

Der Simonian and Laird's random effects meta-analysis was employed to estimate the pooled effects of unused medicines. Heterogeneity across studies was evaluated using the I^2 inconsistency statistic, with an I^2 value of 70 % or higher indicating substantial heterogeneity. In cases where significant heterogeneity was detected, a sensitivity

analysis was conducted to identify potential sources of variation. Specifically, a leave-one-out sensitivity analysis was performed by sequentially excluding individual authors or studies to assess their influence on the pooled prevalence of unused medicines and to determine the potential causes of heterogeneity.

2.9. Subgroup analyses

Subgroup analyses are useful for examining between-group differences or determining how a given group's characteristics affect the prediction of the pooled prevalence and the cause of heterogeneity across studies. In this study, the prevalence of unused medicines among households in Ethiopia was examined by subgrouping the regions where the study was conducted, study designs, and reason for possessing unused medicines. The prevalence of unused medicines among households in Ethiopia is reported as percentages with 95 % confidence intervals (CIs).

3. Result

3.1. Article search results

A total of 84 articles were initially identified from the database. After removing duplicates, 47 unique articles remained for screening. Following title and abstract screening process, 22 articles were excluded. The remaining 25 articles underwent a thorough evaluation based on predefined inclusion criteria, leading to the exclusion of an additional 13 articles. Ultimately, 12 full-text articles met the eligibility criteria, passed the quality assessment, and were included in the final systematic review and meta-analysis (Fig. 1).

3.2. General characteristics of the included studies

Twelve primary articles, encompassing a total of 6123 households, were included in the final systematic review and meta-analysis on the prevalence and determinants of unused medicines in Ethiopian households. Of these, eleven studies employed a cross-sectional study design, while one utilized a cohort study design. The included studies were published between 2017 and 2024 and covered five regions and one city administration (Addis Ababa). Geographically, two studies focused on rural communities, whereas the remaining ten were conducted in urban settings (Table 1).

3.3. Quality of the included studies

No studies were excluded due to quality concerns, as all included

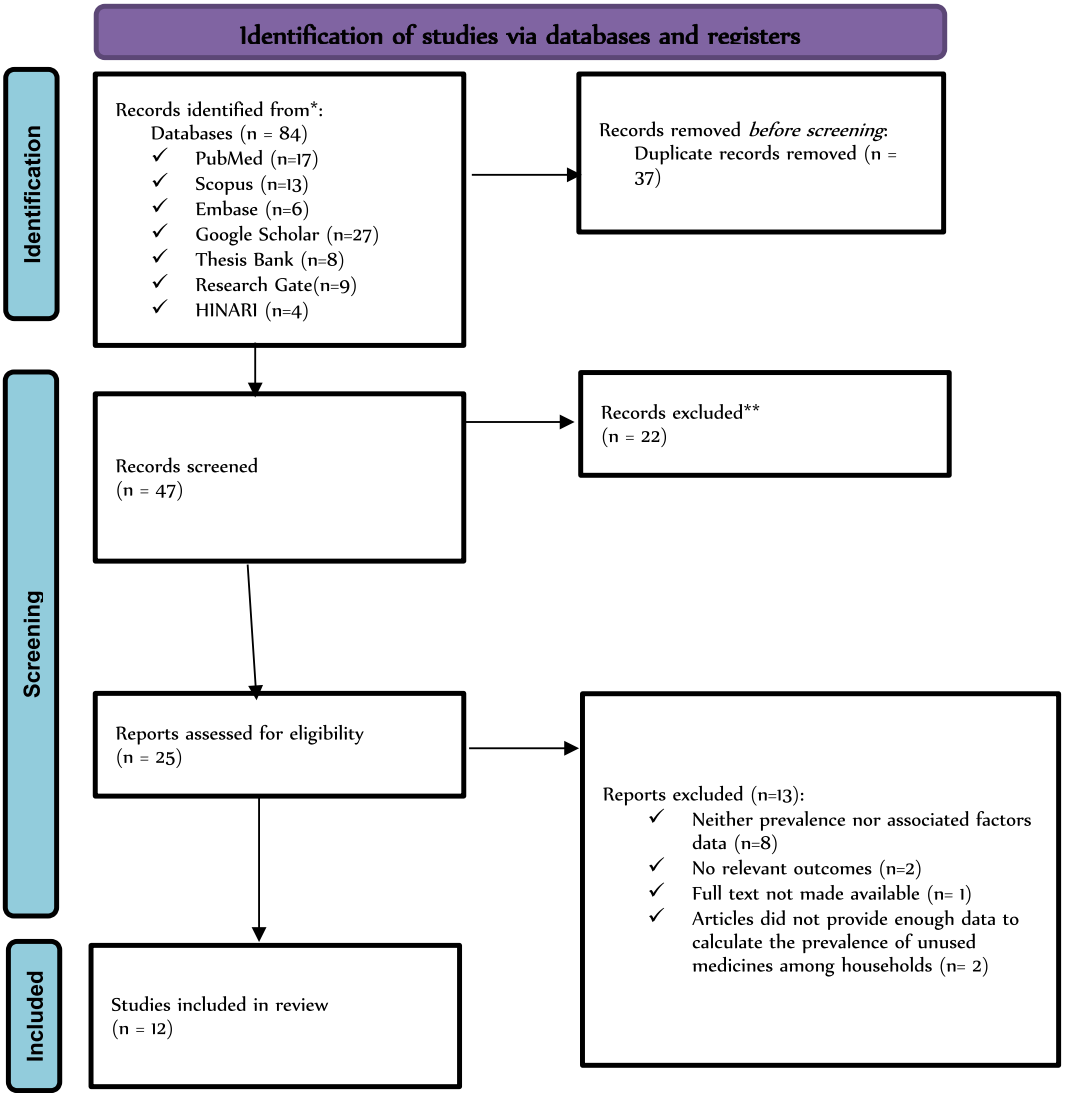

Fig. 1. PRISMA 2020 flow diagram of study selection.

Table 1
Characteristics of the studies included in this systematic review and meta-analysis on unused medicines among households in Ethiopia.

Authors	Publication year	Study design	Study period	Region	Sample size	Setting	Prevalence of unused medicines (%)
Gebregeorgise et al.[26]	2024	Cohort	April to September 2022	Amhara	178	Rural	40.4
Dekeba et al.[28]	2017	cross-sectional	April 2016	Oromia	300	Urban	27.2
Ayele et al.[24]	2018	cross-sectional	February to April 2018.	Harari	695	Urban	66
Thomas et al.[30]	2018	cross-sectional	October 2016	South Ethiopia	824	Urban	25.7
Kahsay et al.[13]	2020	cross-sectional	October to November 2019	Tigri	359	Urban	52.4
Ymenu et al.[10]	2020	cross-sectional	April to May 2018	Amhara	507	Rural	13.8
Woldeyohanins et al.[27]	2021	cross-sectional	August to September 2021	Amhara	404	Urban	55.9
Asmamaw et al.[11]	2023	cross-sectional	June to August 2022	South Ethiopia	330	Urban	49.4
Tegegne et al.[12]	2024	cross-sectional	July to August 2023	Amhara	786	Urban	55
Yimer et al.[31]	2024	cross-sectional	November 2019	Amhara	521	Urban	62.4
Mitiku et al.[29]	2024	cross-sectional	July to August 2021	Oromia	397	Urban	23
Geremew et al.[25]	2024	cross-sectional	April to May 2021	Addis Ababa	759	Urban	61

studies achieved an overall quality score exceeding 70 %. Specifically, nine of the included studies achieved an overall quality score of 75 % or higher. The majority of the studies employed appropriate sampling methods, with random sampling being the most frequently used approach (83.33 %, $n = 10$). Furthermore, most studies demonstrated strong alignment between their research methodologies and key components such as the research question, data collection, data analysis, and interpretation of results, reflecting overall high quality. The objectives of all studies were clearly articulated, and the results were comprehensively and accurately reported **(**Additional file 2**)**.

3.4. Test of heterogeneity and publication bias, subgroups and sensitivity analyses

3.4.1. Heterogeneity and publication bias

The twelve articles included in this systematic review and meta-analysis exhibited a high degree of heterogeneity, as indicated by the statistical analysis (I2 = 99.0 %, $p < 0.001$). To assess potential publication bias in the included studies, two methods were employed. A funnel plot (Fig. 3) was initially employed to assess the symmetry of the distribution, suggesting an absence of publication bias among the included studies. Furthermore, Egger's test confirmed this finding, yielding a *p*-value of 0.465 (Table 2), which provides additional statistical support for the lack of publication bias. To distinguish between the various causes of heterogeneity, both sensitivity and subgroup analyses were conducted.

3.4.2. Subgroup analyses

To explore the potential sources of heterogeneity, a subgroup analysis was conducted based on the region, study design, and study setting. The findings revealed significant variations in the prevalence of unused medicines across these subgroups. Subgroup analysis based on the region revealed that the highest prevalence of unused medicines among households in Ethiopia was observed in Addis Ababa, Tigray, and the Harari region, with a prevalence of 60.1 % (95 % CI: 53.34–66.84). This was followed by the Amhara region and southern Ethiopia, with prevalence rates of 45.49 % (95 % CI: 24.50–66.49) and 37.48 % (95 % CI: 14.25–60.70), respectively. In contrast, the lowest prevalence was reported in the Oromia region at 24.82 % (95 % CI: 20.74–28.90). Furthermore, the highest prevalence of unused medicines was identified in studies employing a cross-sectional design, with a prevalence of 44.69 % (95 % CI: 32.5–56.88). This was followed by studies utilizing a cohort design, which reported a prevalence of 40.40 % (95 % CI: 33.19–47.61). Finally, geographically, the prevalence of unused medicines was higher among urban households (47.80 %; 95 % CI: 36.82–58.77) compared to rural households (26.89 %; 95 % CI: 0.83–52.95) (Table 5).

Table 2
Egger's test for unused medicines among households in Ethiopia.

Std_Eff	Coef.	Std. Err.	t	P > |t|	[95 % Conf. Interval]
Slope	23.58439	25.47125	0.93	0.376	−33.16909 80.33787
Bias	9.545259	12.55695	0.76	0.465	−18.43337 37.52389

3.4.3. Sensitivity analysis

A sensitivity analysis was conducted in this systematic review and meta-analysis to assess the impact of individual studies on the pooled prevalence of unused medicines among households in Ethiopia. This was performed using a leave-one-out approach, systematically removing one study at a time. The results indicated that all estimates remained within the expected 95 % confidence interval, suggesting that the exclusion of any single study did not substantially affect the overall prevalence reported in this review (Table 6).

3.5. Study outcome measures

3.5.1. Prevalence of unused medicines among households in Ethiopia

A systematic review and meta-analysis of 12 published studies were conducted to determine the pooled prevalence of unused medicines among households in Ethiopia.[10–13,24–31] The study found that the pooled prevalence of unused medicines among Ethiopian households was 44.34 % (95 % CI: 32.83, 55.84) (Fig. 2**)**. The reported prevalence of unused medicines varied widely across studies, ranging from 13.8 % in the Amhara region[10] to 66 % in the Harari region.[24] Antibiotics were the most frequently unused class of medications, accounting for 31.49 % (95 % CI: 21.81–41.18) of all unused medicines in households. Analgesics followed at 26.14 % (95 % CI: 16.72–35.56), while antacids constituted 8.7 % (95 % CI: 4.57–12.84). In contrast, cardiovascular medicines 5.75 % (95 % CI: 2.14–9.37) and dietary supplements 3.4 % (95 % CI: 0.8–5.8) were the least commonly reported as unused (Table 3).

3.6. Common reason for the presence of unused medicines among households in Ethiopia

Self-discontinuation upon symptom relief accounted for 34.21 % of the primary reasons for the accumulation of unused medications among households in Ethiopian. This was followed by the anticipation of future use (20.47 %), changes in treatment regimens by physicians (10.67 %), forgetfulness (9.90 %), and sharing medications with others (9.38 %). Experiencing side effects (7.24 %) and expiration of medications (5.86 %) were the least common reasons for medication accumulation (Table 4).

3.7. Factors associated with the prevalence of unused medicines among households in Ethiopia

Key determinants contributing to the prevalence of unused medicines in Ethiopian households include self-medication with non-steroidal anti-inflammatory drugs (NSAIDs), the acquisition of medications without a prescription, and higher household income (Fig. 4).

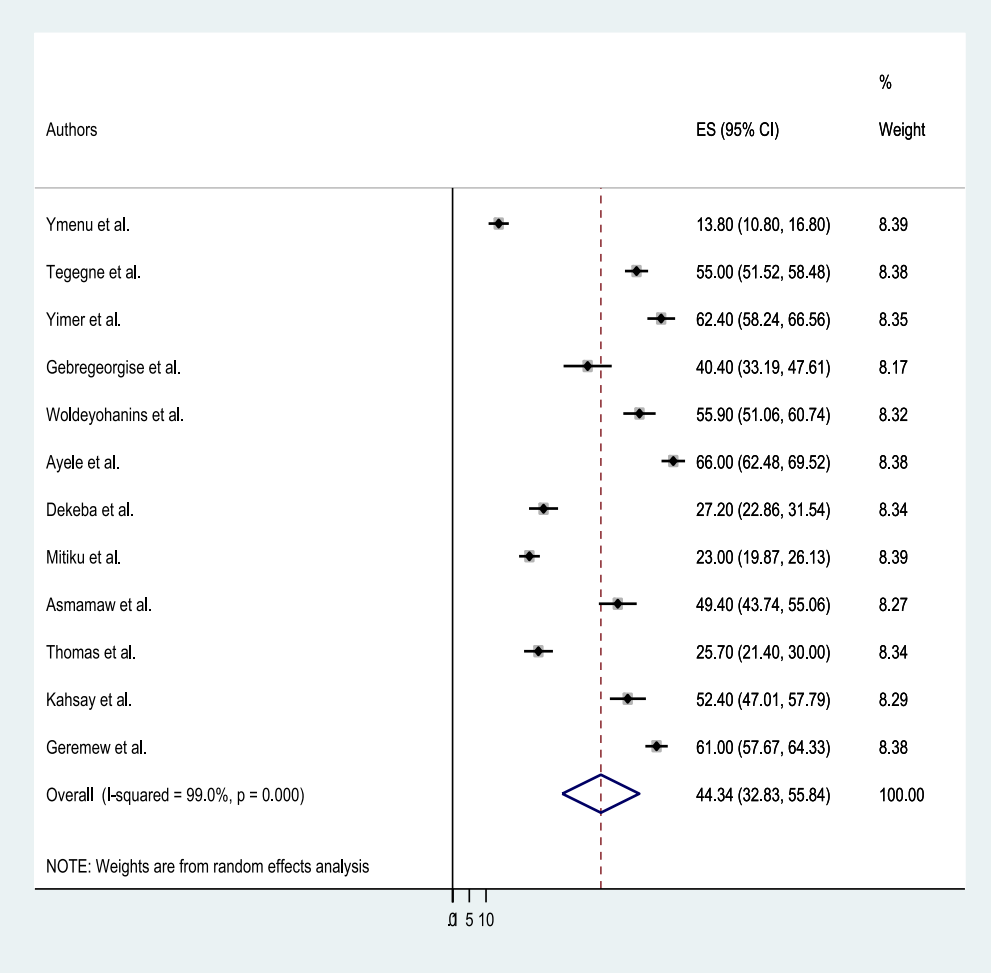

Fig. 2. The pooled prevalence of unused medicines among households in Ethiopia.

Table 3
The most commonly unused class of medicines among households in Ethiopia.

Class of unused medicines	Number of study	Prevalence (95 % CI)	Heterogeneity	
			I2 (%)	p-value
Antibiotics	11	31.49 % (21.81, 41.18)	98.6	<0.001
Analgesics	11	26.14 % (16.72, 35.56)	98.5	<0.001
Antacids	11	8.7 % (4.57, 12.84)	92.0	<0.001
Cardiovascular drugs	10	5.75 % (2.14, 9.37)	89.5	<0.001
Dietary supplements	10	3.30 % (0.80, 5.80)	77.7	<0.001

4. Discussion

The present study provides a comprehensive quantitative summary of the prevalence of unused medicines among households in Ethiopian. The pooled prevalence of 44.34 % (95 % CI: 32.83, 55.84) highlights a significant burden of unused medications in the country. This finding is consistent with studies from Uganda 35.1 %[32] and India 38 %,[33] where the accumulation of unused medicines remains a common issue. This may be due to firstly; in many low- and middle-income countries, lack of proper disposal mechanisms and low public awareness contribute to the persistence of unused medicines in households. Lack of inadequate infrastructure for safe medicine disposal, leading households to store expired or unused medications rather than discarding them appropriately. In addition to this, to a certain degree, unused medicines is unavoidable due to various reason, such as patient death, treatment failure, medication changes, and side effects.[22] Furthermore, similarity in healthcare access challenges across three countries play a role. Many

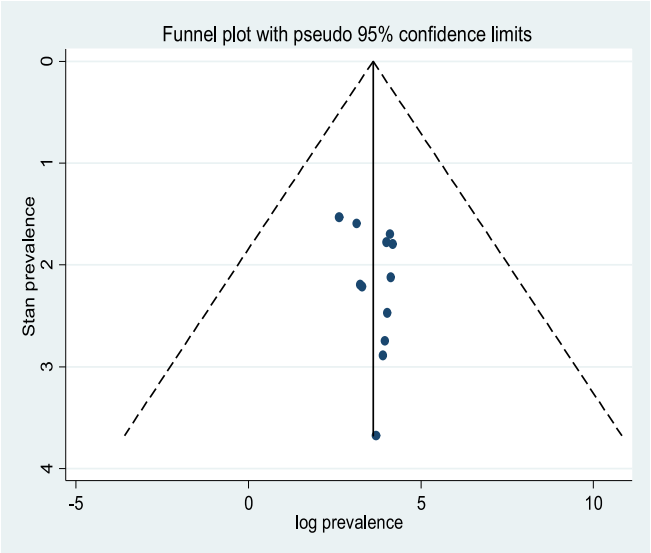

Fig. 3. Random effects funnel plot of logit event rate of unused medicines effect sizes by standard error.

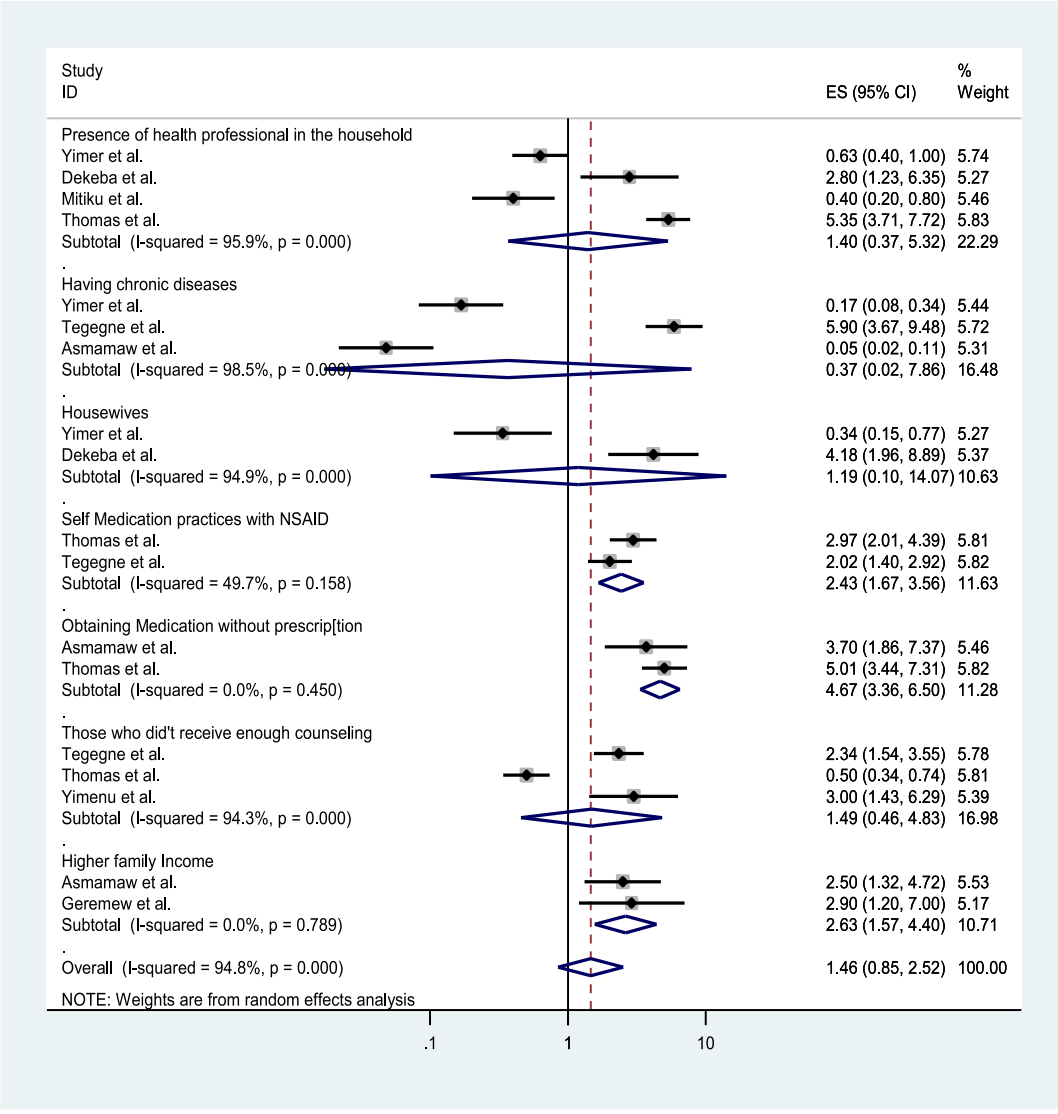

Fig. 4. Determinants of unused medicines among households in Ethiopia.

Table 4
Common reason for the presence of unused medicines among households in Ethiopia.

Variables	Number of study	Prevalence (95 % CI)	Heterogeneity	
			I2 (%)	p-value
Self-discontinuation up on reliefs	9	34.21 % (21.09, 47.33)	99.2	<0.001
Anticipated future use	10	20.47 % (6.34, 34.61)	99.3	<0.001
Doctors changed treatments	10	10.67 % (5.12, 1621)	95.6	<0.001
Forgetfulness	7	9.9 % (2.28, 17.52)	97.7	<0.001
Sharing for others	8	9.38 (2.58, 16.18)	96.7	<0.001
Experiencing side effects	9	7.24 % (4.00, 10.47)	86.1	<0.001
Passed expire date	8	5.86 % (1.51, 10.20)	92.8	<0.001

Table 5
Subgroup analysis of unused medicines among households in Ethiopia.

Variable	Subgroup	Number of studies	Prevalence (%) (95 % CI)	Heterogeneity	
				I^2%	p-value
Region	Amhara	5	45.49 (24.50, 66.49)	99.2	<0.001
	Oromia	2	24.82 (20.74, 28.90)	57.8	0.124
	South Ethiopia	2	37.48 (14.25, 60.70)	97.7	<0.001
	Other*	3	60.1 (53.34, 66.84)	88.4	<0.001
Study design	Cohort	1	40.40 (33.19, 47.61)	–	–
	Cross-sectional	11	44.69 (32.5, 56.88)	99.1	<0.001
Settings	Urban	10	47.80 (36.82, 58.77)	98.7	<0.001
	Rural	2	26.89 (0.83, 52.95)	97.8	<0.001

Other* = Addis Ababa, Harari and Tigri region.

Table 6
Sensitivity analysis of unused medicines among households in Ethiopia.

Authors	Estimate prevalence (%) (95 % CI)	Heterogeneity	
		I2 (%)	p-value
Ymenu et al.	47.14 (36.83, 57.45)	98.5	<0.001
Mitiku et al.	46.29 (34.38, 58.21)	98.9	<0.001
Thomas et al.	46.04 (33.86, 58.21)	99.0	<0.001
Dekeba et al.	45.90 (33.67, 58.13)	99.0	<0.001
Gebregeorgise et al.	44.69 (32.50, 56.88)	99.1	<0.001
Asmamaw et al.	43.88 (31.60, 56.17)	99.1	<0.001
Kahsay et al.	43.61 (31.34, 55.88)	99.1	<0.001
Tegegne et al.	43.37 (30.90, 55.83)	99.0	<0.001
Woldeyohanins et al.	43.29 (31.04, 55.54)	99.0	<0.001
Geremew et al.	42.81 (30.77, 54.86)	98.9	<0.001
Yimer et al.	42.69 (30.69, 57.70)	99.0	<0.001
Ayele et al.	42.36 (30.76, 53.95)	98.9	<0.001

patients may obtain multiple prescriptions from different healthcare providers, either due to seeking alternative treatments or due to fragmented healthcare systems. Lastly, cultural beliefs and misconceptions regarding medicine use and storage may contribute to the problem. In many communities, people hold onto unused medicines for future illnesses or to share with family members, increasing the accumulation of expired or unnecessary drugs.[20] The high prevalence of unused medicines raises several concerns. Firstly, improper disposal of these medications can lead to environmental pollution, as pharmaceuticals that are not disposed of properly may contaminate water sources and soil.[34] Secondly, the presence of unused medicines in households increases the risk of accidental ingestion, misuse, and antimicrobial resistance,[35] particularly in low- and middle-income countries like Ethiopia, where self-medication practices are prevalent.

However, the prevalence of unused medicines among households in the present study was lower than the 63.8 % reported in a previous systematic review[36]. Additionally, it was considerably lower compared to findings from studies conducted in Nigeria (94.1 %)[37], Indonesia (95 %),[38] Tanzania (70.19 %),[9] and India (78.7 %).[39] This may be due to variations in prescription patterns and healthcare accessibility. In countries with high prevalence rates, over prescription and self-medication may be more common, leading to increased medicine accumulation in households. Ethiopia may have relatively stricter prescription regulations, resulting in fewer unused medicines. In addition to this, public awareness and health literacy play a crucial role. In countries with higher rates, there may be lower awareness regarding appropriate medicine use, storage, and disposal, leading to the unnecessary retention of medicines. In contrast, better adherence to prescribed treatments and disposal practices in Ethiopia may contribute to the lower prevalence observed in this study. Moreover, economic and cultural factors influence medicine storage behaviors. In some countries, individuals may stockpile medicines due to affordability concerns, fear of future shortages, or cultural beliefs about keeping medications for potential future use. In contrast, the finding of the present study was higher than those reported in Serbia, where only 10.3 % of urban households and 11.8 % of rural households accumulated unused medicines.[40] This may be attributed to differences in healthcare policies and prescription regulations. Serbia may have more stringent pharmaceutical regulations and prescription-monitoring systems, which may help reduce unnecessary medication distribution and accumulation. In contrast, Ethiopia, like in many low- and middle-income countries, may have less strict enforcement of prescription guidelines, leading to over prescription and medication stockpiling.

However, the pooled prevalence estimates of unused medicines in Ethiopia, as determined through meta-analysis, revealed significant heterogeneity across studies. This variability can be attributed to several factors, including regional differences, geographical settings (urban versus rural), and variations in study design. The substantial differences in prevalence estimates observed in this systematic review are consistent with findings from recent review, which also highlight the wide range of unused medicine prevalence in similar contexts.[16] The heterogeneity in prevalence estimates may stem from multiple sources. First, differences in study designs, such as cross-sectional versus longitudinal approaches, and variations in sample sizes could influence the reported prevalence. For instance, studies with more representative samples may yield more reliable estimates compared to smaller. Second, disparities in healthcare infrastructure, prescribing practices, and dispensing behaviors across regions may contribute to the observed variability. In urban areas, where access to healthcare facilities is relatively better, the prevalence of unused medicines might differ significantly from rural areas, where healthcare access is limited and self-medication practices are more common.[41] Additionally, patient-related factors, such as adherence to prescribed regimens, affordability of medications, and socio-economic status, play a critical role in determining the accumulation of unused medicines. Furthermore, regulatory frameworks governing medicine use and disposal vary across regions, which may also contribute to the heterogeneity in prevalence estimates. In some areas, stricter regulations and better public awareness campaigns may reduce the accumulation of unused medicines, while in others, lax enforcement and limited awareness may exacerbate the problem.[42] Another contributing factor is the variation in the types of medicines included in the studies. Some studies may focus on specific categories of medicines, while others may include a broader range of pharmaceutical products. This inconsistency in the scope of medicines studied can lead to differing prevalence estimates. Moreover, public awareness and education regarding proper medication use and disposal vary widely across Ethiopia, further influencing the prevalence of unused medicines in households.

Subgroup analyses based on geographical setting revealed significant variation in the pooled prevalence estimates of unused medicines between urban and rural households in Ethiopia. The prevalence of unused medicines was found to be substantially higher in urban households (47.80 %) compared to rural households (26.89 %). This disparity may be attributed to differences in healthcare access, prescribing practices, medication availability, and socio-economic factors between urban and rural areas. Urban households often have better access to healthcare facilities and pharmacies, which may lead to higher rates of medicine accumulation due to over-prescription or stockpiling. In contrast, rural households may face limited access to healthcare services, resulting in lower rates of medicine acquisition and, consequently, fewer unused medicines. This finding contrasts with a recent study conducted in Serbia, which reported no significant difference in the prevalence of unused medicines between urban and rural households.[40] The discrepancy may be explained by contextual differences in healthcare systems, cultural practices, and socio-economic conditions between Ethiopia and Serbia. In Serbia, the healthcare system is more uniformly accessible across urban and rural areas, potentially reducing disparities in medicine use and accumulation. Additionally, public awareness campaigns and medicine take-back programs in Serbia may have contributed to more consistent patterns of medicine use and disposal across geographical settings.

The observed variation in the prevalence of unused medicines between study designs may reflect differences in how data is collected and the time frames over which they are observed. The prevalence of unused medicines in studies employing a cross-sectional design, was found to be 44.69 % (95 % CI: 32.5–56.88), which assess data at a single point in time typically capture a snapshot of the prevalence of unused medicines within a specific population.[43] This design more likely to capture a higher proportion of unused medicines because it includes all available medicines, whether currently needed or not. Which could also reflect acute medication misuse, stockpiling, or inappropriate use. In contrast, studies using a cohort design, which follow participants over a longer period,[44] reported a lower prevalence of 40.40 % (95 % CI: 33.19–47.61). Cohort studies generally track the accumulation and consumption of medicines over time, which may result in a lower reported prevalence of unused medicines. Participants in cohort studies

may have been more likely to use medications over time, leading to less accumulation and waste. Additionally, cohort studies often focus on specific groups with known health conditions, which may influence medication consumption patterns and reduce the likelihood of unused medicines.

Specifically, antibiotics were the most frequently unused class of medications, accounting for 31.49 % of all unused medicines in households. The finding from the present study is comparable with studies conducted in Saudi Arabia (48.7 %),[45] India (28.1 %),[18] and Ghana (46.5 %).[46] The high prevalence of unused antibiotics could be linked to the common practice of dispensing them without a prescription. A study in Ethiopia revealed that more than 80 % of visits to community drug outlets led to the acquisition of antibiotics without a prescription.[47] The widespread presence of unused antibiotics in households poses significant public health risks, particularly the growing threat of antimicrobial resistance.[48] This resistance can arise from the easy access to leftover antibiotics at home and the common practice of sharing them with family and friends who experience similar symptoms. Analgesics, antacids and dietary supplements were also commonly reported unused medicine. These findings were also supported by previously conducted studies in India.[18] In Ethiopia, these class of medicines are available without prescription and are commonly purchased in bulk for future use.[49] The regulatory framework permits the sale of certain OTC drugs in both community pharmacies and licensed drug retail outlets, although enforcement of prescription-only rules for certain medications may vary in practice. Given the chronic or episodic nature of conditions treated with OTCs, their presence in households does not always indicate non-adherence or irrational use. Instead, retaining such medications for anticipated future use is common and culturally accepted. Therefore, in our analysis, we recognize that the term unused medications may carry different implications for OTC versus prescription drugs. For prescription medications such as antibiotics, antihypertensive, and prescription NSAIDs unused quantities are more clearly indicative of issues like non-adherence, over prescription, or premature discontinuation.

The accumulation of unused medicines among households in Ethiopian is a multifaceted issue influenced by patient behavior, healthcare system factors, and cultural practices. The most common reason suggests a widespread tendency for individuals to stop taking prescribed medications once they feel better. This finding is supported by previous studies conducted in New Zealand,[50] Saudi Arabia,[45] USA[6] and India.[18] This behavior could indicate a lack of awareness about the importance of completing prescribed treatments, people in such contexts may discontinue medication once symptoms subside; mistakenly believing they are fully healed, not understanding that incomplete treatment can lead to complications, resistance in the case of antibiotics, or recurrence of illness. This issue may be linked to inadequate patient counseling by healthcare providers and a lack of effective follow-up mechanisms.[51] Additionally, a significant proportion of households retain unused medicines for potential future needs, reflecting concerns about healthcare accessibility, financial constraints, or the cost of obtaining new prescriptions that make people reluctant to discard medications they might need later. While this practice might seem practical, it poses risks such as self-medication, incorrect dosage administration, and using expired or inappropriate drugs.[20] A notable percentage of unused medicines also arise due to modifications in treatment plans by healthcare providers. This can happen when initial prescriptions are ineffective, adverse reactions occur, or a more suitable medication becomes available.[52] While these changes are necessary for patient safety, they also contribute to medication wastage. Implementing better prescribing practices and ensuring that physicians consider medication adherence factors before switching treatments may help reduce this issue.[53]

Furthermore, forgetfulness in taking medication is another reason that leads to the accumulation of unused medicine, particularly among elderly patients and those managing multiple medications. This finding is supported by a previous literature review.[20] This challenge underscores the need for adherence-support mechanisms such as medication reminders, pill organizers, and educational initiatives to help patients develop consistent medication routines. Sharing of unused medicines to others is another reason lumped by 9.38 % of the households. The practice of sharing medications among family members or friends highlights cultural and economic influences on medicine use.[54] While this may be driven by good intentions, it increases the risk of incorrect treatment, adverse drug interactions, and the spread of antimicrobial resistance. Public awareness campaigns emphasizing the dangers of medication sharing could help mitigate this issue. Although the least common reason, medication expiration still contributes to the overall problem of unused medicines. Previous studies in USA[6] supports the present finding. Expired drugs can be ineffective or even harmful, making proper disposal is crucial. This issue could be linked to excessive prescribing, stockpiling of medications, or poor storage practices.[55]

This study was also aimed to identify determinants associated with unused medicines among households in Ethiopia. Self-medication with NSAIDs, the acquisition of medications without a prescription, and higher household income were positively associated with the accumulation of unused medications. These determinants reflect gaps in healthcare regulation, accessibility, and public awareness, contributing to medication waste and potential health risks. None-steroidal anti-inflammatory drugs (NSAIDs) are among the most commonly used over-the-counter (OTC) medications globally, and Ethiopia is no exception. Many individuals self-medicate with NSAIDs to manage pain, fever, or inflammation without consulting a healthcare provider. The excessive and unsupervised use of NSAIDs can lead to over-purchasing, resulting in leftover medicines when symptoms subside. A lack of awareness regarding the risks of prolonged or inappropriate NSAID use further exacerbates this issue. Additionally, the ease of obtaining medicines without a prescription is another significant driver of unused medications in Ethiopia. In many low- and middle-income countries, including Ethiopia, weak regulatory enforcement allows pharmacies and informal drug vendors to dispense medications without proper authorization.

Households with higher incomes were also significantly associated with the accumulation of unused medicines. Studies indicate that households with higher incomes are more likely to accumulate unused medicines. This trend may be attributed to several factors increased purchasing power, allowing families to buy medications in excess, and making it easier to abandon medications if side effects occur or newer alternatives are available. Furthermore, households with higher incomes may have better healthcare access, leading to more frequent doctor visits and changes in treatment plans, which may leave previously prescribed medications unused.[56]

4.1. Implication of the study

The present study highlights the importance of establishing systematic medicine return or disposal programs as a practical solution to address the accumulation of unused medications. These programs can be integrated into healthcare delivery systems. Public drop-boxes located in accessible areas of the pharmacy near the checkout or entrance, which may serve as a low-barrier disposal option for the general public, and pharmacy-led take-back programs, where medications are returned directly to pharmacy staff, which may require specific legal authorization and adherence to pharmaceutical waste handling regulations. While safe disposal of unused medicines is an important component of pharmaceutical waste management, it is equally critical to address the root causes of medicine accumulation across the prescribing, dispensing, and consumption stages. To reduce the generation of unused medicines, health systems should adopt rational prescribing practices, such as prescribing the exact quantities needed for the full course of treatment and avoiding polypharmacy unless clinically necessary. At the dispensing stage, pharmacists can play a proactive role by reviewing prescriptions for appropriateness, providing clear instructions, and ensuring patients understand the intended use and duration of treatment. Furthermore, strengthening follow-up systems to monitor

medication adherence and therapeutic outcomes can help identify early non-compliance or treatment discontinuation, thus minimizing waste.

The observed variation due to geographical setting in Ethiopia underscores the need for context-specific interventions to address the issue of unused medicines. In urban areas, interventions could focus on improving prescribing practices, enhancing patient education on proper medicine use, and establishing medicine take-back programs. In rural areas, efforts should prioritize improving access to healthcare services and ensuring the availability of essential medicines to reduce the need for stockpiling. Tailoring interventions to the unique needs of urban and rural populations will be critical to effectively mitigating the risks associated with unused medicines. Furthermore, the study underscore the need for targeted educational programs to raise awareness about the risks of improper medication retention and disposal. By promoting proper medication use and disposal, these interventions can reduce the prevalence of unused medicines and the associated health risks, such as drug resistance and disease recurrence. Over time, consistent education and programmatic efforts can instill lasting behavior changes in medication use and management, even beyond the country. Finally, the study serves as a basis for future research to evaluate the effectiveness of targeted interventions in reducing unused medication and improving health literacy.

4.2. Limitation of the study

The included studies have totally focused on quantitative analyses of unused medicines among households, leaving a significant gap in understanding the preferences and experiences of households, which are key influential factors contributing to inappropriate storage and medication wastage. By concentrating solely on numerical data, these studies have overlooked the qualitative aspects of household behavior, such as cultural practices, perceptions, and decision-making processes related to medication use and storage. Addressing this gap through future research that incorporates qualitative methods, such as interviews or focus group discussions, would provide deeper insights into the underlying reasons for the accumulation of unused medicines among households. Such research could inform the development of more effective, context-specific interventions to promote proper medication management and reduce wastage in households. Second, a notable limitation of this systematic review and meta-analysis is the heterogeneity observed among the included studies, which may have influenced the overall results. For instance, the analysis revealed significant variations in the prevalence estimates of unused medicines across different regions. However, the review was unable to incorporate data from all regions due to the absence of relevant studies in certain areas. This gap raises questions about whether there are substantial differences in the prevalence of unused medicines among households in regions not represented in this analysis. As a result, the findings should be interpreted with caution, as they may not fully reflect the broader context of unused medicines across all regions of Ethiopia.

5. Conclusion

This systematic review and meta-analysis revealed a high prevalence of unused medicines among households in Ethiopian, with significant regional variations. Antibiotics were the most commonly unused medications, followed by analgesics, while cardiovascular medicines and dietary supplements were the least reported. The primary reasons for the accumulation of unused medicines included self-discontinuation upon symptom relief, anticipation of future use, and changes in treatment regimens. Key determinants such as self-medication with NSAIDs, acquisition of medications without prescriptions, and higher household income were significantly associated with the prevalence of unused medicines. The study identified substantial heterogeneity among the included articles ($I^2 = 99.0$ %, $p < 0.001$), with subgroup analyses revealing higher prevalence rates in urban areas compared to rural areas and regional disparities, with the highest prevalence in Addis Ababa, Tigray, and Harari. Sensitivity analysis confirmed the robustness of the findings, as the exclusion of individual studies did not significantly alter the pooled prevalence. These findings underscore the need for targeted interventions to address the high prevalence of unused medicines in Ethiopia, particularly in urban settings and regions with higher rates. Public health strategies should focus on improving medication adherence, regulating the sale of prescription drugs, and promoting awareness about the risks of self-medication and improper medication disposal. Further research is also needed to explore regional disparities and identify context-specific solutions to mitigate the accumulation of unused medicines and its associated risks.

Human ethics and consent to participate

Not applicable.

Author contribution

TTA conceptualized the study; conceived the idea and design for the work; and was involved in the article search, data extraction, analysis, and review of the article interpretation, reporting, and manuscript writing. GWG, MAE, AFB, EDG, ZWB, AEF, TM and TBA were involved in the search, data extraction, analysis, and review of the article. RBA, TKZ, MDM, MT, ATG, and MJT made substantial contributions to the quality assessment of the included studies and the drafting of the manuscript. All the authors contributed to this manuscript approved the submitted version.

CRediT authorship contribution statement

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analysis, Writing – review & editing.

Ethical approval

Not applicable.

Funding

The authors were not funded for this work.

Declaration of competing interest

The authors declare that they have no competing interests.

Acknowledgments

The investigators extend their gratitude to the authors of the primary studies included in this review, as their valuable contributions laid the essential foundation for this systematic review and meta-analysis.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.rcsop.2025.100639.

Data availability

All relevant data are available within the manuscript.

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