HARAMAYA UNIVERSITY
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POTENTIALLY INAPPROPRIATE MEDICATION USE AND ASSOCIATED FACTORS AMONG GERIATRIC PATIENTS HOSPITALIZED WITH CARDIOMETABOLIC DISORDERS IN PUBLIC HOSPITALS OF EASTERN ETHIOPIA; A MULTI-CENTER PROSPECTIVE OBSERVATIONAL STUDY

MSc THESIS

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Potentially inappropriate medication use and associated factors among geriatric patients hospitalized with cardiometabolic disorder in public hospitals of eastern Ethiopia; a multi-center prospective observational study.

A Research Thesis Submitted to the School of Graduate Studies, College of Health and Medical Sciences, Haramaya University in Partial Fulfillment of the Requirements of a Master's Degree in Clinical Pharmacy.

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APPROVAL SHEET
HARAMAYA UNIVERSITY

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I wholeheartedly declare my commitment to carrying out this research, which explores the patterns and contributing factors related to the inappropriate use of medications among older patients admitted with cardiometabolic illnesses in public hospitals located in Eastern Ethiopia. I affirm that this work is entirely my own creation and has not been submitted either wholly or partially to any institution for an academic award or any other purpose. I take full responsibility for ensuring the scientific accuracy, ethical soundness, and technical quality of the entire study.

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Co-Advisor Signature Date

As a member of the examining committee for the MSc thesis defense, I hereby confirm that I have carefully reviewed and evaluated the thesis prepared by Hamza Abdureman and have also conducted an oral defense session with the candidate. After thorough consideration and assessment, I find the work to meet the academic standards and requirements for the completion of the Master's Degree in Clinical Pharmacy.

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I hereby confirm that this thesis represents my own original research. From the initial stages of data collection and analysis to the final preparation of this document, I have adhered to all recognized academic, ethical, and technical standards. All sources, materials, and contributions have been properly acknowledged and cited. This thesis is submitted in partial fulfillment of the requirements for the Master of Science degree at Haramaya University. A copy will be preserved in the Haramaya University Library and made accessible to readers according to the library's policies. I also affirm that this work, in whole or in part, has not been submitted for any other degree, diploma, or certificate at any institution.

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School Pharmacy

BIOGRAPHICAL SKETCH

I was born on December 14, 1998, in Kombolcha, a town in Ethiopia's Eastern Hararge zone. My educational journey began at Kombolcha Primary School and continued at Kombolcha Senior Secondary and Preparatory School, where I completed my secondary education. On December 30, 2021, I graduated with a Bachelor of Pharmacy (B. Pharm) degree from Haramaya University. Shortly thereafter, on March 2, 2022, I joined the School of Pharmacy at the College of Health and Medical Sciences, Haramaya University, as an Assistant Lecturer, marking the start of my academic career. Motivated to deepen my expertise, I enrolled in the Master of Science program in Clinical Pharmacy at the same institution on October 25, 2022, further advancing my professional and academic development.

Acknowledgment

Above all, I am deeply grateful to God, whose unwavering guidance, wisdom, and strength have accompanied me throughout this journey. This achievement would not have been possible without His blessings. I also wish to extend my heartfelt appreciation to Haramaya University, especially the College of Health and Medical Sciences and the School of Pharmacy, for providing the academic environment, resources, and support that made my Master's studies in Clinical Pharmacy both meaningful and successful. I am particularly thankful to my advisors, Mr. Kirubel Minsamo, Dr. Abreham Nigussie, and Mr. Chala Ibrahim, for their patient supervision, insightful guidance, and constructive feedback. Their expertise and dedication were instrumental in refining this research. I would also like to acknowledge the staff and administrators of HFCSH, Dil Chore Referral Hospital, Bisidimo General Hospital, and Jugol General Hospital. Their cooperation, assistance, and provision of essential information played a crucial role in completing this study successfully.

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List of Abbreviations and Acronyms

ACEI	Angiotensin converting enzyme inhibitor
ADE	Adverse drug effects
AGS	American geriatric society
BMI	Body mass index
CAD	Coronary artery disease
CMD	Cardiometabolic disorders
CVD	Cardiovascular disease
DRH	Dilchora Referral Hospital
HFCSUH	Hiwot Fana Comprehensive Specialized University Hospital
JGH	Jugal General Hospital
PIM	Potentially Inappropriate Medications
PPO	Potentially prescription omission
SIADH	Syndrome of inappropriate antidiuretic hormone
START	Screening Tools to Alert Prescribers to Right Treatment
STOPP	Screening Tool of Older Persons potentially inappropriate Prescriptions
UFH	Unfractionated heparin

ABSTRACT

Background: Potentially inappropriate medications (PIMs) are drugs where the risks of taking them are more than the benefits or where safer alternatives exist. Among geriatric patients with cardiometabolic conditions, PIMs are emerging as a public health priority due to vulnerability to harm from medications, polypharmacy, and comorbidities where prudent prescribing and evidence-based treatment are needed.

Objective: To evaluate the prevalence of PIM use and identify factors associated with it among geriatric patients hospitalized with cardiometabolic disorders in public hospitals of Eastern Ethiopia from January 20 to July 20, 2025.

Methodology: A multi-center prospective observational study was conducted across four public hospitals in Eastern Ethiopia. Patient-specific data were collected using a structured data collection tools via the Kobo Collect v2024.2.4 tool. The 2023 AGS Beers criteria and STOPP/START version 3 criteria were applied to identify potentially inappropriate medications and any omissions in prescribed medications. Bivariate and multivariate logistic regression analyses were performed to determine factors associated with the outcomes, with statistical significance set at a p-value < 0.05 and a 95% confidence interval.

Results: A total of 409 patients were included in the study, with a mean age of 74.33 ± 7.29 years. The prevalence of at least one potentially inappropriate medication was 47.4% (95% CI: 42.6–52.3) according to the 2023 AGS Beers criteria and 26.4% (95% CI: 22.1–30.6) based on the STOPP version 3 criteria. Potential prescription omissions (PPOs) were identified in 44 patients (10.8%, 95% CI: 7.8–13.8). The likelihood of having a PIM according to the AGS Beers criteria was significantly higher among older patients (AOR = 15.118, 95% CI: 5.325–42.919, $p < 0.001$), females (AOR = 8.502, 95% CI: 3.278–22.051, $p < 0.001$), patients experiencing polypharmacy (AOR = 13.644, 95% CI: 4.437–41.958, $p < 0.001$), and those with heart failure (AOR = 9.341, 95% CI: 2.406–36.270, $p = 0.001$). Using the STOPP criteria, the risk of PIM was significantly associated with age (AOR = 8.622, 95% CI: 3.327–22.347, $p < 0.001$), female sex (AOR = 4.384, 95% CI: 1.978–10.312, $p < 0.001$), presence of comorbidities (AOR = 5.540, 95% CI: 2.189–14.022, $p < 0.001$), and diabetes mellitus (AOR = 2.795, 95% CI: 1.256–6.219, $p = 0.012$).

Conclusion: The findings revealed a high prevalence of PIM use among geriatric patients with cardiometabolic disorders, regardless of the screening criteria applied. A notable proportion of potential prescription omissions was also observed. Key independent

predictors of PIM use included advanced age, female sex, polypharmacy, heart failure, presence of comorbidities, and diabetes mellitus. These findings highlight the vulnerability of geriatric patients in clinical practice and emphasize the need to enhance prescriber awareness for safer medication management.

Keywords: AGS beers criteria, Cardiometabolic disease, Geriatrics, potentially inappropriate medications, STOPP/START version 3 criteria

1. INTRODUCTION

1.1 Background

The growing aging population worldwide puts huge pressure on healthcare, particularly with regard to the health status of the geriatric, who are at higher risk of medication-related morbidity and mortality (Kallestrup-Lamb *et al.*, 2024). According to Laskar (2024) from 703 million in 2019, the population of those aged 65 and above will double to 1.5 billion by the year 2050; hence, this is a much deeper implication for healthcare provision. In addition, in Ethiopia, the share of older adults has also increased; in 2019, this age group comprised 3.52% of the total population (Nigussie and Demeke, 2024).

Aging is accompanied by progressive physiological changes affecting all major organ systems, including alterations in body composition and metabolic capacity. These changes increase vulnerability to chronic diseases and complicate pharmacological management in older adults. Because age-related physiological changes differ considerably between individuals, medication prescribing in geriatric patients is often complex. Furthermore, the coexistence of multiple chronic conditions frequently necessitates polypharmacy, thereby increasing the risk of adverse drug events and negatively influencing overall health outcomes (Khader et al., 2021; Muhlack et al., 2020).

Cardiometabolic disorders (CMDs), such as cardiovascular disease, diabetes mellitus, and metabolic syndrome, remain among the leading causes of global mortality. These conditions account for nearly one-third of all deaths worldwide, with projections indicating a continued rise in mortality over the coming decades (Katare and Banerjee, 2016). Older adults bear a disproportionate burden of CMDs due to age-related physiological decline, reduced physical activity, and unhealthy lifestyle behaviors, all of which contribute to disease development and progression (Afzal, 2021).

The management of CMDs in older adults often involves long-term pharmacotherapy, increasing the likelihood of exposure to potentially inappropriate medications (PIMs). PIMs are defined as medications in which the potential risks outweigh the anticipated benefits, particularly when safer or more effective alternatives are available. This includes medications that are inappropriate due to age-related factors, drug–drug or drug–disease interactions, incorrect dosing, or underuse of clinically indicated therapies (Idrisnur et al., 2024; Tesfaye et al., 2023).

Globally, the use of PIMs among older adults with chronic diseases is common, with studies reporting prevalence rates ranging from 25% to 50%. In certain high-risk populations, such as older patients with coexisting heart failure and diabetes, the prevalence has been reported to exceed 80% (Sharma et al., 2020; Rus et al., 2023). Factors contributing to inappropriate prescribing include physiological changes associated with aging, multimorbidity, polypharmacy, cognitive and physical impairment, challenges with medication adherence, and limited geriatric pharmacotherapy training among healthcare providers (Chiapella et al., 2018).

Screening tools such as the 2023 AGS Beers Criteria and the STOPP/START version 3 criteria are widely used to identify PIMs and promote safer prescribing in older adults. Evidence from Ethiopian studies conducted between 2014 and 2023 demonstrates a wide variation in PIM prevalence, ranging from 18.5% to 61.5% using the STOPP/START criteria and from 6% to 83.2% according to the AGS Beers Criteria (Nigussie and Demeke, 2024; Tesfaye et al., 2023).

In Ethiopia, cardiometabolic diseases are highly prevalent, and their management often requires complex medication regimens. Among older adults with multiple comorbidities, this increases vulnerability to polypharmacy-related risks and inappropriate medication use (Abegaz *et al.*, 2018). Addressing these challenges is critical for improving medication safety and health outcomes in this population.

Clinical pharmacists play a crucial role in reducing PIM use through comprehensive medication reviews, identification of drug-related problems, and application of validated screening tools. Their involvement has been shown to reduce adverse drug events, optimize pharmacotherapy, and enhance overall patient outcomes among geriatric populations (Nader Babaei *et al.*, 2024; Sharma *et al.*, 2020)

1.2 Statement of the Problem

Cardiometabolic disorders are a leading cause of morbidity and mortality among older adults globally and are commonly managed with long-term pharmacotherapy. However, age-related physiological changes, multiple comorbidities, and polypharmacy place geriatric patients at a substantially increased risk of potentially inappropriate medication (PIM) use, adverse drug events, and hospitalization. Evidence indicates that PIM use contributes to approximately 5% of all hospital admissions and significantly increases healthcare costs and patient harm (Motter *et al.*, 2018 ; Fralick *et al.*, 2020)

Patients with cardiometabolic diseases are particularly vulnerable to PIMs due to the frequent coexistence of hypertension, diabetes, dyslipidemia, and cardiovascular complications, which necessitate complex medication regimens. Studies demonstrate that each additional medication increases the risk of PIMs by over 5%, underscoring the strong association between polypharmacy and inappropriate prescribing (Lu et al., 2022). Despite this heightened risk, evidence from low-income countries, including Ethiopia, remains limited

In Ethiopia, the available studies assessing PIM use among older adults are few and methodologically constrained. Most existing studies employed retrospective designs, which are susceptible to incomplete documentation and underreporting of clinical variables such as body mass index, functional status, and disease severity. Furthermore, some studies evaluated only medications to be avoided, rather than the full spectrum of inappropriate prescribing, increasing the likelihood of underestimating PIM prevalence. Importantly, these studies relied on outdated versions of the Beers criteria, which lack the expanded scope and clinical relevance of recent updates (Teka et al., 2016; Sada, 2017; Tesfaye et al., 2023).

Additionally, none of the existing Ethiopian studies prospectively evaluated PIMs among hospitalized geriatric patients with cardiometabolic disorders using the most recent prescribing tools. The absence of prospective data and the use of outdated criteria limit the applicability of existing findings for clinical decision-making and policy development.

Therefore, there is a critical need for a prospective study to determine the prevalence of potentially inappropriate medication use and its associated factors among geriatric patients hospitalized with cardiometabolic disorders in public hospitals of Eastern Ethiopia, using the 2023 AGS Beers Criteria and STOPP/START version 3. Generating robust and up-to-

date evidence is essential for improving prescribing practices, reducing adverse drug events, and optimizing patient outcomes in this vulnerable population.

1.3 Significance of the study

Managing therapy in geriatric patients presents a significant challenge, as clinicians must carefully balance the anticipated benefits of treatment with the potential risks, particularly given the reduced physiological reserves that accompany aging. Investigating the prevalence of potentially inappropriate medication use, along with the factors that contribute to such prescribing, among geriatric patients hospitalized with cardiometabolic disorders at HFCSH, Jugol General Hospital, Bisidimo General Hospital, and Dilchora Referral Hospital can provide valuable insights. These findings are essential for guiding safer and more effective pharmacological management, ultimately improving clinical outcomes and the overall quality of care in this vulnerable population.

To promote rational medication use, older adults should receive medications that align with their clinical needs, administered at the correct dose and for an appropriate duration. Ensuring appropriate prescribing is crucial not only for enhancing health outcomes and quality of life but also for reducing preventable healthcare costs. The results of this study may guide policymakers and healthcare providers in developing strategies to optimize prescribing practices and minimize avoidable adverse effects.

Despite the significant consequences of inappropriate prescribing in the elderly, the problem remains widespread, highlighting the need for further research to generate evidence and build consensus on effective interventions. In Ethiopia, there is limited information on prescribers' knowledge of proper geriatric prescribing and the use of standardized screening tools. Additionally, the lack of a national guideline specifically addressing geriatric pharmacotherapy emphasizes the significance of this study as a contribution toward encouraging rational medication use in older adults and informing the creation of upcoming guidelines.

1.4 Objective

1.4.1 General Objective

- To assess the prevalence of PIM use and associated factors among geriatric patients hospitalized with cardiometabolic disorders in public hospitals in Eastern Ethiopia from January 20 to July 20, 2025.

1.4.2 Specific Objectives

- To determine the prevalence of PIM, use among geriatric patients hospitalized with cardiometabolic disorders in public hospitals in Eastern Ethiopia
- To determine the prevalence of PPO, use among geriatric patients hospitalized with cardiometabolic disorders in public hospitals in Eastern Ethiopia
- To identify factors associated with PIM use among geriatric patients hospitalized with cardiometabolic disorders in public hospitals in Eastern Ethiopia

2. LITRETURE REVIEW

2.1 Introduction

In this chapter, a systematic literature search was conducted across Google scholar, Embase, Web of science, Cochrane, and PubMed to identify studies on use of potentially inappropriate medication and related factors among hospitalized geriatric patients with cardiometabolic diseases. The search utilized keywords such as “potentially inappropriate medication,” “geriatric patients,” “cardiometabolic disease,” and “related factors,” along with geographic terms like Ethiopia, Africa, and worldwide. The search yielded 5,432 articles globally, 45 from Africa, and 12 from Ethiopia. Of these, only 27 articles were directly relevant to the study topic. The reviewed literature provides a focused overview pertinent to the specific objectives of this research.

2.2 The Prevalence of Potentially Inappropriate Medication Use

A global systematic review and meta-analysis, incorporating 94 studies and 132 prevalence estimates, examined around 371.2 million older adults from 17 countries and found that 36.7% were prescribed PIMs. The analysis highlighted that PIM use was particularly common in healthcare settings with limited resources and has steadily increased among the elderly over the past two decades. These findings underscore the growing importance of careful medication management in older populations to reduce the risks associated with inappropriate prescribing (Tian *et al.*, 2023).

A retrospective cohort analysis in the United States reported a decline in the use of PIMs from 37.6% in 2007 to 34.2% in 2012, equating to an average annual reduction of 2%, which was statistically significant. The study also showed that the one-year prevalence decreased from 64.9% to 56.6% during the same period (Jirón *et al.*, 2016). In a similar investigation, a chart review at a U.S. tertiary hospital indicated that PIMs made up 20% of all prescribed medications, with patients receiving an average of 2.4 PIMs, and 87.4% of patients were prescribed at least one (Zahra *et al.*, 2023).

A prospective population-based review conducted in Germany involving 874 participants, 97 individuals (11.1%) were prescribed potentially inappropriate medications (PIMs). Most of these patients (86, or 9.8%) received one PIM, nine participants were prescribed two, and two individuals (0.2%) were given three PIMs (Sarganas *et al.*, 2024).

In Finland, research revealed that the prevalence of potentially inappropriate medication uses among the elderly varied between 10.7% and 57.0%, with differences largely influenced by the evaluation method applied. According to statutory data from the Meds75+ database, the annual prevalence was between 30.4% and 33.6%. Over a three-year period, PIM use showed a declining trend, decreasing from 14.2–57.0% in 2017 to 10.7–55.3% in 2019, indicating a reduction regardless of the criteria used (Paulamäki *et al.*, 2023).

A prospective review of 255 patient prescriptions in Bulgaria revealed that a significant proportion of the study population 67% of those experiencing polypharmacy were taking at least one PIM. The study identified a total of 173 PIMs, with the majority (75.72%) related to cardiovascular drugs. Specific medications and their associated PIMs were also reported: digoxin and antiarrhythmics each accounted for 11 PIMs, trimetazidine for 9 PIMs, and antiadrenergic agents were linked to 22 PIMs, with moxonidine being the common frequently noted within this class (Milushewa *et al.*, 2023).

A prospective family health study conducted in northeastern Brazil included 142 participants and reported a PIM usage rate of 34.5%. The most commonly prescribed potentially inappropriate medications were immediate-release nifedipine (34.5%) and methyldopa (9.1%) (Oliveira *et al.*, 2012).

A retrospective record review conducted at a tertiary teaching hospital in Australia involving 534 participants revealed that 54.8% (284) were taking at least one PIM at admission, with 26.8% using commonly prescribed PIMs. The study also found that 60.8% of patients were discharged while still on a PIM. Additionally, it was estimated that PIM use may be associated with 6% of all hospital admissions (Ní Chróinín *et al.*, 2016).

A retrospective record study conducted at a major clinic in Saudi Arabia reported that 57.6% geriatric patients were prescribed at least one PIM. Within this group, 39.9% were taking one PIM, 14.5% were on two, and 3.3% were prescribed three. The common frequently identified PIMs were endocrine agents (34.3%) and gastrointestinal drugs (35.6%). Additionally, the study highlighted that 37.5% of these medications were recommended to be used with caution (Alhawassi *et al.*, 2019).

A study in Bulgaria applying the Beers criteria to patients with cardiovascular conditions reported that 71% were prescribed at least one PIM. Among these patients, 56% were taking more than five PIMs, and 64% of those with polypharmacy had PIMs. The most

commonly implicated drug classes were antihypertensive and antidiabetic agents(Sin *et al.*, 2022). n a separate retrospective study in Palestine, 75.1% of participants were on multiple medications (polypharmacy), while 36.8% (95% CI: 32.2%–41.6%) were using PIMs. The most frequently prescribed PIMs included sulfonylureas (24.2%), alpha receptor inhibitors (4.3%), and nonsteroidal anti-inflammatory drug (3.1%) (Samara *et al.*, 2023).

A study carried out in prominent UAE hospital reported that antihypertensive drugs were the most commonly classified as potentially inappropriate medications, with a rate of 34.7% according to the Beers criteria (Alyahawi and Alkaf, 2022). In a separate study from Amman, Jordan, the medications most frequently identified as avoidable included proton pump inhibitors (PPIs) due to prolonged use, as well as long-acting sulfonylureas, particularly glimepiride and glyburide (Faisal and Zairina, 2024).

A retrospective observational study carried out at Universitas Teaching Hospital in Indonesia, which included elderly patients aged between 60 and 96 years, reported that females made up just over half of the study population (50.4%). The study further indicated that among older patients receiving potentially inappropriate medications (PIMs), the majority (73.1%) were hospitalized, while 26.9% were discharged (Hamidah *et al.*, 2023).

In a retrospective hospital study showed in Asmara, Eritrea, an overall of 2,680 prescriptions were dispensed to elderly patients. The study revealed that 18.1% of these prescriptions contained potentially inappropriate medications (PIMs). Additionally, the data showed that older patients avoided taking 470 different prescriptions. The common types of PIMs prescribed were sulfonylureas, at 27.2%, and substituted alkylamines, at 16.2% (Idrisnur *et al.*, 2024).

A cross-sectional study conducted at a tertiary hospital in China identified 447 eligible participants out of a total of 2,947 prescriptions reviewed. The study revealed that 38% of these patients were prescribed potentially inappropriate medications (PIMs). These PIMs were categorized as those to be avoided completely (38.4%), those requiring caution (48.9%), and those involving drug-drug interactions (12.7%). The most commonly prescribed PIMs included diuretics (37.1%), hypnotics (15.2%), glimepiride (13.1%), and combinations of renin-angiotensin system inhibitors with potassium-sparing diuretics (9.7%) (Samara *et al.*, 2023).

A retrospective investigation carried out in outpatient departments of a university hospital across Nigeria and South Africa reported differences in potentially inappropriate

prescriptions (PIP) between the two populations. The findings showed that 35.2% of Nigerian patients and 29.6% of South African patients received at least one PIP (Saka *et al.*, 2019).

A prospective cross-sectional investigation carried out at Jimma Medical Center evaluated 162 older patients during their hospital stay. Among them, 103 patients (63.6%) were receiving polypharmacy (5–9 medications), and 16 patients (9.9%) were on hyperpharmacy (more than 10 medications). The study reported that 118 participants (73%) were prescribed at least one PIM, with a total of 191 PIMs, 27 (14.1%) of which were considered recommended (Tesfaye *et al.*, 2023). In a separate study by Nigussie and Demeke (2024), PIM prevalence was evaluated using two different criteria, revealing rates of 18.5% according to STOPP/START and 28.5% according to the Beers Criteria (Nigussie and Demeke, 2024).

2.3 Factor Associated with Potentially Inappropriate Medication

2.3.1 Socio-demographic factors

An Australian systematic review and meta-analysis identified several factors linked to potentially inappropriate medication (PIM) use, including age, gender, hospital stay duration, and quality of life. According to Atey and his coworkers in 2023 found that seven studies showed a clear association between older age and higher PIM risk. The pooled analysis indicated that elderly patients were 26% more likely to receive PIMs (RR: 1.26, $p < 0.001$), and those aged 65 and above had a 71% greater risk compared to younger individuals (RR: 1.71, $p < 0.001$) (Atey *et al.*, 2023). Similarly in Germany, assessed 409 participants and reported that 97.4% were non-smokers, while 12.5% had a history of smoking (Muhlack *et al.*, 2020).

A cross-sectional study in India reported that both a patient's age and gender significantly influenced the likelihood of being prescribed potentially inappropriate medications (Kumar *et al.*, 2025). Similarly, in Canada highlighted age as a major factor, noting that the chance of receiving a PIM decreased by roughly 2% with each additional year. Their findings also indicated that older adults taking five or more medications were nearly three times more likely to be prescribed a PIM compared with those on fewer drugs (Aubert *et al.*, 2023).

A retrospective chart review in the United States identified a notable relationship between gender and PIM use, showing that older male patients were less likely to be given potentially inappropriate medications compared to older female patients. The study found

no significant link between patient age and PIM use. However, it did highlight that a more number of drugs were linked with a greater probability of receiving a PIMs prescription (Samara *et al.*, 2023)

A longitudinal study conducted in France reported that women, older adults, and individuals with lower educational attainment were more likely to be prescribed potentially inappropriate medications (PIMs). The research also highlighted notable differences by gender and education: 27.9% of women with low education levels were taking at least one PIM, compared to 13.0% of men with higher education (Lechevallier-Michel *et al.*, 2005).

2.3.2 Medication related factors

A prospective observational study in Malaysia, carried out between April and October 2016, evaluated 300 elderly patients. Results showed that 27% of the participants were taking at least one potentially inappropriate medication upon hospital admission. The most frequently identified PIMs were vasodilators, due to the risk of falls, as well as metformin and beta-blockers. Additionally, a high rate of potential prescribing omissions was observed, affecting 47.6% of patients. The most common omissions involved treatments for the cardiovascular system (28.6%), musculoskeletal system (14.3%), and respiratory system (11.3%) (Liew *et al.*, 2019).

A study conducted in Romania examined 646 electronic prescriptions for chronic conditions and found that 25.8% included potentially inappropriate medications, while potential prescribing omissions were observed in 41.72% of cases. The most common PIMs were related to treatment length (6.65%), the use of theophylline (5.72%), and inappropriate medication indications (4.64%). Among PPOs, the most frequently missed medications were beta-2 agonists/bronchodilators (5.88%), beta-blockers (8.04%), and statins (24.76%) (Buda *et al.*, 2020).

A cross-sectional investigation in Vitória, Brazil, identified several factors linked with the use of potentially inappropriate medications (PIMs), including the consumption of psychotropic, musculoskeletal, gastrointestinal drugs, self-medication, and a high vulnerability risk (Tranhago *et al.*, 2024). Similarly, research conducted in Switzerland and Brazil indicated that elderly patients on polypharmacy are at increased risk of unplanned hospitalizations (Misrina *et al.*, 2023).. Another study highlighted that geriatric patients are more vulnerable to adverse effects related to PIMs due to their use of multiple medications (Misrina *et al.*, 2023).

A meta-analysis in Ethiopia, which included three studies, explored whether polypharmacy was linked with a higher risk of potentially inappropriate medication use in geriatric patients. The results showed no significant rise in PIM prescriptions among those taking multiple medications. Additionally, the studies demonstrated moderate heterogeneity, with an I^2 value of 62.3% ($p = 0.070$) (Abegaz *et al.*, 2018).

2.3.3 Medical Factors

In Ethiopia, a prospective study revealed that individual with thrombocytopenia and heart failure were significantly likelihood to be prescribed PIMs(Tesfaye *et al.*, 2023). Meanwhile, findings from a separate retrospective study indicated that several factors including male sex, older age, diabetes mellitus, chronic kidney disease, hypertension, and deep vein thrombosis were important predictors of PIM use (Nigussie and Demeke, 2024).

A research conducted in Ethiopia found that males from lower socioeconomic backgrounds exhibited a higher prevalence of cardiovascular diseases, which increased their likelihood of being prescribed potentially inappropriate medications (PIMs) for these conditions (Dagnew *et al.*, 2024). In a similar vein, another Ethiopian study reported that patients with cardiovascular disorders were over four times likelihood to receive PIMs, whereas those with endocrine disorders had approximately a 2.6-fold higher probability of being prescribed such medications (Alemneh, 2023).

2.4 Conceptual framework

The existing literatures indicates that prevalence of PIM and associated factor are varying from place to place around the globe and Polypharmacy are the most prevalent factors associated with poor treatment outcomes, but different contributors' factors are addressed in different literature.

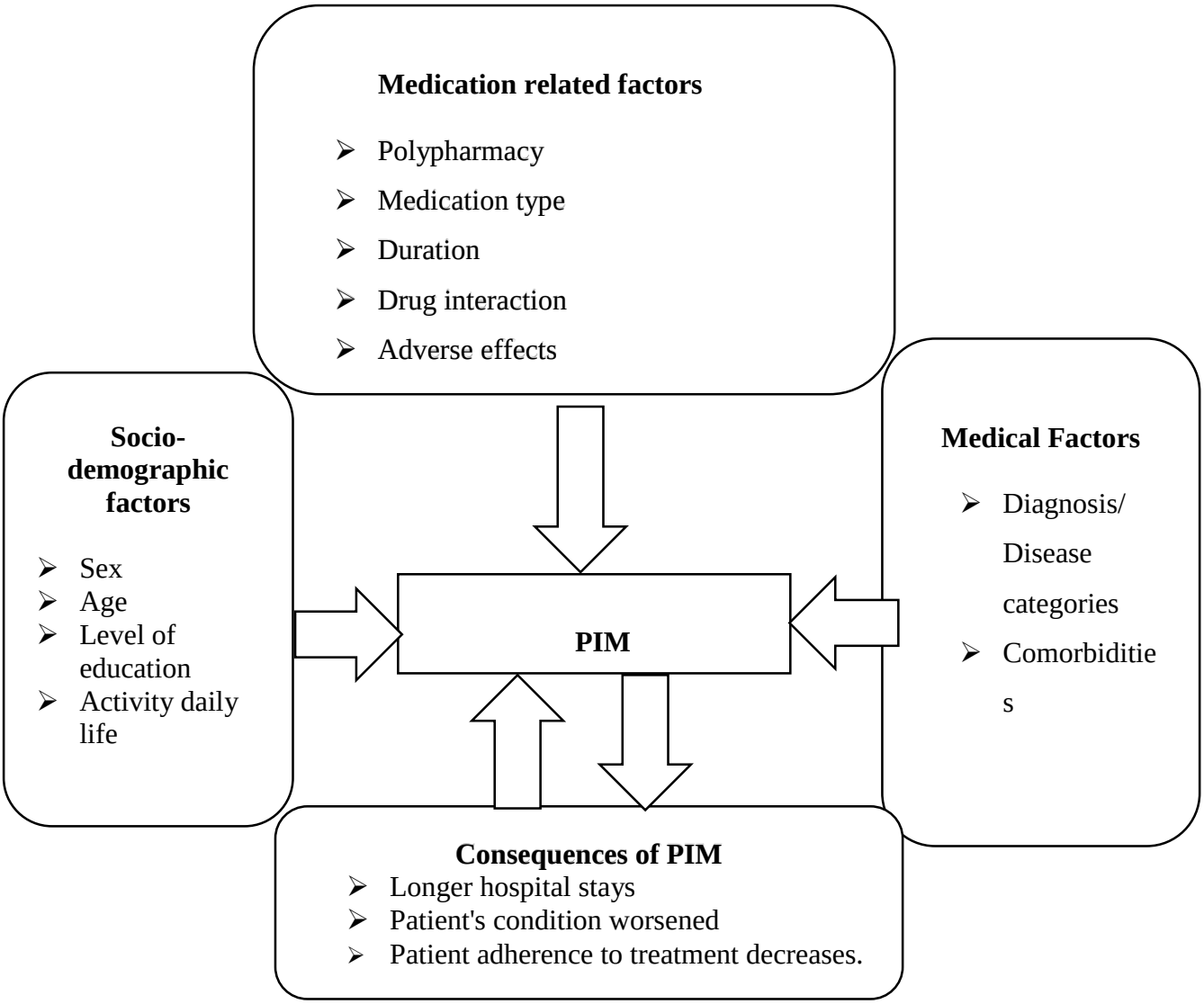

Figure 1: Conceptual Framework: Risk Factors and PIM.

This framework, synthesized from a review of the relevant scholarly literature, depicts the hypothesized relationships linking several risk factors to the prescription of PIMs (Abegaz *et al.*, 2018; Gallagher and O'Mahony, 2008; Nigussie and Demeke, 2024; Shrestha *et al.*, 2019; Tesfaye *et al.*, n.d.).

3. METHOD AND MATERIAL

3.1 Study Area/Setting and Period

A study was conducted at four public Hospitals; Bisidimo General Hospital (BGH), Dil Chore Referral Hospital (DCRH), Hiwot Fana Comprehensive Specialized Hospital (HFCSUH), and Jugol General Hospital (JGH) in Eastern Ethiopia from January 20 to July 20, 2025.

Bisidimo General Hospital (BGH) is located in the East Hararge Zone of the Oromia Region in eastern Ethiopia, approximately 22 kilometers east of Harar town and 548 kilometers from Addis Ababa. Established in 1958 by the German Leprosy and Tuberculosis Relief Association, the hospital has been offering a wide range of healthcare services to the local community. Its services include internal medicine, surgery, dermatology, ophthalmology, gynecology, obstetrics, and TB/HIV care, among others. Over the years, BGH has remained a key institution in enhancing healthcare access and supporting disease prevention and treatment initiatives in the region.

Dil Chore Referral Hospital (DCRH) found in Dire Dawa a city, in eastern Ethiopia bordering the Ethiopia Somali and Oromia region. The city is situated approximately 515 kilometers east of Addis Ababa and around 47 kilometers from Harar, featuring a warm climate with an average annual temperature near 25°C. Based on the 2013 population projections by the Central Statistical Agency of Ethiopia (CSA), Dire Dawa had an estimated population of 395,000, with women representing roughly 51.6% of residents. DCRH delivers a comprehensive range of healthcare services, including psychiatry, internal medicine, surgery, gynecology and obstetrics, as well as TB/HIV care. As a primary medical and referral center in eastern Ethiopia, the hospital caters not only to the residents of Dire Dawa but also to patients from surrounding areas.

Hiwot Fana Comprehensive Specialized Hospital (HFCSUH) found in Harar, a centuries old city located in eastern Ethiopia, roughly 526 kilometers east of Addis Ababa, the national capital. Based on projections made by the Central Statistical Agency (CSA) in 2013, the Harari Regional State was home to around 232,000 people, consisting of approximately 117,000 men and 115,000 women. The region's health service network comprises five hospitals three government-owned and two privately operated alongside eight health centers and twenty health posts. HFCSUH, established during the period of Italian occupation between 1928 and 1933, stands among the earliest hospitals constructed

in Ethiopia. At present, it delivers healthcare services to an estimated 5.2 million individuals from Harar and its surrounding regions, including Dire Dawa, Oromia, and the Somali Regional State. Beyond patient care, the hospital also plays a significant role as a teaching and referral institution in eastern Ethiopia, providing diverse services such as internal medicine, surgery, psychiatry, obstetrics and gynecology, as well as tuberculosis and HIV.

Jugol General Hospital (JGH) a prominent healthcare facility located in Harar, approximately 526 kilometers east of Ethiopia's capital, Addis Ababa. Harar, celebrated for its historical and cultural significance, is part of the Harari Regional State, which had an estimated population of 232,000 in 2013, including 117,000 men and 115,000 women (Central Statistical Agency, CSA). The region's healthcare system comprises five hospitals three public and two private alongside eight health centers and twenty health posts. As a leading public hospital, JGH delivers comprehensive medical services covering internal medicine, surgery, gynecology, pediatrics, and obstetrics, as well as TB and HIV care. In addition to providing direct patient care, the hospital actively engages in preventive and community health initiatives and functions as a key referral center, significantly enhancing both access to and quality of healthcare throughout Eastern Ethiopia.

3.2 Study Design

A hospital-based, multi-center prospective observational study was conducted to assess the prevalence of potentially inappropriate medication (PIM) use and to identify factors associated among geriatric patients hospitalized with cardiometabolic disorders.

3.3 Population

3.3.1 Source of population

All geriatric patients (aged ≥65 years) hospitalized with cardiometabolic disease in public hospital of eastern Ethiopia were the source of population.

3.3.2 Study population

All geriatric patients who fulfilled the inclusion criteria and admitted to the selected four public hospitals during the study period were study population.

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3.4 Inclusion and Exclusion criteria

3.4.1. Inclusion Criteria

- A patients aged 65 years and above who were admitted to the selected hospitals with cardiometabolic disorders and taking at least medications.

3.4.2. Exclusion Criteria

- Patients discharged within 24 hours of hospital admission.
- Patients who were non responsive (patients with aphasia)
- Patients who had readmitted during the study period.
- Patients whose charts did not list any medications prescribed to them.

3.5. Sample Size Determination.

The sample size for assessing PIM use was calculated using the single population proportion formula.

$$n_i = \frac{(Z\alpha/2)^2 p(1-p)}{d^2}$$

Where:

n_i= sample size

p= proportion of inappropriate medicine use among geriatric patients

d= margin of sampling error tolerated

z= the standard value at the confidence interval

P- 0.651 was taken as the best possible available estimate for the prevalence of PIM which was reported medical ward in Gondar hospital, Ethiopia (Abegaz *et al.*, 2018). With this prevalence estimate, 95% confidence and 5% margin of error. This value had been taken to determine the sample size.

So $n = \frac{(1.96)^2 (1-0.651) * 0.651}{(0.05)^2} = \frac{0.873}{0.0025} \approx 349$

The double population proportion method was applied to calculate the sample size for the associated factors, assuming a 95% confidence interval, a 5% margin of error, and 80% statistical power.

Table 1: Sample size for the associated factor using Epi Info V.7.2.6.

Factor	% of unexposed with outcome	OR	Power	Z a/2	The ratio unexposed exposed	Sample size	References
Diabetes Mellitus	42.5	0.28	80	1.96	0.756	158	(Nigussie and Demel 2024)
Sex (Male)	24.4	1.78	80	1.96	1.32	492	(Nigussie and Demel 2024)
Chronic kidn disease	26.9	6.68	80	1.96	18.6	216	(Nigussie and Demel 2024)
Heart failure	53.4	7.35	80	1.96	1.89	66	(Tesfaye *et al.*, 2023)
Presences thrombocytopenia	96.61	0.17	80	1.96	15.2	574	(Tesfaye *et al.*, 2023)
Hypertension	31.3	2.1	80	1.96	0.7	274	(Tesfaye *et al.*, 2021)
Polypharmacy	67.7	6.1	80	1.96	0.75	93	(Tesfaye *et al.*, 2021)
Ischemic heart Disease	81.8	2.84			6.3	737	(Tesfaye *et al.*, 2021)

The sample size of the presences of ischemic heart disease (737) was used as it gives the highest number.

Since the source population is less than 10,000, the final sample size had been adjusted as;

The number of elderly patients admitted at HFCSUH, JGH, Dilchora and Bisidimo hospital were 270, 160, 180 and 140 patients', respectively in the past 2 months.

$Nf=n/ (1+ (n/ N)$ Where,

$=737/ (1+(737/750)$ N_f= final sample size

= 372 N=source of populations which are 750

The final sample size, with an additional 10% included for contingency, was 409.

3.6. Sampling Techniques and procedure

The sample size was proportionally allocated to four selected public hospitals (HFCSUH, Jugol, Dilchora, Bisidimo Hospital), and study subjects were selected using a simple random sampling technique.

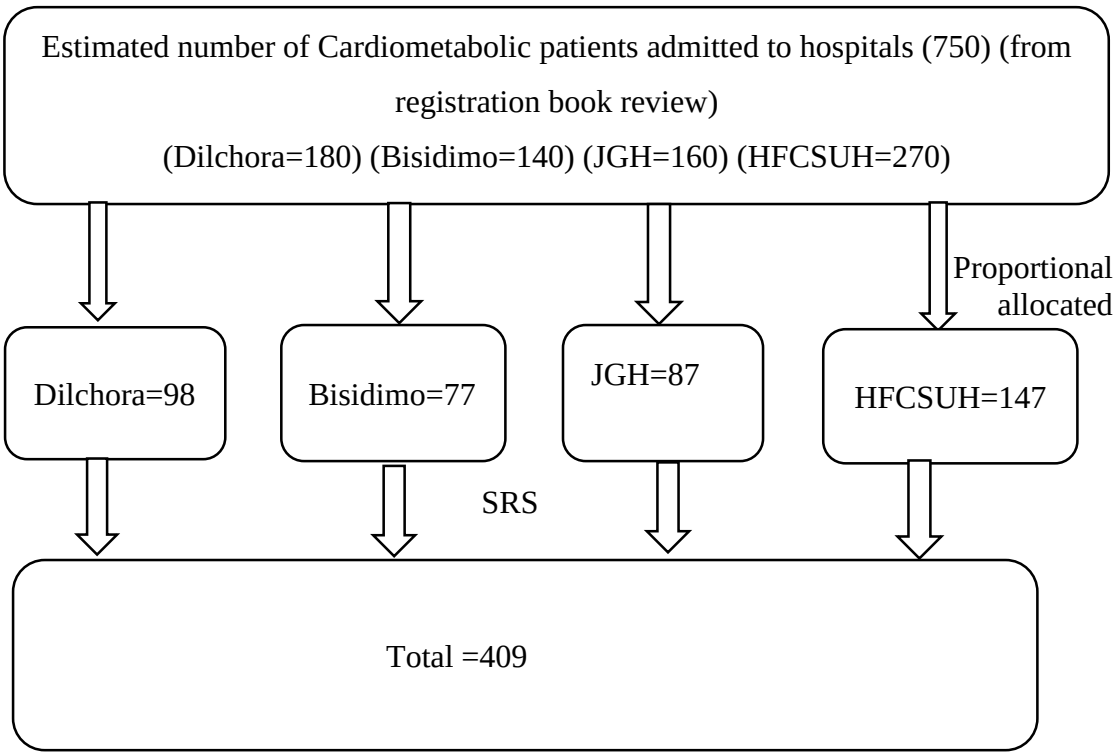

Figure 2: Schematic representation of the sampling method used to evaluate potentially inappropriate medication use and its associated factors among geriatric patients admitted with cardiometabolic disorders in public hospitals of eastern Ethiopia.

3.7. Data Collection method

3.7.1. Data collection Instrument

A data collection instrument was developed based on relevant literature to gather comprehensive information from patients using Kobo Collect v2024.2.4. The tool covered four areas: sociodemographic data, clinical characteristics, medication-related information, and outcomes. To improve accessibility, it was translated into the two main local languages, Afaan Oromo and Amharic. Patients who met eligibility criteria were enrolled upon

admission and monitored until discharge. Data sources included patient charts, laboratory reports, and interviews with patients or their caregivers.

Participants' height and weight were measured to determine body mass index (BMI) using the standard formula: BMI = weight (kg) /height $(m)^2$. Functional status at admission was evaluated using the Katz Index of Independence in Activities of Daily Living (ADL), which examines six basic activities: eating, dressing, bathing, transferring, continence, and toileting. Each activity was scored as dependent (0) or independent (1). A total score of 6 indicated full independence, 3–5 partial dependence, and 2 or below severe dependence. Laboratory tests required to identify potentially inappropriate medications (PIMs) according to the 2023 AGS Beers Criteria and STOP/START version 3 were extracted from charts.

3.7.2. Data collectors and Supervisors

Two master's clinical pharmacists and two bachelor degree pharmacist was participated during data collection, and the principal investigator was supervised during data collection

3.7.3. Data collection procedure

All eligible participants were recruited at the time of ward admission and followed until discharge. During their hospital stay, they were continuously observed, and relevant information was gathered from medical records, direct patient interactions, and healthcare professionals between January 20 and July 20, 2025.

Assessing appropriateness of medications

Two standardized tools were employed to identify potentially inappropriate medications (PIMs): one focused on medication-related issues and the other on disease-specific considerations.

1. 2023 AGS Beers Criteria:

The 2023 AGS Beers Criteria were utilized to classify PIMs into five major categories: (1) medications considered potentially inappropriate in older adults, (2) drugs inappropriate for patients with certain diseases or syndromes, (3) medications that should be used cautiously, (4) potentially harmful drug–drug interactions, and (5) medications requiring dose adjustments according to renal function (Tesfaye *et al.*, 2023).

2. STOPP/START version 3 criteria:

The STOPP/START version 3 criteria comprised two main parts. The STOPP criteria were applied to determine inappropriate medication use among patients aged 65 years and above, specifying the rationale for each medication's inappropriateness. These rationales were grouped by both therapeutic indication (e.g., use without clinical justification, prolonged use beyond recommended duration, or duplication within the same drug class) and physiological system affected—such as cardiovascular, central nervous, renal, gastrointestinal, respiratory, musculoskeletal, urogenital, and endocrine systems (Nigussie and Demeke, 2024).

The START criteria were used to detect potential prescribing omissions (PPOs) in cases where appropriate treatments were not prescribed without a valid reason. Like the STOPP criteria, these were organized by physiological systems, including cardiovascular, respiratory, central nervous, gastrointestinal, musculoskeletal, endocrine, and urogenital systems (Nigussie and Demeke, 2024).

3.8. Variables

3.8.1. Dependent Variable

- PIM use

3.8.2. Independent Variable

Socio-demographic factors

- Sex
- Age
- Level of education
- Activity daily life

Medication related factors

- Polypharmacy
- Medication type
- Duration
- Drug interaction
- Adverse effects

Medical Factors

- Diagnosis/ Disease categories
- Comorbidities

3.9. Operational Definition

Adverse Drug Reaction (ADR): is an unfavorable event that caused by medications which may require hospitalization or medical remedy(Motter *et al.*, 2018).

Cardiometabolic disorders: is medical conditions such as hypertension, type 2 diabetes mellitus, dyslipidemia, obesity, stroke, and heart failure (Idrisnur *et al.*, 2024).

Comorbidity: describes the occurrence of one or more accompanying medical conditions in addition to a main disease (Parsons, 2017).

Geriatric: refers to individuals aged 65 years and above (Puig *et al.*, 2024).

Length of Hospital Stay: refers to the total duration, measured in days, that a patient remains in the hospital from admission until discharge (Nader Babaei *et al.*, 2024).

Medication Adherence: the extent of patients taking medications as prescribed which is usually expressed in percentage of some defined number of doses taken correctly over time (Liu *et al.*, 2023)**.**

Polypharmacy: this term means taking five or more medications at the same time (Parsons, 2016).

Potentially Inappropriate Medications are medication deemed unsuitable for elderly patients, as they carry a high risk of adverse effects while offering minimal or no therapeutic benefit (Hamidah *et al.*, 2023).

3.10. Data Quality Control

To ensure the quality of the data, data collectors (four clinical pharmacists) were trained for two days and orientation was also be given by the principal investigator. Pretest was performed on 5% of the sample participants at Haramaya Hospital before the actual data collection to assess the validity of the data collection tool. The feedback obtained was used to modify and enhance the questionnaires. The data collection tool was evaluated and commented by senior clinical pharmacists who were academicians and researchers for face validity. On a daily basis the principal investigator was also closely supervise the activity of data collector. On each data collection weeks, all collected data were reviewed by the principal investigator for completeness, accuracy and clarity.

3.11. Methods of data analysis

After data collection through the Kobo Collect tool, the dataset was exported to SPSS version 27 for analysis. The data were coded, edited, and cleaned to maintain accuracy,

consistency, and completeness. Categorical variables were summarized using frequencies and percentages, while continuous variables were represented by their median values. The main outcome variable, PIM use (as defined by the 2023 AGS Beers Criteria and STOPP version 3 criteria), was treated as a binary variable (1 = Yes, 0 = No) for logistic regression analysis.

Before running the regression, cell adequacy was checked for each covariate. A bi-variate logistic regression was then performed, and variables with a p-value less than 0.25 were included in the final multivariable model. Multicollinearity was assessed using the Variance Inflation Factor (VIF), where a value slightly > one and < 2 indicated no Multicollinearity problem.

Model fitness was evaluated using the Hosmer-Lemeshow goodness-of-fit test, which showed that the logistic regression models fit well for both the AGS Beers criteria (p = 0.367) and the STOPP version 3 criteria (p = 0.828). A p-value of less than 0.05 was considered statistically significant in all analyses. The findings were presented using tables, figures, and text.

3.12. Ethical Considerations

Ethical approval was granted by the Institutional Health Research Ethics Review Committee (IHRERC) of Haramaya University, College of Health and Medical Sciences. Written information about the study was shared with the medical directors of HFCSUH, Jugol, Bisidimo, and Dilchora Hospitals, and their permission was obtained to access patient records. To maintain confidentiality, only medical record numbers were used, omitting patient names. Data collectors received training on privacy and reported information exclusively to the research team. All data were used solely for research purposes, and written informed consent was obtained from each participant before enrollment.

3.13. Plan for dissemination of the findings

This study's results will be formally submitted to Haramaya University, targeting both the College of Health and Medical Sciences and the School of Pharmacy. As part of fulfilling the requirements for a Master's degree in Clinical Pharmacy. Furthermore, copies of the research will be provided to the respective health institutions, including HFCSH, DCRH, BGH and JGH. Efforts will also be undertaken to disseminate the results through presentations at scientific conferences and publication in reputable, peer-reviewed journals.

4. RESULT

4.1 Sociodemographic and Behavioral characteristics of the patient

A total of 409 participants were enrolled in this study, with a mean age of 74.33 ± 7.29 years. Over half (53.8%) of the participants were aged 65 to 74 years, and 54.8% were female. Only a small proportion (2.7%) of participants were current smokers. Regarding activities of daily living (ADLs), 264 participants (64.8%) were physically independent. Additionally, the majority of participants (85.8%) fell within the normal BMI category (Table 2).

Table 2: Sociodemographic and behavioral characteristics of geriatric patients hospitalized with cardiometabolic disease in Eastern Ethiopia, 2025.

Variable	Category	Frequency	Percent
Age	65-74	218	53.3
	75-84	119	29.1
	≥85	72	17.6
Sex	Male	185	45.2
	Female	224	54.8
Marital status	Single	6	1.5
	Married	295	72.1
	Widow	99	24.2
	Divorced	9	2.2
Educational status	No formal education	161	39.4
	Primary school	155	37.9
	Secondary school	68	16.6
	Graduated and above	25	6.1
Cohabitation	Alone	27	6.6
	With family	369	90.2
	With other*	13	3.2
Current working	Yes	54	13.2
	No	355	86.8
Current occupation	Retired	290	70.9
	Employed	16	3.9
	House wife	50	12.2
	Private work	28	6.8
	Other specify**	25	6.1
Alcohol drinking	Never	302	73.8

	Previously	97	23.7
	Current	10	2.4
Cigarette smoking	Never	290	70.9
	Ex-smoker	108	26.4
	Current	11	2.7
Khat chewing	Never	233	57.0
	Previously	136	33.3
	Current	40	9.8
Activity of daily living	Dependent	37	9.0
	Partially dependent	107	26.2
	Full independent	265	64.8
BMI	BMI < 18.5	35	8.0
	BMI: 18.5-24.9	352	86.0
	BMI > 25	22	6.0

BMI, Body mass index * farmers ** Relative

4.2 Type of Cardiometabolic Disease

Hypertension was the most diagnosed (28.4%) cardiometabolic condition, followed by diabetes mellitus (24.2%) among the study participants (Figure 3).

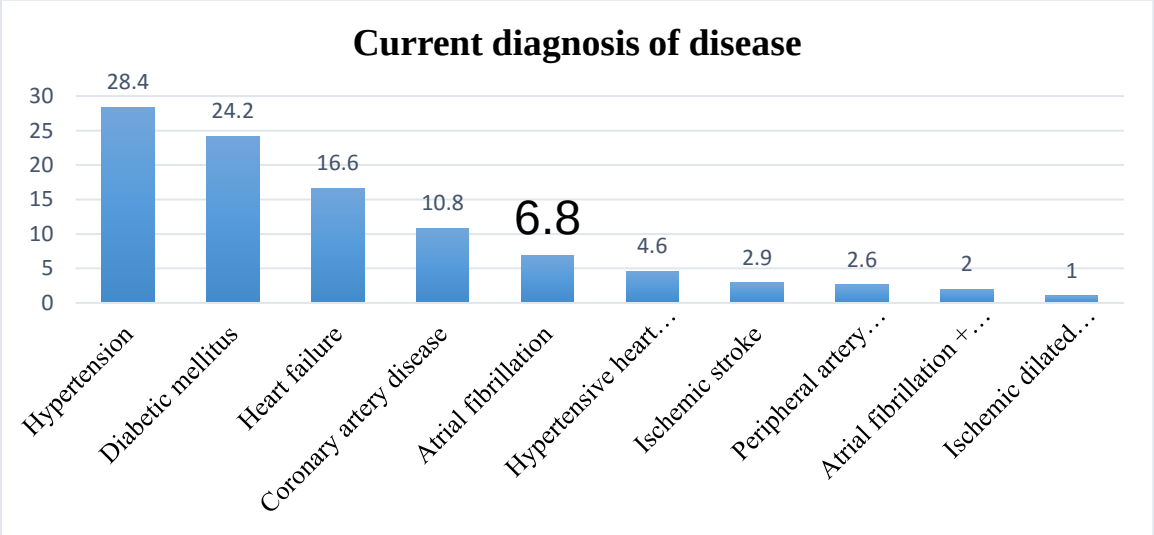

Figure 3: Type of cardiometabolic disorders diagnosed among geriatrics patients hospitalized in Eastern Ethiopia, 2025

4.3 Clinical and related characteristics

Among the 409 patients who participated in this study, the majority, 312 (76.3%), had cardiovascular diseases. Additionally, most participants, 143 (52.2%), also had comorbidities. Furthermore, nearly half of the study participants (49.6%) had a past medical history (Table 3).

Table 3: Clinical and related characteristics of geriatrics patients hospitalized with cardio-metabolic disorder in Eastern Ethiopia, 2025.

Variable	Category	Frequency	Percentage
Primary diagnosis	Disease of cardiovascular system	312	76.3
	Disease of metabolic system	97	23.7
Comorbidity	Yes	274	67.2
	No	135	32.8
Number of comorbid diseases	One comorbid	143	52.2
	Two comorbid	94	34.3
	Three and above comorbid	37	13.5
Length of hospital stay, days	(1-5 days)	162	39.6
	(6-10 days)	239	58.4
	(> 10 days)	8	2.0
Hospitalization in last 1 year before study period	None	307	75.1
	Ones	82	20.0
	Twice and above	20	4.9
Patient with previous medical history	Yes	203	49.6
	No	206	50.4

Hypertension was the most comorbidity (15.8%), followed by dyslipidemia (14.1%) among the study participants (table 4)

Table 4: Specific type of comorbidity among geriatrics patients hospitalized in Eastern Ethiopia, 2025

Type of comorbidity	Frequency	Percentage
Hypertension	70	15.8
Dyslipidemia	62	14.1
Diabetic mellitus	60	13.5
Heart failure	55	12.5
Cardiomyopathy	40	9
Chronic kidney disease	40	9
Coronary artery disease	30	6.8
Asthma	30	6.8
Others*	55	12.5

* Community acquired pneumonia, Dyspepsia, Chronic obstructive pulmonary disease, Osteoporosis, Anemia, Peripheral neuropathy, Urinary tract infection, depression

4.4 Medication and related information

A total of 950 medications were administered to the study participants, resulting in an average of 4 medications per patient. Throughout the hospital stay, polypharmacy was observed in 171 patients, accounting for 41.8% of study. Among the prescribed medications, a significant portion belonged to the cardiovascular class, which comprised 33.1% of the total. The most frequently prescribed drug in this category was furosemide, representing 43.2% of all medications administered. Additionally, Antihyperlipidemic was another commonly prescribed medication, accounting for 16.1% of prescriptions (Table 4).

Table 5: Type of medications prescribed for geriatrics patients hospitalized with cardiometabolic in Eastern Ethiopia, 2025.

Drugs class	Drug	Frequency	Percentage
Cardiovascular drug	Furosemide	76	8
	Hydrochlorothiazide	5	0.5
	Spironolactone	21	2.2
	Valsartan	20	2.1
	Losartan	20	2.1
	Enalapril	60	6.3
	Lisinopril	43	4.5
	Captopril	10	1.1
	Amlodipine	30	3.2
	Nifedipine	22	2.3
	Propranolol	10	1.1
	Bisoprolol	10	1.1
	Carvedilol	20	2.1
	Metoprolol	35	3.7
	Candesartan	15	1.8
	Digoxin	9	9.5
	Atenolol	5	0.5
Antidiabetic drug	Metformin	65	6.8
	Glibenclamide	32	3.4
	Regular insulin	12	1.3
	NPH insulin	16	1.7
Antihyperlipidemic	Atorvastatin	70	7.4
	Rovastatine	43	4.5

	Simvastatin	40	4.2
Antiplatelet	Aspirin	44	4.6
	Clopidogrel	40	4.2
Analgesics	Paracetamol	53	5.7
	Tramadol	14	1.5
	Morphine	5	0.5
	Indomethacin	1	0.1
Anticoagulation	Warfarin	22	2.3
	UFH	30	3.2
Others*		58	6.1
Total			
		950 (100%)	
Number drug given per patient			
1-4		238	58.2
≥5		171	41.8

*Antiemetic, Antibiotics, Respiratory drugs, Minerals, PPI

4.5 Prevalence of potentially inappropriate medication

In the study, the prevalence of PIMs among the total participants were significant. According to the 2023 AGS Beers Criteria, 194 participants 47.4% (95% CI: 42.6–52.3) were found to be using PIMs. Similarly, the STOPP version 3 criteria identified 108 participants 26.4% (95% CI: 22.1–30.6) as having PIM use. Additionally, using the START version 3 criteria, approximately 44 patients (10.8%) (95%CI: 7.8-13.8) were found to have at least one potentially prescribing omission (PPO) (Table 6).

Table 6: Prevalence of potentially inappropriate medication use and related information in geriatrics patients hospitalized with cardiometabolic disorders in Eastern Ethiopia, 2025.

PIM prescription over hospital stay	Category	Frequency	Percentage
Based on AGS Beers criteria	Patient with PIMs	194	47.4
Based on AGS Beers criteria, number of PIMs per patient	One PIM	149	76.8
	Two PIMs	34	17.5
	Three PIMs	11	5.7
Total number PIMs			250
Beers recommendation on PIMs	Avoid	131	52.4
	Use with caution	107	42.8
	Drug-drug interaction	11	4.4
	Renal dose adjustment	1	0.4
Based on STOPP criteria	Patient with PIMs	108	26.4
Based on STOPP criteria, number of PIMs per patient	One PIM	97	89.8
	Two PIMs	11	10.2
Total number PIMs			119
PPO Based on the START criteria	Patient with PPOs	44	10.8
Total number PIMs	44		

AGS: American Geriatric Society, PPO: potentially prescribing omission, PIM: potentially inappropriate medications, STOPP: Screening Tool of Older Persons potentially inappropriate Prescriptions, START: Screening Tools to Alert Prescribers to Right Treatment.

Based on the 2023 AGS Beers Criteria, furosemide was the most frequently prescribed medication to be used with caution for cardiovascular diseases, with 76 instances (30.4%). This was followed by Glibenclamide, with 32 instances (12.8%), which should be avoided in patients aged 65 or older. Warfarin was the third most frequent, with 22 instances (8.8%), as it should be avoided as first line the treatment of nonvalvular atrial fibrillation. (Table 7).

Table 7: Specific potentially inappropriate medications used according to AGS Beers Criteria 2023 in geriatrics patients hospitalized with cardiometabolic disorders in Eastern Ethiopia, 2025.

Specific PIMs	Drug class	Frequency (%)	Beers recommendation	Reason
Independent Diagnosis				
Amitriptyline	Tricyclic antidepressants	12(4.8)	Avoid	characterized by powerful anticholinergic effects, which can cause sedation and orthostatic hypotension
Aspirin	Anti-platelet	18(7.2)	Avoid	Aspirin for primary prevention of cardiovascular disease
Digoxin	Digitalis glycosides	9(3.6)	Avoid	Should not be administered for heart failure when the systolic function of the ventricles is normal.
Furosemide	Loop diuretics	76(30.4)	Use with caution	Can worsen or trigger SIADH or low sodium levels; closely monitor sodium levels when initiating or adjusting dosages in elderly patients.
Glibenclamide	Sulphonyl urea	32(12.8)	Avoid.	Sulfonylureas are linked to higher risk of cardiovascular events, overall mortality, and hypoglycemia compared to other treatment options. Moreover, these medications may raise the likelihood of cardiovascular-related deaths and ischemic strokes.
Hydrochlorothiazide	Thiazide diuretics	5(2)	Use with caution	Can worsen or trigger SIADH or low sodium levels; closely monitor sodium levels when

				initiating or adjusting dosages in elderly patients.
Indomethacin	NSAID	1(0.4)	Avoid	a higher likelihood of experiencing gastrointestinal bleeding, peptic ulcers, and acute kidney injury.
Nifedipine	CCBs	22(8.8)	Avoid	Risk of low blood pressure with the potential to trigger myocardial ischemia.
Sliding-scale regular Insulin alone	Hormone	12(4.8)	Avoid	Regimens that utilize only short-acting or rapid-acting insulin are associated with an elevated risk of hypoglycemia and do not confer significant improvements in overall glycemic control
Spironolactone	Aldosterone antagonists	12(4.8)	Use with caution	Can worsen or trigger SIADH or low sodium levels; closely monitor sodium levels when initiating or adjusting dosages in elderly patients.
Tramadol	Narcotic analgesics	14(5.6)	Use with caution	Can worsen or trigger SIADH or low sodium levels; closely monitor sodium levels when initiating or adjusting dosages in elderly patients.
Warfarin	Anticoagulant	22(8.8)	Avoid	Initiating warfarin as the first-line treatment for nonvalvularatrial fibrillation or venous thromboembolism should be avoided unless other options are not suitable or significant obstacles exist that prevent their use.
Depend on Diagnosis				
Metoclopramide	Antiemetics	3(1.2)	Should be avoided unless treating gastroparesis, with a maximum treatment duration of 12 weeks.	can lead to extrapyramidal side effects, such as tardive dyskinesia, with increased risk in elderly patients who are frail.

drug–drug interactions

Warfarin + ciprofloxacin	Anticoagulant and antibiotics	3(1.2)	Avoid when possible; or when used in combination, careful monitoring of INR is required	The risk of bleeding increased
Enalapril + spironolactone	ACEIs and potassium sparing diuretics	8(3.2)	Avoided routine use of a RAS inhibitor together with a potassium-sparing diuretic in patients with chronic kidney disease stage 3a or higher.	Increased risk of hyperkalemia
Medications whose dosages should be adjusted based on renal function				
Spironolactone	Aldosterone antagonists	1(0.4)	Avoid in patients with CrCl<30	Increased potassium
Total PIM		250(100)		

ACEI: Angiotensin converting enzyme inhibitor, INR: International normalized ratio

CrCl: Creatine clearance, SIADH: Syndrome of inappropriate antidiuretic hormone

CCB: Calcium channel blocker RAS: Renin angiotensin system

Using STOPP version 3 criteria, Glibenclamide was the most frequently prescribed medication, with 32 instances (26.9%). This was followed by metoprolol (17 instances, 15.1%) and furosemide (16 instances, 13.4%). Additionally, the medications that were omitted were angiotensin-converting enzyme inhibitors, antiplatelet therapy, statin therapy, and beta-blockers. (Table 8).

Table 8: Specific potentially inappropriate medications and potential prescription omissions according to STOPP and the START version 3 criteria in geriatrics patients hospitalized with cardio-metabolic disorders in Eastern Ethiopia, 2025.

Specific PIMs	Drug class	Frequency	Percentage
Using STOPP version 3 criteria			
Glibenclamide	Sulphonyl urea	32	26.9
Furosemide	Loop diuretics	16	13.4
Aspirin	Anti-platelet	15	12.6
Amitriptyline	Tricyclic antidepressants	11	9.2
Tramadol	Narcotic analgesics	5	4.2

Metoprolol	Beta blocker	17	15.1
Digoxin	Digitalis glycosides	4	3.4
Indomethacin	NSAID	1	0.8
Spironolactone	Aldosterone antagonists	7	5.9
Enalapril	Angiotensin-converting enzyme inhibitors	10	10.9
Total PIM			119(100)
Using START version 3 criteria			
Sacubitril/ valsartan	Angiotensin receptor neprilysin inhibitors (ARNIs)	3	6.8
Beta-blocker	Beta-blocker	4	9.1
Cardio-selective Beta-blocker	Beta-blocker	10	22.7
Antiplatelet therapy	Antiplatelet	2	4.5
Statin therapy	Statin	9	20.5
Angiotensin converting enzyme inhibitors	Angiotensin converting enzyme inhibitors	16	36.4
Total			44(100)

4.6 Factors associated with potentially inappropriate medication (PIM) use based on the AGS Beers criteria

A bivariate logistic regression analysis identified several factors associated with potentially inappropriate medication (PIM) use according to the 2023 AGS Beers criteria, using a significance level of 0.25. These factors included age, gender, marital status, education, cohabitation status, employment status, cigarette smoking, khat use, BMI, comorbidities, length of hospital stay, and specific conditions such as hypertension, heart failure, coronary artery disease (CAD), peripheral artery disease (PAD), and atrial fibrillation. Variables significant in the bivariate analysis were included in a multivariate logistic regression model. Key determinants of PIM use were age, gender, living arrangements, cigarette smoking, number of medications, heart failure, CAD, PAD, and hypertensive heart disease.

Patients aged 75–84 were 44 times more likely to use PIMs than those aged 65–74 (AOR = 44.35; 95% CI: 12.99–151.35; *P* < 0.001). Female patients had an 8.5-fold higher likelihood of PIM use compared to males (AOR = 8.50; 95% CI: 3.28–22.05; *P* < 0.001). Never smokers were significantly less likely to receive PIMs than current smokers (AOR = 0.004; 95% CI0.000-0.117; *P* <0.001), while patients with polypharmacy were 13.6 times more likely to use PIMs (AOR = 13.64; 95% CI: 4.44–41.96; *P* < 0.001).

Specific disease diagnosis analysis revealed that heart failure increased the likelihood of PIM use ninefold (AOR = 9.34; 95% CI: 2.41–36.27; *P* = 0.001), hypertensive heart disease nearly 25-fold (AOR = 24.92; 95% CI: 2.21–281.20; *P* = 0.009), while CAD (AOR = 0.098; 95% CI: 0.025–0.38; *P* = 0.001) and PAD (AOR = 0.032; 95% CI: 0.001–0.943; *P* = 0.046) were associated with a lower likelihood of PIM use (Table 9)

Table 9: Factors associated with potentially inappropriate medication use based on the AGS Beers criteria in geriatrics patients hospitalized with cardiometabolic disorders in Eastern Ethiopia, 2025.

Variable	Category	PIMs none-user	PIMs user	COR (95%CI)	*P*-value	AOR (95%Cl)	*P*-value
Age	65-74	183	35	1		1	
	75-84	24	95	20.696(11.640-36.800)	**<0.001**	15.118(5.325-42.919)	**<0.001**
	≥85	8	64	41.829(18.439-94.888)	**<0.001**	44.346(12.994-151.348)	**<0.001**
Gender	Male	146	42	1		1	
	Female	69	152	8.410(5.346-13.229)	<0.001	8.502(3.278-22.051)	**<0.001**
Marital status	single	1	5	1		1	
	married	154	141	0.183(0.021-1.586)	0.123	0.765(0.000-33964.436)	0.961
	widow	56	43	0.154(0.017-1.363)	0.093	0.113(0.000-5116.967)	0.690
	divorced	4	5	0.250(0.020-3.100)	0.280	0.606(0.000-39660.493)	0.930
Educational level	No formal education	76	85	1		1	
	Primary school	78	77	0.883(0.568-1.372)	0.579	0.968(0.398-2.352)	0.942

	Secondary school	45	23	0.457(0.253-0.824)	0.009	0.482(0.146-1.590)	0.231
	Graduated and above	16	9	0.503(0.210-1.204)	0.123	0.530(0.066-4.259)	0.551
Cohabitation	Alone	9	18	1		1	
	With others	1	12	6.000(0.671-53.681)	0.109	5.297(0.115-243.598)	0.393
	With family	205	164	0.400(0.175-0.914)	0.030	0.160(0.022-1.163)	0.070
Current working	No	179	176	1		1	
	Yes	36	18	0.509(0.278-0.929)	0.028	1.773(0.319-9.857)	0.513
Current occupation	Retired	154	136	1		1	
	Employed	9	7	0.881(0.319-2.429)	0.806	1.791(0.263-12.186)	0.552
	House wife	27	23	0.965(0.528-1.761)	0.907	1.571(0.392-6.297)	0.524
	Private work	18	10	0.629(0.281-1.409)	0.260	0.289(0.032-2.625)	0.270
	Other specify	7	18	2.912(1.180-7.183)	0.020	3.108(0.527-18.327)	0.210
Alcohol drinking	Never	166	136	1		1	
	Previously	46	51	1.353(0.856-2.140)	0.196	2.072(0.729-5.889)	0.172
	Current	3	7	2.848(0.723-11.223)	0.135	0.328(0.009-11.899)	0.543
Cigarette smoking	Never	154	136	0.976(0.627-1.520)	0.915	0.004(0.000-0.117)	**<0.001**
	Ex-smoker	58	50	3.020(0.785-11.611)	0.108	0.013(0.001-0.296)	**0.006**
	Current	3	8	1		1	
Khat chewing	Never	135	98	1		1	
	Previously	62	74	1.644(1.074-2.518)	0.022	1.358(0.521-3.539)	0.531
	Current	18	22	1.684(0.857-3.307)	0.130	0.418(0.058-3.028)	0.388
BMI	BMI < 18.5	13	22	1		1	
	BMI 18.5-24.5	186	165	0.524(0.256-1.074)	0.077	0.814(0.150-4.420)	0.812
	BMI > 24.5	16	7	0.259(0.084-0.794)	0.018	0.536(0.050-5.704)	0.605
	No	103	32	1		1	

Comorbidity	Yes	112	162	4.656(2.927-7.405)	<0.001	2.578(0.998-6.658)	0.050
Length of hospital stay, days	(1-5 days)	113	49	1		1	
	(6-10 days)	101	138	3.151(2.066-4.806)	<0.001	2.063(0.865-4.916)	0.102
	(> 10 days)	1	7	16.143(1.934-134.750)	0.010	29.764(0.256-3461.604)	0.162
Patient with previous medical history	No	139	67	1		1	
	Yes	76	127	3.467(2.307-5.209)	<0.001	2.584(0.898-7.437)	0.078
Hospitalization in previous 1 year before study period	None	180	127	1		1	
	Ones	25	57	3.231(1.917-5.447)	<0.001	2.494(0.725-8.578)	0.147
	Twice and above	10	10	1.417(0.573-3.505)	0.450	0.625(0.082-4.745)	0.649
Number of drugs given per patient	1-4	172	66	1		1	
	≥5	43	128	7.758(4.961-12.131)	<0.001	13.644(4.437-41.958)	**<0.001**
Hypertension	NO	145	148	1		1	
	Yes	70	46	0.644(0.416-0.997)	0.048	0.702(0.241-2.046)	0.517
Heart failure	No	195	146	1		1	
	Yes	20	48	3.205(1.824-5.634)	<0.001	9.341(2.406-36.270)	**0.001**
Coronary artery disease	No	184	181	1		1	
	Yes	31	13	0.426(0.216-0.841)	0.014	0.098(0.025-0.380)	**0.001**
Hypertensive heart disease	No	211	179	1		1	
	Yes	4	15	4.420(1.441-13.558)	0.009	24.920(2.208-281.203)	**0.009**
Peripheral artery disease	No	205	193	1		1	
	Yes	10	1	0.106(0.013-0.838)	0.033	0.032(0.001-0.943)	**0.046**
Atrial fibrillation + hypertension	No	209	192	1		1	
	Yes	6	2	0.363(0.072-1.819)	0.218	0.551(0.018-16.996)	0.733
Ischemic dilated	No	214	190	1		1	
	Yes	1	4	4.505(0.499-40.660)	0.180	0.082(0.004-1.566)	0.096

cardiom yopathy

4.7 Factors associated with potentially inappropriate medication (PIM) use based on the STOPP criteria

In a binary logistic regression analysis, several factors were found to be significantly associated with potentially inappropriate medication (PIM) use according to the STOPP criteria, using a significance threshold of 0.25. These factors included age, gender, marital status, cohabitation status, activities of daily living, khat use, body mass index (BMI), comorbidities, length of hospital stay, prior hospitalization within the year before the study, polypharmacy, diabetes mellitus, atrial fibrillation, ischemic stroke, and peripheral artery disease. Variables showing significant associations in the initial analysis were included in a multivariable logistic regression model. This analysis identified age, gender, comorbidity, length of hospital stay, diabetes mellitus, atrial fibrillation, and ischemic stroke as independent predictors of PIM use.

Specifically, patients aged 85 years and older were about 47 times more likely to receive PIMs compared to those aged 65–74 years (AOR = 46.719; 95% CI: 16.226–134.518; $P < 0.001$). Female patients were 4.5 times more likely to use PIMs than male patients (AOR = 4.384; 95% CI: 1.978–10.312; $P < 0.001$). The presence of comorbid conditions increased the likelihood of PIM use by 5.5 times compared to patients without comorbidities (AOR = 5.540; 95% CI: 2.189–14.022; $P < 0.001$). Medium-length hospital stays (6–10 days) were associated with a 2.2-fold higher likelihood of PIM use compared to shorter stays (1–5 days) (AOR = 2.206; 95% CI: 1.007–4.835; $P = 0.048$).

Regarding specific medical conditions, diabetes mellitus was linked to a 2.8-fold increased risk of PIM use (AOR = 2.795; 95% CI: 1.256–6.219; $P = 0.012$). In contrast, patients with atrial fibrillation were significantly less likely to use PIMs (AOR = 0.136; 95% CI: 0.025–0.749; $P = 0.022$), and those with ischemic stroke had a reduced likelihood as well (AOR = 0.086; 95% CI: 0.008–0.944; $P = 0.045$) (Table 10).

Table 10: Factors associated with potentially inappropriate medication use based on the STOPP criteria in geriatrics patients hospitalized with cardiometabolic disorders in Eastern Ethiopia, 2025.

Variable	Category	PIMs user	PIMs none-user	COR (95%CI)	*P*-value	AOR (95%Cl)	*P*-value
Age	65-74	207	11	1		1	
	75-84	74	45	11.443(5.622-23.292)	<0.001	8.622(3.327-22.347)	**<0.001**
	≥85	20	52	48.927(22.071-108.463)	<0.001	46.719(16.226-134.518)	**<0.001**
Gender	Male	171	14	1		1	
	Female	130	94	8.832(4.818-16.190)	<0.001	4.516(1.978-10.312)	**<0.001**
Marital status	Single	2	4	1		1	
	married	218	77	0.177(0.032-0.983)	0.048	0.702(0.038-13.040)	0.812
	widow	75	24	0.160(0.028-0.929)	0.041	0.786(0.040-15.455)	0.874
	divorced	6	3	0.250(0.028-2.237)	0.215	1.705(0.051-56.584)	0.765
Cohabitation	Alone	16	11	1		1	
	With other	6	7	1.697(0.447-6.439)	0.437	0.688(0.087-5.451)	0.723
	With family	279	90	0.469(0.210-1.048)	0.065	0.783(0.219-2.808)	0.708
Current working	No	257	98	1		1	
	Yes	44	10	0.596(0.289-1.231)	0.162	0.457(0.153-1.367)	0.161
Khat chewing	Never	179	54	1		1	
	Previously	97	39	1.333(0.824-2.155)	0.241	0.585(0.276-1.240)	0.162
	Current	25	15	1.989(0.979-4.040)	0.057	1.893(0.595-6.015)	0.280
Activity of daily living	Dependent	33	4	1		1	
	Partially dependent	82	25	2.515(0.812-7.788)	0.110	2.541(0.377-17.106)	0.338
	Full independent	186	79	3.504(1.201-10.221)	0.022	4.920(0.726-33.325)	0.103
BMI	BMI < 18.5	19	16	1		1	
	BMI 18.5-24.5	261	90	0.409(0.202-0.830)	0.013	0.289(0.082-1.020)	0.054
	BMI > 24.5	21	2	0.113(0.023-0.558)	0.007	0.177(0.013-2.472)	0.198
Comorbidity	No	123	12	1		1	
	Yes	178	96	5.528(2.907-10.511)	<0.001	5.540(2.189-14.022)	**<0.001**

Length of hospital stay, days	Short stay (1-5 days)	137	25	1		1	
	Medium stay (6-10 days)	160	79	2.706(1.634-4.480)	<0.001	2.206(1.007-4.835)	**0.048**
	Long stay (> 10 days)	4	4	5.480(1.285-23.361)	0.021	1.581(0.238-10.529)	0.636
Hospitalization in previous 1 year before study period	None	233	74	1		1	
	Ones	54	28	1.633(0.965-2.763)	0.068	1.013(0.449-2.283)	0.976
	Twice and above	14	6	1.349(0.501-3.637)	0.554	0.506(0.090-2.851)	0.440
Number of drugs given per patient	1-4	199	39	1		1	
	≥5	102	69	3.452(2.180-5.465)	<0.001	0.898(0.418-1.926)	0.782
Diabetic mellitus	No	236	74	1		1	
	Yes	65	34	1.668(1.022-2.723)	0.041	2.795(1.256-6.219)	**0.012**
Atrial fibrillation	No	275	106	1		1	
	Yes	26	2	0.200(0.047-0.856)	0.030	0.136(0.025-0.749)	**0.022**
Ischemic stroke	No	290	107	1		1	
	Yes	11	1	0.246(0.031-1.931)	0.182	0.086(0.008-0.944)	**0.045**
peripheral artery disease	No	291	107	1		1	
	Yes	10	1	0.272(0.034-2.150)	0.217	0.293(0.017-4.912)	0.394

5. DISCUSSION

This multi-center prospective study investigated the prevalence and factors associated with potentially inappropriate medication use among geriatric patients hospitalized with cardiometabolic disorders in Eastern Ethiopia. According to the 2023 AGS Beers criteria, 194 participants (47.4%, 95% CI: 42.6–52.3) were prescribed PIMs, while 108 participants (26.4%, 95% CI: 22.1–30.6) had PIMs based on the STOPP Version 3 criteria. Additionally, 44 patients (10.8%, 95% CI: 7.8–13.8) had at least one potentially inappropriate prescription (PPO) as determined by the START Version 3 criteria.

In the current study, the prevalence of potentially inappropriate medications, according to the 2023 AGS Beers Criteria, was 47.4% (95% CI: 42.6%–52.3%). This finding align with prior studies conducted in the USA at 50.0% (Orenstein *et al.*, 2025), Kuwait at 53.1% (Alanazi *et al.*, 2024), and Lebanon at 45.2% (Nader Babaei *et al.*, 2024). However, it is lower than reports from Qatar, where the prevalence was 76.0% (Al-Dahshan and Kehyayan, 2021), India at 61.9%(Patel *et al.*, 2020), and norhwest, Ethiopia, which reported in recent multicenter study with a prevalence of 63% (Tesfaye *et al.*, 2023). Conversely, this study's PIM prevalence was higher than that reported in research from Brazil, which found a 26.9% prevalence (Amorim *et al.*, 2024), and another study in India 24.6% (Giri *et al.*, 2025). Differences in prevalence are likely driven by variations in study design, patient populations, clinical settings, and the AGS Beers Criteria version used. Higher prevalence in studies from Qatar, India, and Jimma could be due to inclusion of broader patient groups, while lower rates in Brazil and another Indian study may result from older criteria versions (2012 and 2015) and a focus on outpatient settings.

This study demonstrated a notable prevalence of potentially inappropriate medications among geriatrics, with 52.4% of the medications evaluated being categorized as avoidable according to the Beers criteria. Glibenclamide, a long-acting sulfonylurea, emerged as a commonly identified drug to avoid, with a prevalence of 12.8%. According to the AGS Beers Criteria, Glibenclamide should generally be avoided as first- or second-line monotherapy or as an add-on treatment, except when safer and more effective alternatives are not feasible (Wondm *et al.*, 2024). These findings align with a study conducted at HFSCH in Ethiopia, which reported a prevalence of 15.7% (Nigussie and Demeke, 2024). But are notably higher than the 1.9% prevalence documented in Turkey (Sarganas *et al.*, 2024).

The study also revealed that 42.8% of the potentially inappropriate medications (PIMs) fell into the category of drugs that should be used with caution. Furosemide, a loop diuretic commonly prescribed for hypertension and fluid overload, was a notable concern in this group, with a prevalence of 30.4%. The AGS Beers Criteria recommend that furosemide be administered with caution in older adults, as it can potentially cause or worsen hyponatremia and the syndrome of inappropriate antidiuretic hormone secretion (SIADH). Consequently, it is important to closely monitor sodium levels when initiating or modifying furosemide therapy in this population. The prevalence of furosemide use observed in this study was greater than reported in the Netherlands (11%) (Orenstein *et al.*, 2025), but lower than findings from JUMC, which documented a prevalence of 43% (Tesfaye *et al.*, 2023).

The concurrent use of Enalapril and Spironolactone without monitoring blood potassium levels was 3.2% of older patients. The AGS Beers Criteria advise against the routine combination of a renin-angiotensin system inhibitor with a potassium-sparing diuretic in patients with chronic kidney disease stage 3a or higher, as this practice may elevate potassium levels and lead to hyperkalemia. Hyperkalemia can result in adverse effects such as muscle weakness, abdominal discomfort, and cardiac arrhythmias. Comparable findings were reported in Spain, where the prevalence was 2.3% (Leache *et al.*, 2024), whereas a higher prevalence of 9% was documented in Gondar (Wondm *et al.*, 2024).

In the current study, the prevalence of at least one potentially inappropriate medication among older adults, based on the STOPP version 3 criteria, was 26.4% (95% CI: 22.1%–30.6%). This rate is higher than those reported in Malaysia (19.4%) (Puig *et al.*, 2024), India (18.5%) (Patel *et al.*, 2020), and Turkey (15.6%) (Samara *et al.*, 2023). However, it is lower than the rates found in northwestern Italy (54.4%) (Sarganas *et al.*, 2024), China (72.54%) (Chiapella *et al.*, 2018), and Spain (73.2%) (Leache *et al.*, 2024). In northwest Ethiopia a study reported a prevalence of 34.4% (Wondm *et al.*, 2024). The slight differences across these studies may be explained by several factors, including differences in the criteria used, the availability of sophisticated diagnostic equipment and materials, the status of diseases, and the availability of drugs in healthcare facilities. A key concern stemming from these variations is the lack of comprehensive medication review for geriatric patients.

According to the STOPP version 3 criteria, Glibenclamide was identified as a potentially inappropriate medication in 26.9% of geriatric patients. This study highlights that Glibenclamide, used for managing type 2 diabetes, poses a risk of prolonged hypoglycemia

because of its long duration of action, making it less suitable for older adults. Oral hypoglycemic agents with shorter durations of action are recommended for this population instead. The prevalence found in this study exceeds that reported in China (13.1%) (Atak Tel *et al.*, 2023), and in Jordan (5%) (Rababa *et al.*, 2024). These variations could result from differences in the availability of alternative medications across the healthcare facilities included in each study.

The second most frequently identified PIM was metoprolol (15.1%), followed by furosemide (13.4%), according to the STOPP version 3 criteria. These findings contrast with studies from Kuwait and Palestine, where antiplatelet and beta-blocker medications were reported as the common frequently prescribed medication (Rababa *et al.*, 2024; Rus *et al.*, 2023).

In this study, 44 patients (10.8%) had at least one clinically necessary medication omitted from their treatment without an appropriate justification, according to the START version 3 criteria. This prevalence was similar to that reported at JUMC (10.9%) (Tesfaye *et al.*, 2023), but lower than the rates observed in Eritrea (35.5%) (Idrisnur *et al.*, 2024), and Saudi Arabia (47.6%) (Alnaim *et al.*, 2023). These discrepancies may be explained by variations in the availability of medications at healthcare facilities and the financial resources of patients. ACE inhibitors were the most frequently omitted drugs for patients with coronary artery disease and heart failure with reduced ejection fraction, accounting for 36.4% of cases, which is notably higher than the 14.5% reported in Gondar (Wondm *et al.*, 2024).

Most patients were on multiple medications, with an average of four drugs. Notably, 41% of patients were taking five or more medications daily, which is considerably higher than the 24.1% reported in Gondar (Wondm *et al.*, 2024).

According to the 2023 AGS Beers criteria, the study found a significant link between a geriatric patient's age and their likelihood of experiencing potentially inappropriate medications (PIMs). The findings showed a strong connection between age and the occurrence of PIMs in this patient population. Specifically, patients aged 85 and older were over 44 times more likely to experience PIMs compared to 65-74 age group (AOR = 44.346, 95% CI: 12.994-151.348, $P < 0.001$). Additionally, patients aged 75-84 had a PIM risk that was 15 times greater than that of the 65-74 age group (AOR = 15.118, 95% CI: 5.325-42.919, $P < 0.001$).

The wide confidence interval observed for the greater 85 age and above group indicates a potential limitation, likely due to a smaller sample size, which may increase result variability. The substantial increase in odds ratios from the 75-84 age group to those aged greater than 85 highlights a critical threshold where age-related health deterioration accelerates, markedly raising the likelihood of PIM use. This emphasizes the importance of careful medication oversight in older adults, particularly those 85 years and above. With advancing age, individuals often accumulate multiple chronic conditions, leading to numerous prescriptions, some of which may lack clear clinical justification. Regular evaluation of treatment plans is therefore essential to minimize the risks associated with potentially inappropriate medications in this high-risk population.

Gender also played a significant role, with females being 8.5-fold higher likelihood being experience PIMs than male (AOR = 8.502, 95% CI: 3.278–22.051, $P < 0.001$) compared to males. Interestingly, ex-smokers were much less likely to receive PIMs, with (AOR = 0.013, 95% CI: 0.001–0.296, $P = 0.006$) relative to current-smokers. The observed gender difference aligns with findings from studies in Jordan (Al-Dahshan and Kehyayan, 2021), and Saudi Arabia(Nader Babaei *et al.*, 2024). A potential explanation for this trend is the association between females and a higher utilization of healthcare services. Increased healthcare utilization can lead to a greater likelihood of receiving inappropriate care, including PIMs.

Polypharmacy emerged as another critical risk factor for PIM use. Patients with polypharmacy were over 13 times more likely to experience PIMs than those without it (AOR = 13.644, 95% CI: 4.437-41.958, $P < 0.001$). This aligns with findings from a large multicenter study across five Central and Eastern European countries, which also identified polypharmacy burden as key drivers of PIM use in community-dwelling older adults (Samara *et al.*, 2023). The high prevalence of PIMs among individuals taking multiple medications underscores the need for healthcare providers to implement thorough medication reconciliation processes. Additionally, it is essential to educate patients about potential inappropriate medications and to adjust treatment plans accordingly to alleviate the risks linked with polypharmacy.

The study showed that certain medical conditions were a strong link to the use of potentially inappropriate medications (PIMs). Patients diagnosed with heart failure were about 9.3 times more likely to receive PIMs than those without the condition (AOR = 9.341, 95% CI: 2.406–36.270, $P = 0.001$). Likewise, those with hypertensive heart disease had nearly 25

times higher of being prescribed PIMs compared to individuals without the disease (AOR = 24.920, 95% CI: 2.208–281.203, *P* = 0.009). This could be explained to the fact that a substantial proportion of the study participants were receiving cardiovascular treatments. Consistent with these findings, previous research has also identified heart failure and hypertensive heart disease as key predictors of PIM use(Tesfaye *et al.*, 2023; Tranhago *et al.*, 2024)

In contrast, some medical conditions were linked to a reduced likelihood of receiving potentially inappropriate medications (PIMs). For example, patients diagnosed with coronary artery disease were about 0.098 times as likely to be prescribed PIMs compared to those without the condition (AOR = 0.098, 95% CI: 0.025–0.380, *P* = 0.001). Likewise, individuals with peripheral artery disease showed a lower probability of being exposed to PIMs (AOR = 0.032, 95% CI: 0.001–0.943, *P* = 0.046). The relatively small number of patients with these diseases in the current study may partly account for this outcome. These findings align with previous research, including a study conducted at JUMC, which also found that patients with peripheral and coronary artery diseases were less likely to receive PIM prescriptions (Tesfaye *et al.*, 2023).

According to the STOPP version 3 criteria, this study identified several significant associations between various factors and potentially inappropriate medications (PIM) among geriatric patients.

The findings showed that patients aged 85 years and above were 46.7 times more likely to experience potentially inappropriate medication (PIM) use compared to those aged 65–74 years (AOR = 46.719, 95% CI: 16.226–134.518, *P* < 0.001). Likewise, individuals between 75 and 84 years had an eightfold higher risk of PIMs than the younger elderly group (AOR = 8.622, 95% CI: 3.327–22.347, *P* < 0.001). Gender also showed a significant influence, with female patients being 4.516 times more likely to receive PIMs compared to males (AOR = 4.516, 95% CI: 1.978–10.312, *P* < 0.001).

Comorbidity was another major determinant, as older adults with multiple health conditions were 5.540 times more likely to experience PIMs than those without comorbidities (AOR = 5.540, 95% CI: 2.189–14.022, *P* = 0.001). The duration of hospitalization also played a role; patients staying for 6–10 days had roughly twice the risk of receiving PIMs compared to those hospitalized for 1–5 days (AOR = 2.206, 95% CI: 1.007–4.835, *P* = 0.048). These

findings are consistent with previous studies that identified age, gender, comorbidity, and length of hospital stay as significant risk factors (Amorim *et al.*, 2024; Sarganas *et al.*, 2024). A possible explanation for these outcomes is that as patients grow older, they often accumulate more chronic conditions, leading to the use of multiple medications. This increases the risk of being prescribed drugs without clear indications, thereby heightening the probability of PIMs. These findings emphasize the need for close monitoring, comprehensive medication reviews, and appropriate prescribing practices for elderly patients with comorbidities.

Furthermore, the study found that patients with diabetes mellitus were 2.795 times more likely to be exposed to PIMs than those without diabetes (AOR = 2.795, 95% CI: 1.256–6.219, P = 0.012). Conversely, individuals with atrial fibrillation were 0.136 times less likely to receive PIMs compared to those without the condition (AOR = 0.136, 95% CI: 0.025–0.749, P = 0.022). Similarly, patients with ischemic stroke were 0.086 times less likely to experience PIMs than those without a stroke (AOR = 0.086, 95% CI: 0.008–0.944, P = 0.045). However, a study conducted in Gondar reported different results, showing that venous thromboembolism (VTE), stroke, and acute coronary syndrome (ACS) were significantly associated with PIM use (Wondm *et al.*, 2024).

5.1 STRENGTH AND LMITION OF THE STUDY

This study has several key strengths, including a large sample size and thorough data collection. It is the first to conducted thorough assessment of potentially inappropriate medications and identify related factors among geriatric patient admitted to all medical units within a healthcare facility in Ethiopia. The prospective design, use of the most up-to-date PIM assessment tools available, and consideration of important variables contribute to the study's robustness. Additionally, the multi-center approach improves the generalizability of the findings. A limitation is that physicians were not interviewed to explore their reasons for prescribing PIMs and PPOs, nor to assess their awareness of PIM use or monitoring of possible adverse effects.

6. CONCLUSSION AND RECOMMENDATION

6.1 CONCLUSSION

The prevalence of potentially inappropriate medications in geriatric patients with cardiometabolic disorder was found to be high. Therefore, it is essential to implement a PIM screening tool in clinical settings to enhance current prescribing practices and reduce the occurrence of PIMs, along with the adverse health consequences associated with them.

According to the AGS Beers Criteria, factors such as polypharmacy, comorbidities, heart failure, age, and being female were found to have statistically significant associations with the use of potentially inappropriate medications. Additionally, when evaluating the STOPP version 3 criteria, length of hospital stays, diabetes mellitus, and age were identified as statistically significant factors related to the presence of PIMs.

6.2 RECOMMENDATION

For MOH and Regional Health Bureau

It is recommended that screening tools such as the AGS Beers Criteria and the STOPP/START version 3 guidelines be implemented in clinical settings to ensure the safe, appropriate, and effective use of medications among geriatric patients.

For HFCSH, DCRH, BGH and JGH

Clinical pharmacists should actively participate in medication-related decision-making for older adults to help reduce the occurrence of potentially inappropriate medications. Furthermore, prescribers should be encouraged to adopt evidence-based prescribing tools, such as the 2023 AGS Beers Criteria and the STOPP/START version 3 guidelines, to enhance the overall quality of patient care.

For researcher

Further longitudinal and interventional research is required to examine how potentially inappropriate medication prescribing affects the long-term health, economic status, and social well-being of geriatric patients with cardiometabolic diseases.

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8. ANNEXES

8.1. Questionnaire

Section 1- Sociodemographic and behavioral information		
Serial No	**Variables**	**Category**
1	Age in years	----------
2	Gender	A. male B. female
3	Marital Status	A. Single B. Married C. Widowed. D. Divorced
4	What is your education Level ?	A. No formal education B. Primary school C. Secondary school D. Graduate & above
5	Do you live alone or with others?	A. Alone B. With family C. With other
6	Currently working	A. Yes B. No
7	What was occupation before retirement or currently?	A. Retired B. Employed C. Housewife D. Private work E. Other specify_____
8	Do you consume alcohol?	A. Never B. Previously C. Current
9	Do you smoke cigarette?	A. Neve B. Ex-smoker C. Current
10	Do you chew khat?	A. Never B. Previously C. Current
11	Activities of daily living	A. Dependent B. Partially dependent C. Full independent
12	Body weight(Kg)	_____
13	Height (meter)	_____
14	BMI Kg/m2	_____

Section 2: Clinical and related information		
Serial No	**Variables**	**Category**
1	Primary reason for hospitalization	A. Disease of cardiovascular system B. Disease of metabolic disorder
2	Primary diagnosis (select all that apply)	A. hypertension B. diabetic mellitus C. heart failure D. coronary artery disease E. other specify
3	comorbid diseases	A. Yes B. No
4	List of comorbid diseases, if yes for yes 3	_____
5	Length of hospital stay, day	_____
6	History of hospitalization in the last year	A. yes (number of times _____) B. No
7	Patient with previous medical history	A. Yes B. No

Section 3: Medication-Related information		
Serial No	**Variables**	**Category**
1	Medication type	A. Cardiovascular drug B. Metabolic drug C. Other drug
2	List of all medications	_____
3	In hospital medication (Name of drug, dose, frequency and duration)	_____

section 4; PIM		
1	Assessment of medication use (based on AGS Beers criteria)	A. Is the patient taking any medications that are considered to avoided. 1. If yes please specify _____ 2. No B. Is there any medication that should be use with caution or based on the health status? 1. If yes please specify_____ 2. No C. Is there any medication that should be drug-drug interaction? 1. If yes please specify_____ 2. No D. Is there any medication that should be reduced dose in older adult based on the health status? 1. If yes please specify_____ 2. No E. D. Is there any medication that should be exacerbated with patient condion? 1. If yes please specify_____ 2. No
2	Assessment of potentially inappropriate prescribing (STOPP criteria)	A. Is the patient taking any medications that are considered potentially inappropriate according to the STOPP criteria?" 1.If yes please specify _____ 2. No
3	Assessment of potentially inappropriate prescribing (START criteria)	A. Is there any omission of clinically relevant medication that should be consider for this patient? 1. If yes, please specify_____ 2. No_____

Assessing appropriateness of medications

Two standardized tools were employed to identify potentially inappropriate medications (PIMs): one focused on medication-related issues and the other on disease-specific considerations.

1. 2023 AGS Beers Criteria:

The 2023 AGS Beers Criteria were utilized to classify PIMs into five major categories: (1) medications considered potentially inappropriate in older adults, (2) drugs inappropriate for patients with certain diseases or syndromes, (3) medications that should be used cautiously, (4) potentially harmful drug–drug interactions, and (5) medications requiring dose adjustments according to renal function.

2. STOPP/START version 3 criteria:

The STOPP/START version 3 criteria comprised two main parts. The STOPP criteria were applied to determine inappropriate medication use among patients aged 65 years and above, specifying the rationale for each medication's inappropriateness. These rationales were grouped by both therapeutic indication (e.g., use without clinical justification, prolonged use beyond recommended duration, or duplication within the same drug class) and physiological system affected—such as cardiovascular, central nervous, renal, gastrointestinal, respiratory, musculoskeletal, urogenital, and endocrine systems.

The START criteria were used to detect potential prescribing omissions (PPOs) in cases where appropriate treatments were not prescribed without a valid reason. Like the STOPP criteria, these were organized by physiological systems, including cardiovascular, respiratory, central nervous, gastrointestinal, musculoskeletal, endocrine, and urogenital systems.

8.2. Curriculum vitae

1. Background information

Full name: Hamza Abdureman Ahmed

Nationality: Ethiopian

Age; 26 years Date of birth: 02/01/1998

Sex: Male

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Working institution: Haramaya University CHMS

2. Educational background

S. No	Name of school	Place	Grade	Year in E.C
1	Elementary school	Kombolcha	1-8	1997-2004
2	Secondary School	Kombolcha	9-10	2005-2006
3	Preparatory school	Kombolcha	11-12	2007-2008
4	Haramaya University, CHMS	Harar	Degree (B.pharm)	2009-2014
5	Haramaya University	Harar	MSc in Clinical pharmacy student	2015-2017

CHMS: College of Health and Medical Science

3. Qualification: B. pharm Degree in pharmacy with CGPA of 3.59, MSc of clinical pharmacy student (CGPA of 3.79)

4. Language Skills

S. No	Language	Listening	Reading	Speaking	Writing

1	**English**	C2	C2	B2	C2
2	**Amharic**	C2	B2	B2	B2
3	**Afaan Oromo**	C2	C2	C2	C2

5. Computer skills

- Very good in Microsoft Word, Microsoft PowerPoint, and Microsoft Excel
- Very good in Statistical Package for Social Science software (SPSS)

6. Working experiences

- Delivering lectures and facilitating learning sessions for undergraduate pharmacy students.
- Providing academic guidance and mentorship to students engaged in research projects.
- Offering consultation and support to students regarding academic and professional development.
- Engaging in and conducting scholarly research activities within the field of pharmacy.

8.3. Approval sheet

HARAMAYA UNIVERSITY

POST GRADUATE PROGRAM DIRECTOR

Potentially Inappropriate Medication Use and Associated Factors Among Geriatric Patients Hospitalized with Cardiometabolic Disorders in Public Hospitals of Eastern Ethiopia.

Submitted by:

Hamza Abdureman (B. pharm) _____ _____

Name of Student Signature Date

Approved by:

1._____ _____ _____

Name of Major Advisor Signature Date

2._____ _____ _____

Name of Co-Advisor Signature Date

3._____ _____ _____

Research Thematic Area Leader Signature Date

4._____ _____ _____

Chairman, SGC/DGC Signature Date

5._____ _____ _____

PGPD Signature Date