Indonesian Journal of Pharmacy

VOL 36 (1) 2025: 46–63 | REVIEW ARTICLE

# Characteristics and Economic Impact of Pharmacist Intervention on Older Adults with Chronic Disease: A Systematic Review

**Yeni Farida [1,2], Tri M. Andayani[3*], Anna W. Widayanti [4] and Probosuseno[5]**

1. Doctoral Program in Pharmaceutical Sciences, Faculty of Pharmacy, Universitas Gadjah Mada, Sekip Utara 55281, Yogyakarta, Indonesia
2. Department of Pharmacy, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret, Surakarta, Indonesia
3. Pharmacotherapy and Clinical Pharmacy, Faculty of Pharmacy, Universitas Gadjah Mada, Sekip Utara 55281, Yogyakarta, Indonesia
4. Pharmaceutical Management and Social Pharmacy, Faculty of Pharmacy, Universitas Gadjah Mada, sekip Utara 55281, Yogyakarta, Indonesia
5. Department of Internal Medicine, Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada, Sekip Utara 55281, Yogyakarta, Indonesia

**Article Info**

**Submitted:** 31-10-2023
**Revised:** 02-04-2024
**Accepted:** 13-05-2024

*Corresponding author
Tri M. Andayani

Email:
trimurtia@ugm.ac.id

**ABSTRACT**

Several pharmacist interventions were carried out to enhance medication safety and effectiveness, but not all are cost-effective. This review aimed to investigate the characteristics and the economic impact of pharmacist intervention for older adults with chronic disease. Articles published from January 2013 to June 2023 were retrieved from PubMed, Science Direct, and Google Scholar. After applying the PICO strategy, a total of 13 studies were included, and the studies without cost evaluation were excluded. The quality of the studies was assessed using the CHEERS checklist. Pharmacist intervention for geriatric patients included medication review, patient-centered care approach intervention, and multidisciplinary collaboration care. The follow-up ranged from 10 days to 36 months. Among the five cost-utility analyses (CUA), four indicated negative incremental total cost, meaning the intervention outperformed the control group. Subsequently, two cost-benefit analyses (CBA) showed benefit-to-cost ratios ranging from 3.3 to 6.2. The cost savings on medication ranged from €37.57 to €232 per patient in a year. This review suggested that pharmacist intervention in both outpatient and inpatient settings could decrease the risk of adverse drug events (ADE), enhance clinical outcomes, improve quality of life, and cut down on medication expenditure for older adult patients. Almost all investigations concluded that pharmacist intervention has a beneficial economic impact. Evaluating the economic impact of a large-scale intervention requires further study with more precise estimates of overall intervention cost and rigorous methodology applied to economic evaluations of initiatives.

**Keywords:** cost saving, geriatric, medication review, pharmacist intervention, quality of life

## INTRODUCTION

The older adult population in every country is experiencing significant growth in both numbers and percentages. The aging process is occurring at a much higher rate than in the past. The proportion of people aged 60 and older is projected to increase from 1 billion in 2020 to 1.4 billion in 2050. There is a prevailing notion that older adults are fragile, reliant, and burdensome on society. Addressing ageist attitudes is crucial for public health workers and society as a whole, as these attitudes can lead to discrimination, affect the way policies are made, and make it more challenging for older adults to age in a healthy way (WHO, 2022). The WHO has formulated 5 priority interventions to be implemented in geriatric patients, including chronic disease management (WHO, 2012). Given the significance of older adults

in the healthcare system, many of them are exposed to multiple pharmacy. However, due to various pharmacodynamic and pharmacokinetic changes, comorbid conditions, polypharmacy, lack of knowledge about medications and medical conditions, inappropriate medication use, and hoarding of old medicines, geriatric patients had a higher risk of drug-related problems. For instance, drug-related problems (DRPs) resulting from "non-conformity to guidelines" were more common in geriatric wards. These DRPs in older adults patients may increase the risk of falls, hospital readmission, death, morbidity, and healthcare expenses (Hoel et al., 2021). Investigating and addressing DRPs contributes to preventing potentially significant adverse effects (Gervais et al., 2021; Pradhan et al., 2021; Sinha et al., 2021).

In community pharmacy, a larger proportion of potentially inappropriate medication (PIM) users were found among patients older than 75 years with a higher rate of taking multiple medications (polymerization). These disorders can increase the risk of hospitalization due to adverse drug effects, drug interactions, or intolerance, which prescribing physicians should consider (Malakouti et al., 2021). The high prevalence of PIM in this population necessitates comprehensive measures to address the issue and improve prescription quality and patient health outcomes. Reducing the rate of inappropriate medication use has a significant effect on decreasing the cost of patients (Hadia et al., 2022; Malakouti et al., 2021; Nader Babaei et al., 2024; Robinson et al., 2022; Schiavo et al., 2022), including a reduction in the number of post-discharge hospital visits for older adults patients (Van der Linden et al., 2020).

In recent years, there has been growing interest in studies examining the impact of clinical pharmacist treatments on hospitalized patients. These studies highlighted the crucial role of clinical pharmacists in reducing prescription mistakes and saving treatment costs (Lankford et al., 2021)r. Specifically in primary care, a higher number of comorbidities has been associated with higher total healthcare services consumption and costs. This highlights the need to improve primary care for the aging and multimorbid population (Buja et al., 2021). Various interventions by clinical pharmacists have been reported in several studies. For instance, a study in Germany showed that the main pharmacist intervention was a recommendation for the addition, withdrawal, or replacement, as well as advice on dosage adjustments based on impaired renal or liver function (Langebrake & Hilgarth, 2010). Several studies focused on pharmacist intervention in order to prevent potential DRPs do to polypharmacy or PIM (Ali et al., 2022; Blum et al., 2021; Bülow et al., 2023; Darmawan et al., 2020; Gunterus et al., 2016; Huibers et al., 2022; Lee et al., 2015; Nachtigall et al., 2019; Rantsi et al., 2022). Pharmacist intervention decreases adverse drug reactions (ADR) occurrence, medication adherence, and quality of life in geriatric patients (Shinu & Dilip, 2020). Interestingly, physicians have shown higher acceptance rates for pharmacist intervention in geriatric patients compared to younger patients (Gervais et al., 2021).

A meta-analysis was conducted to investigate interventions provided by healthcare professionals during and after hospital discharge for older adults. The intervention was classified into three categories informational, management, and relational. Subsequently, this review focused only on the hospital readmission outcome (Facchinetti et al., 2020). Previous reviews reported pharmacist intervention in hospitalized patients, intervention related to pharmacy services (Kiesel & Hopf, 2018) and focused on optimizing prescriptions for older adults patients or reducing inappropriate medication (Laberge et al., 2021; Mucherino et al., 2022; Rankin et al., 2018; Saeed et al., 2022; Viana et al., 2017) while others focused on enhancing patients' adherence (Kini & Michael Ho, 2018; Marcum et al., 2021). Another systematic review highlighted the limited evidence available regarding the effectiveness of community-based professional pharmacy services (PSS) (Varas-Doval et al., 2021). Several prior research examining economic outcomes focused on community-dwelling older adults (Riordan et al., 2016; San-Juan-Rodriguez et al., 2018; Soler & Barreto, 2019). Bezerra et al., (2022) reported on the economic impact of pharmacy services but the studied subject was not specific to older adults population.

Prior review studies provided a limited scope of the outcome, setting, and economic evaluation type. Therefore, this review aimed to investigate the characteristics and economic impact of pharmacist intervention for older adults with chronic disease. The assessed outcome in this review encompasses not only optimizing prescription but also clinical and humanistic outcomes. This review not only included full pharmacoeconomic studies but also cost analysis and cost consequence analysis. It is expected to be able to identify gaps in the evidence to inform future investigations.

## MATERIALS AND METHODS

### Search Strategy

Using the PICO framework, a systematic review was conducted by searching three databases (PubMed, Science Direct, and Google Scholar) that published from January 2013 to June 2023, the search was conducted until June 20th, 2023. The MeSH or text keywords used for the search included terms related to geriatric populations ("geriatric", "elderly", "older adults", "aged"), terms related to pharmacist intervention ("pharmacy services", "clinical pharmacy", "hospital pharmacy", "community pharmacy"), terms related to costs analysis ("economic evaluation" OR "cost" OR "cost analysis" OR "cost-effectiveness analysis" OR "cost-utility analysis"). The subject headings used as search terms were split into three categories: those related to geriatric ("geriatric" OR "elderly" OR "older adults" OR "aged"); AND those related to pharmacist intervention ("pharmacy services" OR "clinical pharmacy" OR "hospital pharmacy" OR "community pharmacy); AND those related to cost ("economic evaluation" OR "cost" OR "cost analysis" OR "cost-effectiveness analysis" OR "cost-utility analysis"). The search terms were used in the title, abstract, keywords, and text word searches. The review also involved screening the references of relevant full-text articles. There was no review protocol nor prospective registration, although this systematic review was conducted in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al., 2021).

### Study selection

During the literature search, all references retrieved were screened based on the titles and abstracts of each citation. Articles that did not focus on the economic evaluation of pharmacist intervention in geriatric populations were eliminated based on the titles. Furthermore, the remaining abstracts were examined to identify articles that measured adherence, number of ADRs, medication errors, quality of life, and economic outcome (Table I). The final selection of articles to be included in this study was conducted after a comprehensive review of each article. The full text of these articles was accessed through the institutions of electronic resources.

### Data extraction

Data extraction was carried out by two blind and independent reviewers (YF, TMA). They extracted relevant information from the articles, including details about the author, year, country, study design, participants, pharmacist intervention, economic evaluation, and sensitivity analysis. In cases where differences in data extraction arose, a third reviewer (AWW) examined the original articles to resolve any discrepancies. All monetary data in this analysis is presented in the similar units used in the original article.

Table I. PICO strategy

| **Populations** | **Patients ≥ 60 years** |
|---|---|
| Type of intervention | Medication reconciliation<br>Medication review<br>Medication therapy management<br>Pharmacy counselling<br>Pharmacy consultation and education<br>Pharmacist collaboration with other health professionals |
| Comparator | Standard care (without pharmacist intervention) |
| Outcome | Reduction of the number of ADR<br>Reduction of drug-related problems (DRPs)<br>Reduction of hospitalization<br>Quality of life<br>Cost-effective/cost-saving /cost avoidance/cost-benefit |
| Study design | Randomised Controlled Trials (RCT), before-after/ Quasi-experimental study |

### Quality Assessment

The quality of the studies was reviewed independently by two authors (YF, TMA) using the updated CHEERS checklist. This checklist consists of 28 items for assessing the quality of reporting from economic evaluation studies. Checklist items were divided into seven categories: (1) Title; (2) Abstract; (3) Introduction; (4) Methods; (5) Results; (6) Discussion; and (7) Other relevant information (Husereau et al., 2022). The users identified which section of the manuscript contains the pertinent information based on the checklist. If there is a lack of information in the manuscript the users write "not reported" while "not applicable (N/A)" if the type of the study did not match the criteria. Disagreements were resolved through consensus, and the third (AWW), as well as fourth reviewers (P), were consulted when needed. Updating the original, CHEERS 2022 has a wider range covering cost analysis as well as cost consequences not only cost-effectiveness (Drummond et al., 2022; Willke & Pizzi, 2022).

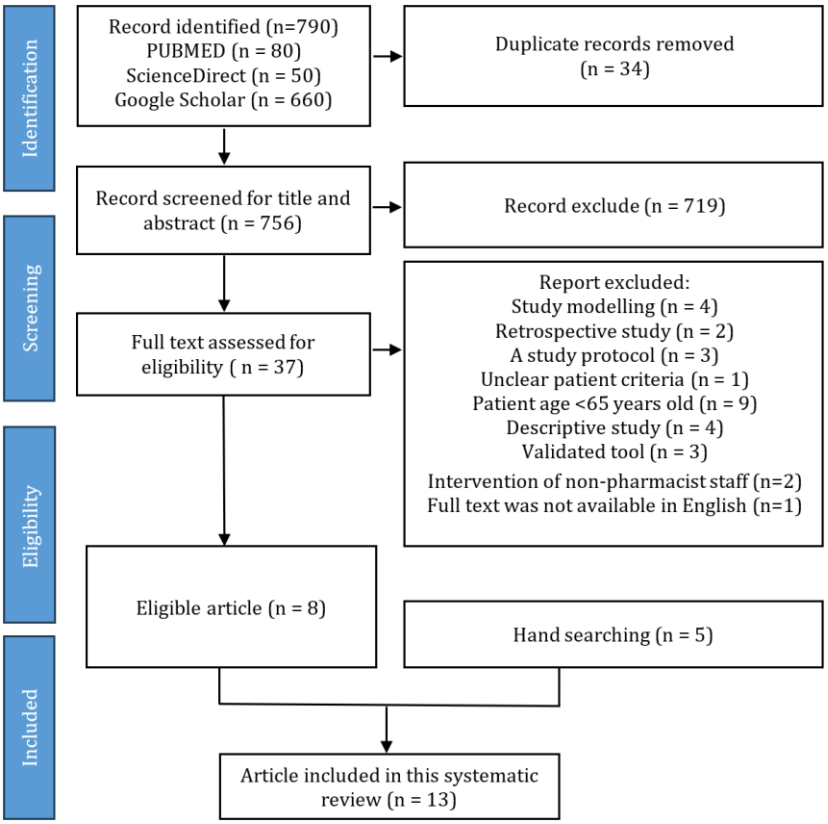


Figure 1. PRISMA Flowchart

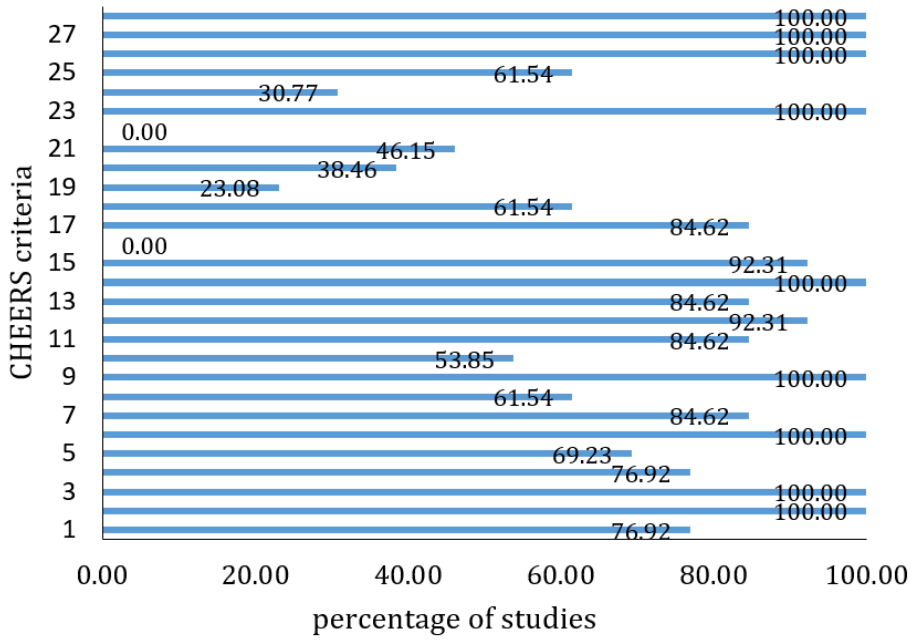


Figure 2. Quality of included studies based on CHEERS checklist

## RESULTS AND DISCUSSION

A total of 790 studies were initially retrieved from the literature search. After removing duplicate publications, the titles and abstracts of 756 studies were assessed for eligibility, and the full texts of 37 articles were evaluated for eligibility. Ultimately, 8 articles were eligible for inclusion. A manual search of the references cited in these 8 studies led to the discovery of five additional relevant articles. Due to the heterogeneity of the included articles, a meta-analysis was not feasible, and a narrative synthesis was conducted instead to summarize the results (Figure 1).

### Quality assessment

Several aspects were well-performed, such as abstract, introduction, setting and location, measurement and valuation of cost, summary of main result, findings and limitation, funding and conflict of interest (Figure 2). None of included studies meet criteria 16 and 22 because all of the studies were trial based not modelling.

In reporting the methods (item 4-21), only three studies not stated clearly about health economic analysis plan (Campins et al., 2019; Leguelinel-Blache et al., 2020; Lin et al., 2018). Most of the studies describe characteristics of the study population in detail about demographic and clinical characteristic except in four studies (Gallagher et al., 2016; Lin et al., 2018; Salari et al., 2022; Twigg et al., 2015). Time horizone of the studies was vary but there were some studies did not reported whether conducted the discount rate or not, and the reason (Lin et al., 2018; Malet-Larrea et al., 2017; Obreli-Neto et al., 2015; Twigg et al., 2015; van der Heijden et al., 2019; Verdoorn et al., 2021). Only one study did not met criteria 11 to 13 because it was cost analysis study (Campins et al., 2019). Characterising uncertainty was missing in most of the study except in three studies (Gallagher et al., 2016; Salari et al., 2022; Singh et al., 2022). Less than 50% (Gallagher et al., 2016; Lin et al., 2018; Malet-Larrea et al., 2017; Salari et al., 2022; Verdoorn et al., 2021) of the studies reported characterising distributional effect (items 20) because the manuscript published before 2022 that used CHEERS 2013 for reporting guideline. In the result, only five studies (30.7%) reported the effect of uncertainty (Jódar-Sánchez et al., 2015; Salari et al., 2022; van der Heijden et al., 2019; Verdoorn et al., 2021).

### Participants

Table II summarizes the features of the included studies. A total of 8,599 older adults patients were recruited across the 13 studies, with the number of participants ranging from 41 to 2,008. Ten studies (Gallagher et al., 2016; Jódar-Sánchez et al., 2015; Kari et al., 2022; Lin et al., 2018; Malet-Larrea et al., 2017; Obreli-Neto et al., 2015; Salari et al., 2022; Singh et al., 2022; van der Heijden et al., 2019; Verdoorn et al., 2021) involved a control group, while 3 used the intervention group only (Campins et al., 2019; Leguelinel-Blache et al., 2020; Twigg et al., 2015). The participants included general geriatric patients in 4 trials (Gallagher et al., 2016; Kari et al., 2022; Leguelinel-Blache et al., 2020; Singh et al., 2022) while 1 study focused on patients with hypertension and diabetes (Obreli-Neto et al., 2015). Eight other studies focused on geriatric patients with polypharmacy (Campins et al., 2019; Jódar-Sánchez et al., 2015; Lin et al., 2018; Malet-Larrea et al., 2017; Salari et al., 2022; Twigg et al., 2015; van der Heijden et al., 2019; Verdoorn et al., 2021).

### Intervention

The intervention in the included studies was delivered by pharmacist either in multidisciplinary team or alone. Pharmacist played a crucial role in providing medication reviews, communicating with physicians, and offering private counseling to address DRPs and negative outcomes associated with medication (NOMs). It is the responsibility of the pharmacist to promote accurate medication reconciliation and to conduct a medication review utilizing the most up-to-date prescription list (Van der Linden et al., 2020). To guarantee that patients were on the most effective treatment regimens possible, pharmacist is uniquely qualified to offer pharmacy support (Monzón-Kenneke et al., 2021). Furthermore, 3 studies used the patient-centered care approach intervention, focusing on patients preferences, personal goals, and health-related complaints (Kari et al., 2022; Lin et al., 2018; Verdoorn et al., 2021). Seven studies directed private consultations and education (Campins et al., 2019; Jódar-Sánchez et al., 2015; Leguelinel-Blache et al., 2020; Lin et al., 2018; Malet-Larrea et al., 2017; Singh et al., 2022; Twigg et al., 2015), while another one conducted group education (Obreli-Neto et al., 2015). In 4 studies the intervention included face-to-face meetings with a physician or the medical staff to discuss the improper prescriptions to patients (Gallagher et al., 2016;

Table II. Characteristics of included studies

| Study | Author (year) | Study Design | Country-Settings | Subject | Number of participants | Intervention | Outcome |
|---|---|---|---|---|---|---|---|
| | | | | **Pharmacist intervention** | | | |
| 1 | Jódar-Sánchez et al., (2015) | Cluster randomized controlled trial | Spain - Community pharmacy | Age of 65 years or over and taking five or more officially registered medicines | 627 (IG) vs 671 (CG) | Pharmacists conducted medication reviews and actions advised to patients and/or physicians to prevent, resolve, or improve the detected DRPs | HR-QoL was measured by EQ-5D-3L |
| 2 | Obreli-Neto, et al., (2015) | Prospective longitudinal randomized controlled clinical trial | Brazil -Primary care | Aged ≥60 years; diagnosed with diabetes or hypertension | 97 (IG) vs 97 (CG) | Pharmacy care intervention consisted of individual follow-ups according to the Pharmacotherapy Workup and educational group activities | Clinical outcomes included blood pressure, fasting glucose, HBA1c, and LDL. Humanistic outcomes estimated QALY |
| 3 | Twigg et al., (2015) | The multicentre, before-after pilot, and paired study | United Kingdom -Community pharmacy | Patients ≥ 65 years with 4 or more medicine | 339 | Pharmacists conducted medication reviews and follow-ups with private consultations | Healthcare use related to drug use, reduced risk of falls appropriate pain management, increasing adherence and quality of life |
| 4 | Gallangher et al., (2016) | Randomized controlled trial | Ireland - Teaching hospital | Patients aged ≥ 65 years admitted under the care of the medical or surgical services through the emergency department | 361(IG) vs 376(CG) | Structured Pharmacist Review of Medication / Clinical Decision Support Software (SPRM/ CDSS | Number of ADR |
| 5 | Malet-Larrea et al., (2017) | Cluster randomized controlled trial | Spain - Community pharmacy | Aged 65 years and older, taking 5 or more medications for at least 6 months | 646 (IG) vs 685 (CG) | Pharmacists conducted medication reviews and did actions with the patient's and/or physician's approval | Cost savings |
| 6 | Van der Heijden et.al., (2019) | Randomized controlled trial | Netherland-Community pharmacy | Patients ≥ 60 years old with 5 or more medicine | 160 (CG) vs 180 (IG) | Community pharmacists identified DRPs using Amsterdam CMR tools and gave recommendations to the prescribers | Number of drug-related problems |
| 7 | Verdoorn et.al., (2021) | A pragmatic randomized controlled trial | Netherland - Primary care | Patients aged 70 years and over using seven or more chronic drugs | 294 (IG) vs 294 (CG) | Pharmacist conducted clinical medication reviews (CMR), discussed the personal goals, preferences, and other DRPs with the GP then proposed actions plan | HR-QoL measured by EQ-5D-3L and EQ-VAS |

| Study | Author (year) | Study Design | Country-Settings | Subject | Number of participants | Intervention | Outcome |
|---|---|---|---|---|---|---|---|
| **Pharmacist in multidisciplinary collaboration** | | | | | | | |
| 8 | Lin et.al., (2018) | A prospective, randomized controlled trial | Taiwan - Hospital | Age of 65 and older with three or more chronic conditions, more than six prescription items, and more than four outpatient appointments or two or more specialties in one year | 62 (IG) vs 44 (CG) | Clinical pharmacists offered extensive intervention aspects to patients in the MTM group through direct patients' contact, physician contact, or comprehensive medical chart review | Clinical: improvements in several clinical markers such as LDL, HDL, and ACR (MTM group) were mostly positive but non-significant.<br>Humanistic:<br>QoL measured by EQ-5D-3L |
| 9 | Campins et.al (2019) | A randomized, open-label, multicenter, parallel-arm clinical Trial | Spain - Primary care | People aged ≥ 70 years, receiving eight or more drugs | 251 (CG) vs 252 (IG) | Pharmacist evaluated drug prescriptions using the GP-GP algorithm and STOPP/START criteria and discussed recommendations with a physician, and a final decision was agreed upon by physicians and their patients in a face-to-face routine visit | Cost savings |
| 10 | Leguelinel-Blache et.al., (2020) | Monocentric, before-after pilot and paired study | French - Community pharmacy | Patients ≥ 65 years resident in the nursing home | 41 | Multidisciplinary (senior and junior pharmacist, physician, and nurse) medication review | ADE geriatric risk score, length of stay in hospitalization |
| 11 | Kari et.al. (2022) | A prospective longitudinal randomized controlled trial | Finland - Community | Aged ≥75 years with multimorbidity | 126 (CG) vs 151 (IG) | Interprofessional people-centered care model (PCCM) | Physical performance was measured by Short Performance Physical Battery (SPPB); Quality of Life was measured by SF-6D; ICER |
| 12 | Singh et al. (2022) | Multisite open parallel participant randomized controlled trial | United Kingdom - Community | Aged ≥75 years, patients with acute coronary syndrome, suspected stroke, required acute surgical assessment, were receiving end-of-life care, and at high risk of home care were excluded | 274 (CG) vs 563 (IG) | Comprehensive geriatric assessment hospital at home (CGAHAH) done by a team consisting of consultant geriatricians, junior doctors, nurse practitioners, health care assistants or support workers, physiotherapists, occupational therapists, and community pharmacist | Quality of life was measured by EQ-5D-5L |

ACR: urinary albumin-creatinine ratio; ADE: Adverse drug event; DRPs : Drug Related Problems; IG: Intervention Group; CG: Control Group; GP-GP: Good Palliative-Geriatric Practice; MTM: Medication Therapy Management; QALY: Quality adjusted life year

Table IV. An economic evaluation of included studies

| Reference | Type of economic evaluation | Time frame | Perspective | Type of cost (pricing) | ICER or Cost Savings or Cost-Benefit Ratio or Net benefit | Author's Conclusion |
|---|---|---|---|---|---|---|
| Jódar-Sánchez et.al.,(2015) | Cost-utility analysis | 6 months | Health service | Cost of medication, hospital admissions, emergency department visits, pharmacist labor and investment in the infrastructure and training of community pharmacies (Euro at 2014 prices) | Not calculated (the MRF service was the dominant strategy) | MRF service was cost-effective |
| Verdoorn et.al., (2021) | Cost-utility analysis | 6 months | Societal | Direct healthcare costs including drug and informal care costs (Euro at 2017 prices) | € 86.360 (ICER) | A CMR focused on patients' preferences, personal goals, and health-related complaints was cost savings |
| Kari et.al. (2022) | Cost-utility analysis | 2 years | Healthcare service provider | Total medical cost in primary and secondary care either outpatient or inpatient care, and also the cost of home care service (Euro at 217 prices) | €−73,638 (ICER in the base case) | PCCM including pharmacist-led medication review dominated usual care community-living older adults |
| Singh et al. (2022) | Cost-utility analysis | 6 months | Societal | Cost of health and social care including hospital admission, outpatient care, home care, residential care and also informal care. (Pounsterling at 2018 prices) | CGAHAH was dominant (ICER not calculated) | CGAHAH was a feasible and cost-effective option for hospitalization for a subset of older adult's patients presenting with sudden worsening health |
| Twigg et.al., (2015) | Cost-utility analysis | 6 months | Health care | Cost of pharmacist, physician, healthcare assistant, hospital admission, emergency visits, specialist consultant, physycian or nurse overtime work (Euro, no pricing information) | £32,466.03 (ICER for threshold of £30,000 per QALY) | Pharmacist medication review with consultation was potentially cost-effective if the 6-month gains were maintained at 12 months at no further cost |
| Lin et.al., (2018) | Cost-benefit analysis | 12 months | Health service | Total medical costs including outpatient department visits, emergency visits, and hospital admission (TWD at 2016 prices) | The benefit-to-cost ratio for the MTM service program was 3.53:1 | The use of a clinical pharmacist in a physician-pharmacist MTM program facilitated a high quality of care and had a positive impact on economic effects and some clinical and humanistic outcomes |
| Maret-Larrea et.al., (2017) | piggyback cost-benefit analysis | 6 months | Health service | Cost of medication, hospital admissions, emergency department visits, pharmacist labor and investment in the infrastructure and training of community pharmacies (Euro at 2014 prices) | Ratio benefit to cost 1:3.3-6.2 | The MRF would achieve savings of 398 € per patient in the scenario where 240 patients were included in the service per pharmacy during 1 year |

| Reference | Type of economic evaluation | Time frame | Perspective | Type of cost (pricing) | ICER or Cost Savings or Cost-Benefit Ratio or Net benefit | Author's Conclusion |
|---|---|---|---|---|---|---|
| Gallangher et.al., (2016) | cost-effectiveness analysis | 10 days | Healthcare provider | Health care costs inclucing the cost of pharmacists, physicians, senior nurses, hospital admissions, and cost of investment including software and training (Euro at 2012 prices) | SPRM/CDSS intervention was dominant compared with usual care | A software-supported structured pharmacist intervention is likely to be cost-effective even if the healthcare payer was unwilling to assign any additional finance for the prevention of ADR |
| Obreli-Neto et.al., (2015) | Cost-effectiveness analysis | 36 months | Health care service | Direct health care costs including general practitioner, pharmacist, specialist consultant, nurse, emergency visits, and drug costs (US dollars) | $53.5/QALY (ICER) | Implementing pharmacy services in older adults patients with diabetes or hypertension was affordable |
| Van der Heijden et.al., (2019) | Cost-effectiveness analysis | 12 months | Societal | Formal healthcare cost including cost of physicians, specialist consultants, physiotherapy, home care, and hospital readmission. Informal care cost including caregiver cost (Dutch unit prices) | € 8270 for improvement in DRPs (ICER) | A CMR at discharge was more expensive and only slightly more successful at reducing DRPs than usual care |
| Salari, et.al., (2022) | Cost-effectiveness analysis | 12 months | Societal | Direct costs including cost of inpatient care, outpatient care, nursing home care, and medicine. Indirect cost by calculating productivity loss of family caregiver (Swiss Francs, CHF at 2018 prices) | Potential cost savings were CHF 3'500 and a gain of 0.025 QALY per patient | Pharmacist drug review intervention was more dominant than the usual care |
| Leguelinel-Blache et.al., (2020) | Cost consequence | 6 months | Nursing home | Direct medical costs including cost of hospitalization, consultation, medical transport, and drugs (Euro at 2016 prices) | The mean total cost savings per patient was €232 | The pharmacist-led MMR reduced the iatrogenic drug risk for older adults residents and costs from the perspective of nursing home |
| Campins et.al (2019) | Cost analysis | 12 months | Healthcare | Cost of pharmacist, physician, and drugs (Euro at 2012 prices) | The average annual saving resulting was € 37.57 per patient a year | Implementing 1 € in the program would save an average of € 2.38 per patient a year (ranging from € 1.70 - 3.40) |

Abbreviations: ADR (adverse drug reactions); CHF (Swiss franc); CGAHAH (Comprehensive Geriatric Assessment Hospital At Home); CMR (Clinical medication review); DRPs (drug-related problems); ICER (Incremental Cost Effectiveness Ratio); MMR (Multidisciplinary Medication Review); MRF (Medication Review with Follow Up); MTM (Medication Therapy Management); PCCM (People-Centered Care Model); SPRM/CDSS (Structured Pharmacist Review of Medication/Clinical Decision Support Software); TWD (Taiwan New Dollar); QALY (Quality-adjusted life year).

Leguelinel-Blache et al., 2020; Salari et al., 2022; Singh et al., 2022). Pharmacist can work independently, as part of a team, or in collaboration with other health professionals.

Regarding the tools used for identifying DRPs and NOMs, 3 studies explicitly mentioned the use of STOPP/START criteria in manual form, 1 study integrated them into a clinical decision support system, and another study used Amsterdam CMR tools. For several studies, the specific tools used were not explicitly stated. Intervention and follow-up were provided for at least 2 months. Most of the studies (Jódar-Sánchez et al., 2015; Leguelinel-Blache et al., 2020; Malet-Larrea et al., 2017; Singh et al., 2022; Twigg et al., 2015; Verdoorn et al., 2021) conducted interventions and follow-ups for 6 months, while the longest follow-up time was 36 months (Obreli-Neto et al., 2015).

**Outcome**

Post-intervention outcomes in most of the included studies focused on humanistic measures such as quality of life. The majority of the elderly have one or more chronic diseases. Cure is not a possibility for some themes, however maintaining QoL is the most essential consequence of care services (Van der Linden et al., 2020). The instruments used to assess the quality of life were EQ5D (Jódar-Sánchez et al., 2015; Lin et al., 2018; Salari et al., 2022; Singh et al., 2022; Twigg et al., 2015; Verdoorn et al., 2021) and SF-6D (Kari et al., 2022). Several studies reported that there were positive differences in patients quality of life in the intervention group compared to controls (Jódar-Sánchez et al., 2015; Kari et al., 2022; Lin et al., 2018; Obreli-Neto et al., 2015; Singh et al., 2022; Twigg et al., 2015).

In addition, clinical outcomes improved significantly by pharmaceutical care implementation in two studies (Lin et al., 2018; Obreli-Neto et al., 2015). Pharmacists conducted medication reviews in older adults with multimorbidity reduced the incidence of DRP, ADR, ADE, and length of stay in another trial (Gallagher et al., 2016; Leguelinel-Blache et al., 2020; van der Heijden et al., 2019). The intervention of private consultation also resulted in a significant improvement in patients' adherence (Twigg et al., 2015; Verdoorn et al., 2021). This study aligns with another investigation that reported that pharmacists could reduce the use of healthcare services for older adults, and it agrees with the results of the prior analysis (Villeneuve et al., 2021).

**Classification of Economic Evaluations**

This study excluded model-based economic evaluations (Table IV). Cost-utility analyses using QALYs were conducted in 5 studies. Four of the studies (Jódar-Sánchez et al., 2015; Kari et al., 2022; Singh et al., 2022; Verdoorn et al., 2021) showed a negative incremental total cost, indicating that the intervention dominated the control group Meanwhile, another study showed the ICER value was slightly above the cost-effectiveness (CE) threshold (£30,000 per QALY) (Twigg et al., 2015).

The cost-benefit ratio was evaluated in 2 studies (Lin et al., 2018; Malet-Larrea et al., 2017) ranging between 1:3.53 to 1:6.2. One study focused on medication review with follow-up for older adults polypharmacy patients in a community pharmacy and showed a positive net benefit of €97.4 (at 2014 prices) (Malet-Larrea et al., 2017).

Cost-effectiveness analysis was conducted in four studies (Gallagher et al., 2016; Obreli-Neto et al., 2015; Salari et al., 2022; van der Heijden et al., 2019). Three studies indicated that pharmacist intervention in geriatric patients were affordable to implement, with or without clinical decision support software. Another study highlighted the crucial role of pharmacists in older adults healthcare due to their expertise in pharmacotherapy (Delgado-Silveira & Bermejo-Vicedo, 2021). However, 1 study showed different results, where pharmacist medication review was more expensive and slightly more successful at reducing DRPs than usual care (van der Heijden et al., 2019). Another systematic review stated that medication evaluations should be conducted as part of a clinical trial with extended follow-up (Bülow et al., 2023) (Table IV). Two studies (Leguelinel-Blache et al., 2020; Twigg et al., 2015) presented results in terms of cost savings, which compromised cost reductions attributable to clinical pharmacist intervention. Cost savings on medication ranged from € 37.57 to € 232 per patient per year. Furthermore, Campins et al., (2019) estimated saving € 37.57 (at 2012 prices) as an effect of a pharmacist intervention on the appropriateness of prescribed drugs in Spain community pharmacies. Meanwhile, interprofessional collaborations on medication review could save the medication cost to € 232 per patient in a year (at 2016 prices) (Leguelinel-Blache et al., 2020). A multicentre study reported

that during the one-year trial period, the structured medication review led to cost savings of approximately CHF 3,500 (at 2018 prices) per patient and a gain of approximately 0.025 QALYs per patient. Statistically, these results were not significant (Salari et al., 2022).

Most of these studies concluded that pharmacist intervention had a beneficial economic impact. However, one study failed to show any economic benefits as it solely assessed drug-related issues (van der Heijden et al., 2019). This review suggested that pharmacist intervention in both outpatient and inpatient settings could lead to decreased risks of adverse drug events (ADEs), shorter hospital stays, enhance clinical outcomes, improve quality of life, and cut down on medication expenditure for older adults. Another systematic review of clinical pharmacist intervention in inward pharmacy shows geriatric inpatients may benefit from an increase in the appropriateness of prescriptions, seamless care, and drug safety from the presence of ward-based pharmacist, all at a reduced cost (Bullock et al., 2019; Gallagher et al., 2014; Kiesel & Hopf, 2018). It is crucial to recognize that improvements in medication use have the potential to bring benefits not only to healthcare systems but also to the overall well-being and quality of life of older adults.

Pharmacist has drug-related specialties that can supplement the expertise of other health professionals in optimizing therapy for older adults patients. A study showed that a reorganization and more structured management of care for geriatric with multiple diseases can enhance health outcomes at an acceptable cost (Lundqvist et al., 2018). Interprofessional teamwork has a positive impact on clinical, humanistic, and economic outcomes while treating older adults patients (Kari et al., 2022; Lin et al., 2018; Singh et al., 2022; Verdoorn et al., 2021). Furthermore, as shown in a previous study, the multidisciplinary collaboration among healthcare professionals within a shared electronic medical record increased the rate of deprescribing High-Risk Medications (HRM), thereby enhancing the safety of medications for older adults (Delara et al., 2022; Deyo et al., 2020). A randomized controlled trial (RCT) conducted in Sweden reported that providing interdisciplinary comprehensive geriatric assessment to older adults patients who are acutely ill and frail for three months was more cost-effective than standard care (Ekerstad et al., 2018). It was suggested to conduct medication review regularly in older adult patients, especially for frailty or high risk patients (Elliott et al., 2020; Saeed et al., 2022). Unfortunately, there is no standard protocol for conducting medication reviews, there are several variations in different countries (Rose et al., 2020).

The adoption of a decision support system to facilitate drug review by pharmacists and alerts for doctors is recommended (Gallagher et al., 2016; O'Sullivan et al., 2014; Sutton et al., 2020). The development of automated decision support and warning systems for physicians, along with the constant assessment of drugs by pharmacists to improve drug administration, will reduce the prescription of inappropriate medications (Bobrova et al., 2022; Monteiro et al., 2019). With the prevalence of electronic patients' record systems, sophisticated computer algorithms can be implemented in the future to enhance medication use safety in geriatric patients (Damoiseaux-Volman et al., 2021; Hu et al., 2023; Maierhöfer et al., 2022; Mulder-Wildemors et al., 2020; Robert et al., 2023; Sallevelt et al., 2022). Additionally, it can have an impact on enhancing the quality of life (Ahmadi & Nopour, 2022).

There was a single study conducted on diabetic and hypertensive older adults, which highlighted the benefits of pharmacy services for geriatric patients, particularly in managing these two conditions. The study showed that pharmacy services were more cost-effective than conventional services (Obreli-Neto et al., 2015). An economic modeling study of pharmacist intervention in hypertensive patients also showed the same results (Schultz et al., 2021). Other reviews focused on type 2 diabetes patients, also documented an overall improvement in clinical outcome, medication adherence, and modification of lifestyle with various pharmacist-led interventions (Alabkal et al., 2022; Shawahna et al., 2022). Pharmacist can play an important role to help patients with chronic disease including patients support, collecting medication histories, patients education, designing care plans, identifying/resolving medication-related issues, dispensing the proper medicine, monitoring outcomes, and follow-up (Shawahna et al., 2022). Furthermore, pharmacists could participate in medication management for older adult (Abbott et al., 2020; Kwak et al., 2019).

This review emphasized the significant role pharmacists could play as part of the geriatric multidisciplinary team. Meanwhile, communication between members of geriatric teams could become a barrier to the success of interventions (Ali et al., 2022). Effective

communication on the interprofessional approach of clinical pharmacists and physicians could reduce the DRP (Zheng et al., 2022). Bidirectional communication within the interprofessional team, with mutual comprehension of each position, may enable consistent and interdependent teamwork for appropriate medication management (Babu et al., 2023). Pharmacists are highly qualified health experts who play an important role in medication management (Rodrigues et al., 2022).

The strengths include its comprehensive search strategy following the PICO framework across various databases to identify relevant studies. This review included only trial-based studies in order to provide a real overview. However, the review acknowledges the possibility that relevant studies published in languages other than English might have been overlooked, which could impact the comprehensiveness of this review. Another strength is the inclusion of all studies that involve the economic evaluation of interventions aimed at optimizing treatment outcomes in geriatric patients. By not limiting the setting of interventions by pharmacists to either the community or the hospital, the review provides a broader understanding of the pharmacist's role in geriatric care. In this study, the interventions performed by pharmacist to optimize the efficacy of therapy in geriatric patients, particularly those who receive polypharmacy were identified.

This review acknowledges several limitations in the studies included. First, the majority of studies were conducted in Europe, hence they did not accurately represent world situations. Second, there was variability in the inclusion of certain elements in calculating costs among the studies. Additionally, the design in several studies may have limited the validity of their results, and sensitivity analysis to predict uncertainty was not performed in several cases (Lin et al., 2018; Obreli-Neto et al., 2015). Evaluating the economic impact of a large-scale intervention requires further study with more precise estimates of overall intervention cost and rigorous methodology applied to economic evaluations of initiatives.

**Highlight**

It has been demonstrated that pharmacist interventions on older adult patients in both community and hospital settings provide positive outcomes. Healthcare expenditures can be reduced through pharmacist-facilitated drug reviews, physician communication, and individualized counseling, all of which improve patient outcomes and quality of life. Due to the cost component and the study perspective, the range of economic benefits resulting from pharmaceutical interventions remains vast.

## CONCLUSION

In conclusion, this systematic review highlighted that pharmacist intervention including medication review, private consultation, pharmaceutical care, and medication therapy management, in older adults with chronic disease, whether in multidisciplinary collaboration or not, had a beneficial economic impact. Future studies should aim to improve the quality of economic evaluations in this area to provide more robust evidence of the economic benefits of pharmacist intervention for older adults patients with chronic disease.

## ACKNOWLEDGMENTS

The authors thank to Educational Fund Management Institution Scholarship.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## REFERENCES

Abbott, R. A., Moore, D. A., Rogers, M., Bethel, A., Stein, K., & Coon, J. T. (2020). Effectiveness of pharmacist home visits for individuals at risk of medication-related problems: A systematic review and meta-analysis of randomised controlled trials. *BMC Health Services Research*, *20*(1). https://doi.org/10.1186/s12913-019-4728-3

Ahmadi, M., & Nopour, R. (2022). Clinical decision support system for quality of life among the elderly: an approach using artificial neural network. *BMC Medical Informatics and Decision Making*, *22*(1), 293. https://doi.org/10.1186/s12911-022-02044-9

Alabkal, R. M., Medlinskiene, K., Silcock, J., & Graham, A. (2022). Impact of pharmacist-led interventions to improve clinical outcomes for adults with type 2 diabetes at risk of developing cardiovascular disease: A systematic review and meta-analysis. *Journal of Pharmacy Practice*, *0*(0), 1–12. https://doi.org/10.1177/08971900211064459

Ali, M. U., Sherifali, D., Fitzpatrick-Lewis, D., Kenny, M., Lamarche, L., Raina, P., & Mangin, D. (2022). Interventions to address polypharmacy in older adults living with multimorbidity: Review of reviews. *Canadian Family Physician Medecin de Famille Canadien*, *68*(7), E215–E226. https://doi.org/10.46747/CFP.6807E215

Babu, D., Marotti, S., Rowett, D., Lim, R., Wisdom, A., & Kalisch Ellett, L. (2023). What is impacting clinical pharmacists' participation in an interprofessional ward round: a thematic analysis of a national survey. *Journal of Interprofessional Care*. https://doi.org/10.1080/13561820.2023.2289506

Bezerra, H. S., Brasileiro Costa, A. L., Pinto, R. S., Ernesto de Resende, P., & Martins de Freitas, G. R. (2022). Economic impact of pharmaceutical services on polymedicated patients: A systematic review. *Research in Social and Administrative Pharmacy*, *18*(9), 3492–3500. https://doi.org/https://doi.org/10.1016/j.sapharm.2022.03.005

Blum, M. R., Sallevelt, B. T. G. M., Spinewine, A., O'Mahony, D., Moutzouri, E., Feller, M., Baumgartner, C., Roumet, M., Jungo, K. T., Schwab, N., Bretagne, L., Beglinger, S., Aubert, C. E., Wilting, I., Thevelin, S., Murphy, K., Huibers, C. J. A., Clara Drenth-Van Maanen, A., Boland, B., … Rodondi, N. (2021). Optimizing therapy to Prevent Avoidable Hospital Admissions in Multimorbid Older Adults (OPERAM): Cluster randomised controlled trial. *The BMJ*, *374*, 1–13. https://doi.org/10.1136/bmj.n1585

Bobrova, V., Fialová, D., Desselle, S., Heinämäki, J., & Volmer, D. (2022). Identifying potential drug-related problems among geriatric patients with use of an integrated clinical decision support tool. *Frontiers in Pharmacology*, *13*(March), 1–10. https://doi.org/10.3389/fphar.2022.761787

Buja, A., Caberlotto, R., Pinato, C., Mafrici, S. F., Bolzonella, U., Grotto, G., Baldovin, T., Rigon, S., Toffanin, R., & Baldo, V. (2021). Health care service use and costs for a cohort of high-needs elderly diabetic patients. *Primary Care Diabetes*, *15*(2), 397–404. https://doi.org/10.1016/J.PCD.2020.12.002

Bülow, C., Clausen, S. S., Lundh, A., & Christensen, M. (2023). Medication review in hospitalised patients to reduce morbidity and mortality. *Cochrane Database of Systematic Reviews*, *2023*(1). https://doi.org/10.1002/14651858.CD008986.pub4

Campins, L., Serra-Prat, M., Palomera, E., Bolibar, I., Martínez, M. À., & Gallo, P. (2019). Reduction of pharmaceutical expenditure by a drug appropriateness intervention in polymedicated elderly subjects in Catalonia (Spain). *Gaceta Sanitaria*, *33*(2), 106–111. https://doi.org/10.1016/j.gaceta.2017.09.002

Damoiseaux-Volman, B. A., van der Velde, N., Ruige, S. G., Romijn, J. A., Abu-Hanna, A., & Medlock, S. (2021). Effect of interventions with a clinical decision support system for hospitalized older patients: systematic review mapping implementation and design factors. *JMIR Medical Informatics*, *9*(7), e28023. https://doi.org/10.2196/28023

Darmawan, E., Ahmad, H., Perwitasari, D. A., & Kusumawardani, N. (2020). Pharmacist intervention can reduce the potential use of inappropriate drugs medications in Indonesian geriatric patients. *Journal of Applied Pharmaceutical Science*, *10*(1), 88–95. https://doi.org/10.7324/JAPS.2020.101012

Delara, M., Murray, L., Jafari, B., Bahji, A., Goodarzi, Z., Kirkham, J., Chowdhury, Z., & Seitz, D. P. (2022). Prevalence and factors associated with polypharmacy: a systematic review and meta-analysis. *BMC Geriatrics 2022 22:1*, *22*(1), 1–12. https://doi.org/10.1186/S12877-022-03279-X

Deyo, J. C., Smith, B. H., Biola, H., Ferry, E. M., Orto, V. K., Patel, B., & Stillwell, T. K. (2020). Reducing high-risk medication use through pharmacist-led interventions in an outpatient setting. *Journal of the American Pharmacist Association*, e86–e92. https://doi.org/10.1016/j.japh.2020.01.013

Ekerstad, N., Karlson, B. W., Andersson, D., Husberg, M., Carlsson, P., Heintz, E., & Alwin, J. (2018). Short-term resource utilization and cost-effectiveness of comprehensive geriatric assessment in acute hospital care for severely frail elderly patients. *Journal of the American Medical Directors Association*, *19*(10), 871-878.e2.

https://doi.org/10.1016/J.JAMDA.2018.04.003

Elliott, R. A., Chan, A., Godbole, G., Hendrix, I., Pont, L. G., Sfetcopoulos, D., Woodward, J., & Munro, C. (2020). Standard of practice in geriatric medicine for pharmacy services. *Journal of Pharmacy Practice and Research*, *50*(1), 82–97. https://doi.org/10.1002/jppr.1636

Facchinetti, G., D'Angelo, D., Piredda, M., Petitti, T., Matarese, M., Oliveti, A., & De Marinis, M. G. (2020). Continuity of care interventions for preventing hospital readmission of older people with chronic diseases: A meta-analysis. *International Journal of Nursing Studies*, *101*, 103396. https://doi.org/10.1016/J.IJNURSTU.2019.103396

Gallagher, J., O'Sullivan, D., McCarthy, S., Gillespie, P., Woods, N., O'Mahony, D., & Byrne, S. (2016). Structured pharmacist review of medication in older hospitalised patients: a cost-effectiveness analysis. *Drugs & Aging*, *33*(4), 285–294. https://doi.org/10.1007/s40266-016-0348-3

Gervais, F., Novais, T., Goutelle, S., Chappuy, M., Parat, S., Cabelguenne, D., & Mouchoux, C. (2021). Drug-related problems among older patients: Analysis of 8 years of pharmacist's interventions. *Annales Pharmaceutiques Françaises*, *79*(5), 511–521. https://doi.org/10.1016/j.pharma.2021.02.002

Gunterus, A., Lopchuk, S., Dunn, C., Floyd, R., & Normandin, B. (2016). Quantitative and economic analysis of clinical pharmacist interventions during rounds in an acute care psychiatric hospital. *The Mental Health Clinician*, *6*(5), 242–247. https://doi.org/10.9740/mhc.2016.09.242

Hadia, R., Joshi, D., Bhil, D., & Maheshwari, R. (2022). Incidence of adverse drug reactions among elderly patients: A systematic review and meta-analysis. *Journal of the Scientific Society*, *49*(2), 91. https://doi.org/10.4103/jss.jss_50_22

Hoel, R. W., Giddings Connolly, R. M., & Takahashi, P. Y. (2021). Polypharmacy management in older patients. *Mayo Clinic Proceedings*, *96*(1), 242–256. https://doi.org/10.1016/j.mayocp.2020.06.012

Hu, Q., Tian, F., Jin, Z., Lin, G., Teng, F., & Xu, T. (2023). Developing a warning model of potentially inappropriate medications in older chinese outpatients in tertiary hospitals: A machine-learning study. *Journal of Clinical Medicine*, *12*(7). https://doi.org/10.3390/JCM12072619

Huibers, C. J. A., Sallevelt, B. T. G. M., Heij, J. M. J. o., O'Mahony, D., Rodondi, N., Dalleur, O., van Marum, R. J., Egberts, A. C. G., Wilting, I., & Knol, W. (2022). Hospital physicians' and older patients' agreement with individualised STOPP/START-based medication optimisation recommendations in a clinical trial setting. *European Geriatric Medicine*, *13*(3), 541–552. https://doi.org/10.1007/S41999-022-00633-5/FIGURES/5

Jódar-Sánchez, F., Malet-Larrea, A., Martín, J. J., García-Mochón, L., López del Amo, M. P., Martínez-Martínez, F., Gastelurrutia-Garralda, M. A., García-Cárdenas, V., Sabater-Hernández, D., Sáez-Benito, L., & Benrimoj, S. I. (2015). Cost-utility analysis of a medication review with follow-up service for older adults with polypharmacy in community pharmacies in spain: The conSIGUE program. *PharmacoEconomics*, *33*(6), 599–610. https://doi.org/10.1007/s40273-015-0270-2

Kari, H., Äijö-Jensen, N., Kortejärvi, H., Ronkainen, J., Yliperttula, M., Laaksonen, R., & Blom, M. (2022). Effectiveness and cost-effectiveness of a people-centred care model for community-living older people versus usual care — A randomised controlled trial. *Research in Social and Administrative Pharmacy*, *18*(6), 3004–3012. https://doi.org/10.1016/j.sapharm.2021.07.025

Kiesel, E., & Hopf, Y. (2018). Hospital pharmacists working with geriatric patients in Europe: a systematic literature review. *European Journal of Hospital Pharmacy*, *25*(e1), e74–e81. https://doi.org/10.1136/ejhpharm-2017-001239

Kini, V., & Michael Ho, P. (2018). Interventions to improve medication adherence: A review. *JAMA*, *320*(23), 2461–2473. https://doi.org/10.1001/JAMA.2018.19271

Kwak, A., Moon, Y. J., Song, Y. K., Yun, H. Y., & Kim, K. (2019). Economic impact of pharmacist-participated medication management for elderly patients in nursing homes: A systematic review. *International Journal of*

*Environmental Research and Public Health*, *16*, 2955. https://doi.org/10.3390/IJERPH16162955

Laberge, M., Sirois, C., Lunghi, C., Gaudreault, M., Nakamura, Y., Bolduc, C., & Laroche, M. L. (2021). Economic evaluations of interventions to optimize medication use in older adults with polypharmacy and multimorbidity: A systematic review. *Clinical Interventions in Aging*, *16*, 767. https://doi.org/10.2147/CIA.S304074

Langebrake, C., & Hilgarth, H. (2010). Clinical pharmacists' interventions in a German university hospital. *Pharmacy World & Science*, *32*(2), 194–199. https://doi.org/10.1007/S11096-010-9367-Z

Lankford, C., Dura, J., Tran, A., Lam, S. W., Naelitz, B., Willner, M., & Geyer, K. (2021). Effect of clinical pharmacist interventions on cost in an integrated health system specialty pharmacy. *Journal of Managed Care and Specialty Pharmacy*, *27*(3), 379–384. https://doi.org/10.18553/JMCP.2021.27.3.379

Lee, J. K., Alshehri, S., Kutbi, H. I., & Martin, J. R. (2015). Optimizing pharmacotherapy in elderly patients: the role of pharmacists. *Integrated Pharmacy Research & Practice*, *4*, 101. https://doi.org/10.2147/IPRP.S70404

Leguelinel-Blache, G., Castelli, C., Rolain, J., Bouvet, S., Chkair, S., Kabani, S., Jalabert, B., Rouvière, S., Choukroun, C., Richard, H., & Kinowski, J. M. (2020). Impact of pharmacist-led multidisciplinary medication review on the safety and medication cost of the elderly people living in a nursing home: a before-after study. *Expert Review of Pharmacoeconomics and Outcomes Research*, *20*(5), 481–490. https://doi.org/10.1080/14737167.2020.1707082

Lin, H. W., Lin, C. H., Chang, C. K., Chou, C. Y., Yu, I. W., Lin, C. C., Li, T. C., Li, C. I., & Hsieh, Y. W. (2018). Economic outcomes of pharmacist-physician medication therapy management for polypharmacy elderly: A prospective, randomized, controlled trial. *Journal of the Formosan Medical Association*, *117*(3), 235–243. https://doi.org/10.1016/j.jfma.2017.04.017

Lundqvist, M., Alwin, J., Henriksson, M., Husberg, M., Carlsson, P., & Ekdahl, A. W. (2018). Cost-effectiveness of comprehensive geriatric assessment at an ambulatory geriatric unit based on the AGe-FIT trial. *BMC Geriatrics*, *18*(1), 1–6. https://doi.org/10.1186/S12877-017-0703-1

Maierhöfer, S., Waltering, I., Jacobs, M., Würthwein, G., Appelrath, M., Koling, S., & Hempel, G. (2022). Decision support software-guided medication reviews in elderly patients with polypharmacy: a prospective analysis of routine data from community pharmacies (OPtiMed study protocol). *Journal of Pharmaceutical Policy and Practice*, *15*(1), 1–11. https://doi.org/10.1186/s40545-022-00495-z

Malakouti, S. K., Javan-Noughabi, J., Yousefzadeh, N., Rezapour, A., Mortazavi, S. S., Jahangiri, R., & Moghri, J. (2021). A Systematic review of potentially inappropriate medications use and related costs among the elderly. *Value in Health Regional Issues*, *25*, 172–179. https://doi.org/10.1016/J.VHRI.2021.05.003

Malet-Larrea, A., Goyenechea, E., Gastelurrutia, M. A., Calvo, B., García-Cárdenas, V., Cabases, J. M., Noain, A., Martínez-Martínez, F., Sabater-Hernández, D., & Benrimoj, S. I. (2017). Cost analysis and cost-benefit analysis of a medication review with follow-up service in aged polypharmacy patients. *European Journal of Health Economics*, *18*(9), 1069–1078. https://doi.org/10.1007/s10198-016-0853-7

Marcum, Z. A., Jiang, S., Bacci, J. L., & Ruppar, T. M. (2021). Pharmacist-led interventions to improve medication adherence in older adults: A meta-analysis. *Journal of the American Geriatrics Society*, *69*(11), 3301–3311. https://doi.org/10.1111/jgs.17373

Monteiro, L., Maricoto, T., Solha, I., Ribeiro-Vaz, I., Martins, C., & Monteiro-Soares, M. (2019). Reducing potentially inappropriate prescriptions for older patients using computerized decision support tools: Systematic review. *Journal of Medical Internet Research*, *21*(11), e15385. https://doi.org/10.2196/15385

Monzón-Kenneke, M., Chiang, P., Yao, N., & Greg, M. (2021). Pharmacist medication review: An integrated team approach to serve home-based primary care patients. *PLoS ONE*, *16*(5).

https://doi.org/10.1371/JOURNAL.PONE.0252151

Mucherino, S., Casula, M., Galimberti, F., Guarino, I., Olmastroni, E., Tragni, E., Orlando, V., Menditto, E., & On Behalf Of The Edu Re Drug Group. (2022). The Effectiveness of Interventions to Evaluate and Reduce Healthcare Costs of Potentially Inappropriate Prescriptions among the Older Adults: A Systematic Review. *International Journal of Environmental Research and Public Health*, *19*(11). https://doi.org/10.3390/ijerph19116724

Mulder-Wildemors, L. G. M., Heringa, M., Floor-Schreudering, A., Jansen, P. A. F., & Bouvy, M. L. (2020). Reducing inappropriate drug use in older patients by use of clinical decision support in community pharmacy: A mixed-methods evaluation. *Drugs & Aging*, *37*(2), 115–123. https://doi.org/10.1007/S40266-019-00728-Y

Nachtigall, A., Heppner, H. J., & Thürmann, P. A. (2019). Influence of pharmacist intervention on drug safety of geriatric inpatients: a prospective, controlled trial. *Therapeutic Advances in Drug Safety*, *10*, 204209861984336. https://doi.org/10.1177/2042098619843365

Nader Babaei, Y., Niazkhani, Z., Makhdoomi, K., & Esmaeili, A. (2024). Potentially inappropriate medication prescribing based on 2019 Beers criteria and the impact of pharmacist intervention in elderly patients with kidney diseases: A report from Iran. *Health Science Reports*, *7*(3), 1–9. https://doi.org/10.1002/hsr2.1894

O'Sullivan, D., O'Mahony, D., O'Connor, M. N., Gallagher, P., Cullinan, S., O'Sullivan, R., Gallagher, J., Eustace, J., & Byrne, S. (2014). The impact of a structured pharmacist intervention on the appropriateness of prescribing in older hospitalized patients. *Drugs and Aging*, *31*(6), 471–481. https://doi.org/10.1007/s40266-014-0172-6

Obreli-Neto, P. R., Marusic, S., Guidoni, C. M., Baldoni, A. de O., Renovato, R. D., Pilger, D., Cuman, R. K. N., & Pereira, L. R. L. (2015). Economic evaluation of a pharmaceutical care program for elderly diabetic and hypertensive patients in primary health care: A 36-month randomized controlled clinical trial. *Journal of Managed Care Pharmacy*, *21*(1), 66–75. https://doi.org/10.18553/jmcp.2015.21.1.66

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *The BMJ*, *372*, 2020–2021. https://doi.org/10.1136/bmj.n71

Pradhan, A., Shabaraya, A. R., Jose, C., & Professor, A. (2021). Drug Related Problems in Geriatric Patients with Inappropriate Medication Use. *International Journal of Research and Review (Ijrrjournal.Com)*, *8*(5), 487. https://doi.org/10.52403/ijrr.20210559

Rankin, A., Cadogan, C. A., Patterson, S. M., Kerse, N., Cardwell, C. R., Bradley, M. C., Ryan, C., & Hughes, C. (2018). Interventions to improve the appropriate use of polypharmacy for older people. *Cochrane Database of Systematic Reviews*, *2018*(9). https://doi.org/10.1002/14651858.CD008165.pub4

Rantsi, M., Pitkälä, K. H., Kautiainen, H., Hyttinen, V., & Kankaanpää, E. (2022). Cost-effectiveness of an educational intervention to reduce potentially inappropriate medication. *Age and Ageing*, *51*(5), 1–8. https://doi.org/10.1093/AGEING/AFAC112

Riordan, D. O., Walsh, K. A., Galvin, R., Sinnott, C., Kearney, P. M., & Byrne, S. (2016). The effect of pharmacist-led interventions in optimising prescribing in older adults in primary care: A systematic review. *SAGE Open Medicine*, *4*. https://doi.org/10.1177/2050312116652568

Robert, L., Cuvelier, E., Rousselière, C., Gautier, S., Odou, P., Beuscart, J.-B., & Décaudin, B. (2023). Detection of Drug-Related Problems through a clinical decision support system used by a clinical pharmacy team. *Healthcare*, *11*(6), 827. https://doi.org/10.3390/HEALTHCARE11060827/S1

Robinson, E. G., Hedna, K., Hakkarainen, K. M., & Gyllensten, H. (2022). Healthcare costs of adverse drug reactions and potentially inappropriate prescribing in older adults: a population-based study. *BMJ Open*, *12*(9).

https://doi.org/10.1136/BMJOPEN-2022-062589

Rodrigues, D. A., Plácido, A. I., Tavares, A. B., Azevedo, D., Mateos-Campos, R., Figueiras, A., Herdeiro, M. T., & Roque, F. (2022). Potentially inappropriate medication prescribing in older adults according to EU(7)-Potentially inappropriate medication list: A nationwide study in Portugal. *Current Therapeutic Research*, *97*, 100681. https://doi.org/10.1016/J.CURTHERES.2022.100681

Rose, O., Cheong, V. L., Dhaliwall, S., Eislage, K., Erzkamp, S., Jorgenson, D., Martínez, F., & Luetsch, K. (2020). Standards in medication review: An international perspective. *Canadian Pharmacists Journal : CPJ*, *153*(4), 215. https://doi.org/10.1177/1715163520929665

Saeed, D., Carter, G., & Parsons, C. (2022). Interventions to improve medicines optimisation in frail older patients in secondary and acute care settings: a systematic review of randomised controlled trials and non-randomised studies. *International Journal of Clinical Pharmacy*, *44*, 15–26. https://doi.org/10.1007/S11096-021-01354-8

Salari, P., OMahony, C., Henrard, S., Welsing, P., Bhadhuri, A., Schur, N., Roumet, M., Beglinger, S., Beck, T., Jungo, K. T., Byrne, S., Hossmann, S., Knol, W., OMahony, D., Spinewine, A., Rodondi, N., & Schwenkglenks, M. (2022). Cost-effectiveness of a structured medication review approach for multimorbid older adults: Within-trial analysis of the OPERAM study. *PLoS ONE*, *17*(4 April), 1–17. https://doi.org/10.1371/journal.pone.0265507

Sallevelt, B. T. G. M., Huibers, C. J. A., Heij, J. M. J. O., Egberts, T. C. G., van Puijenbroek, E. P., Shen, Z., Spruit, M. R., Jungo, K. T., Rodondi, N., Dalleur, O., Spinewine, A., Jennings, E., O'Mahony, D., Wilting, I., & Knol, W. (2022). Frequency and acceptance of clinical decision support system-generated STOPP/START signals for hospitalised older patients with polypharmacy and multimorbidity. *Drugs and Aging*, *39*(1), 59–73. https://doi.org/10.1007/s40266-021-00904-z

San-Juan-Rodriguez, A., Newman, T. V, Hernandez, I., Swart, E. C. S., Klein-Fedyshin, M., Shrank, W. H., & Parekh, N. (2018). Impact of community pharmacist-provided preventive services on clinical, utilization, and economic outcomes: An umbrella review. *Preventive Medicine*, *115*, 145–155. https://doi.org/https://doi.org/10.1016/j.ypmed.2018.08.029

Schiavo, G., Forgerini, M., Lucchetta, R. C., Silva, G. O., & Mastroianni, P. d. C. (2022). Cost of adverse drug events related to potentially inappropriate medication use: A systematic review. *Journal of the American Pharmacists Association*, *62*(5), 1463-1476.e14. https://doi.org/10.1016/J.JAPH.2022.04.008

Schultz, B. G., Tilton, J., Jun, J., Scott-Horton, T., Quach, D., & Touchette, D. R. (2021). Cost-effectiveness analysis of a pharmacist-led medication therapy management program: hypertension management. *Value in Health*, *24*(4), 522–529. https://doi.org/10.1016/j.jval.2020.10.008

Shawahna, R., Thawabi, F., Salah, R., & Ramadan, S. (2022). Pharmaceutical Care Services for Patients With Diabetes: A Systematic Scoping Review. *American Journal of Managed Care*, *28*(9), 339–346. https://doi.org/10.17605/OSF.IO/5X4GY

Shinu, C., & Dilip, C. (2020). Impact of pharmaceutical care programme on health outcome of geriatric patients. *Clinical Epidemiology and Global Health*, *8*(3), 894–898. https://doi.org/10.1016/j.cegh.2020.02.019

Singh, S., Gray, A., Shepperd, S., Stott, D. J., Ellis, G., Hemsley, A., Khanna, P., Ramsay, S., Schiff, R., Tsiachristas, A., Wilkinson, A., & Young, J. (2022). Is comprehensive geriatric assessment hospital at home a cost-effective alternative to hospital admission for older people? *Age and Ageing*, *51*(1). https://doi.org/10.1093/AGEING/AFAB220

Sinha, A., Mukherjee, S., Tripathi, S., & Dutta, S. (2021). Issues and challenges of polypharmacy in the elderly: A review of contemporary Indian literature. *Journal of Family Medicine and Primary Care*, *10*(10), 3544. https://doi.org/10.4103/JFMPC.JFMPC_2581_20

Soler, O., & Barreto, J. O. M. (2019). Community-level pharmaceutical interventions to reduce the risks of polypharmacy in the elderly: Overview of systematic reviews and economic evaluations. *Frontiers in Pharmacology*, *10*, 302. https://doi.org/10.3389/FPHAR.2019.00302/BIBTEX

Sutton, R. T., Pincock, D., Baumgart, D. C., Sadowski, D. C., Fedorak, R. N., & Kroeker, K. I. (2020). An overview of clinical decision support systems: benefits, risks, and strategies for success. *Npj Digital Medicine*, *3*(1), 1–10. https://doi.org/10.1038/s41746-020-0221-y

Twigg, M. J., Wright, D., Barton, G. R., Thornley, T., & Kerr, C. (2015). The four or more medicines (FOMM) support service: results from an evaluation of a new community pharmacy service aimed at over-65s. *The International Journal of Pharmacy Practice*, *23*(6), 407–414. https://doi.org/10.1111/ijpp.12196

Van der Heijden, A. A. W. A., de Bruijne, M. C., Nijpels, G., & Hugtenburg, J. G. (2019). Cost-effectiveness of a clinical medication review in vulnerable older patients at hospital discharge, a randomized controlled trial. *International Journal of Clinical Pharmacy*, *41*(4), 963. https://doi.org/10.1007/S11096-019-00825-3

Van der Linden, L., Hias, J., Walgraeve, K., Flamaing, J., Tournoy, J., & Spriet, I. (2020). Clinical pharmacy services in older inpatients: An evidence-based review. *Drugs and Aging*, *37*(3), 161–174. https://doi.org/10.1007/s40266-019-00733-1

Van Leeuwen K, Van Loon M, Van Nes F, Bosmans J, De Vet H, & Ket J. (2020). What does quality of life mean to older adults. In *Plos One* (Vol. 14, Issue 3). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6407786/pdf/pone.0213263.pdf

Varas-Doval, R., Saéz-Benito, L., Gastelurrutia, M. A., Benrimoj, S. I., Garcia-Cardenas, V., & Martinez-Martínez, F. (2021). Systematic review of pragmatic randomised control trials assessing the effectiveness of professional pharmacy services in community pharmacies. *BMC Health Services Research*, *21*(1), 156. https://doi.org/10.1186/s12913-021-06150-8

Verdoorn, S., van de Pol, J., Hövels, A. M., Kwint, H.-F., Blom, J. W., Gussekloo, J., & Bouvy, M. L. (2021). Cost-utility and cost-effectiveness analysis of a clinical medication review focused on personal goals in older persons with polypharmacy compared to usual care: Economic evaluation of the DREAMeR study. *British Journal of Clinical Pharmacology*, *87*(2), 588–597. https://doi.org/10.1111/bcp.14421

Viana, S. de S. C., Arantes, T., & Ribeiro, S. C. da C. (2017). Interventions of the clinical pharmacist in an Intermediate Care Unit for elderly patients. *Einstein (São Paulo)*, *15*(3), 283–288. https://doi.org/10.1590/S1679-45082017AO3894

Villeneuve, Y., Courtemanche, F., Firoozi, F., Gilbert, S., Desbiens, M.-P., Desjardins, A., Dinh, C., LeBlanc, V. C., & Attia, A. (2021). Impact of pharmacist interventions during transition of care in older adults to reduce the use of healthcare services: A scoping review. *Research in Social and Administrative Pharmacy*, *17*(8), 1361–1372. https://doi.org/https://doi.org/10.1016/j.sapharm.2020.11.006

WHO. (2012). *Good health adds life to years Policies and priority interventions for healthy ageing*. https://www.who.int/southeastasia/news/detail/01-04-2012-good-health-adds-life-to-years

WHO. (2022). *Ageing and Health*. https://www.who.int/news-room/fact-sheets/detail/ageing-and-health

Zheng, F., Wang, D., & Zhang, X. (2022). The impact of clinical pharmacist-physician communication on reducing drug-related problems: a mixed study design in a tertiary teaching Hospital in Xinjiang, China. *BMC Health Services Research*, *22*(1), 1–11. https://doi.org/10.1186/s12913-022-08505-1