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REVIEW ARTICLE

Variability in the prevalence of inappropriate medication use among older adults: A review highlighting the importance of screening methods and database types

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Aims: The global older population is growing rapidly, and the rise in polypharmacy has increased potentially inappropriate medication (PIM) encounters. PIMs pose health risks, but detecting them automatically in large medical databases is complex. This review aimed to uncover PIM prevalence in individuals aged 65 years or older using health databases and emphasized the risk of underestimating PIM prevalence due to underutilization of detection tools.

Methods: This study conducted a broad search on the Medline database to identify articles about the prevalence of PIMs in older adults using various databases. Articles published between January 2010 and June 2023 were included, and specific criteria were applied for study selection. Two literature reviews conducted before our study period were integrated to obtain a perspective from the 1990s to the present day. The selected papers were analysed for variables including database type, screening method, adaptations and PIM prevalence. The study categorized databases and original screening tools for clarity, examined adaptations and assessed concordance among different screening methods.

Results: This study encompassed 48 manuscripts, covering 58 sample evaluations. The mean prevalence of PIMs within the general population aged over 65 years was 27.8%. Relevant heterogeneity emerged in both the utilized databases and the detection methods. Adaptation of original screening tools was observed in 86.2% (50/58) of cases. Half of the original screening tools used for assessing PIMs belonged to the simple category. About a third of the studies employed less than half of the original criteria after adaptation. Only three studies used over 75% of the original criteria and more than 50 criteria.

Conclusions: This extensive review highlights PIM prevalence among the older adults, emphasizing method intricacies and the potential for underestimation due to data limitations and algorithm adjustments. The findings call for enhanced

methodologies, transparent algorithms and a deeper understanding of intricate rules' impact on public health implications.

KEYWORDS

drug prescription, inappropriate prescription, medication databases, prevalence assessment

1 | INTRODUCTION

The population of older adults increases rapidly, and projections suggest that individuals aged ≥ 65 years will constitute approximately 17% of the world's population by 2050, representing an estimated 1.6 billion individuals.¹ With the increase in life expectancy, there has been a corresponding rise in the prevalence of polypharmacy, leading to a higher likelihood of encountering potentially inappropriate medications (PIMs).² PIMs refer to suboptimal prescribing practices, encompassing overprescribing, underprescribing and misprescribing.³ The detection and mitigation of potentially inappropriate prescriptions are of paramount importance to enhance the safety and quality of medical care provided to older patients. PIMs are widely recognized as a significant public health concern as they have been linked to increased morbidity, mortality and indirect healthcare costs resulting from adverse effects and hospitalizations.^{4,5}

Medical databases, such as electronic health records and national health registries, contain a wealth of information on both patients' medical history and medications. These databases allow for the study of various public health issues, including PIMs.^{6,7} They can provide valuable insights into medication consumption and healthcare practices, enabling targeted public health interventions to prevent PIMs and improve the safety and quality of medical care for the older adults. However, effectively utilizing these databases can be challenging. To accurately detect PIMs, the databases must be well structured, ready to use by programs and contain detailed information about patients (medical history, prescribed medications, dosages and treatment durations). Furthermore, the tools for detecting PIMs, such as the Beers criteria⁸ and the Screening Tool of Older-Person's Prescriptions/Screening Tool to Action the Right Treatment (STOPP/START) (criteria,⁹ are specifically designed to identify PIMs in older individuals. These tools rely on lists of high-risk medications established by experts and are typically used for personalized and individualized care. Adapting these tools to the scale of large databases can present a significant challenge. Some of these tools may require specific information that is not always available in the databases, while variations in the criteria used can lead to discrepancies in the results obtained.

The aim of this literature review was to identify studies on the prevalence of PIMs in subjects aged over 65 years using health databases. We aimed to explore the research hypothesis that the prevalence of PIMs may be underestimated due to the possible under-use of specific detection tools.

2 | METHODS

We conducted a comprehensive search on the Medline database through PubMed (E.L. and G.K.) to find relevant articles about the prevalence of PIMs in older populations from various databases.

To ensure the rigour and transparency of our literature review, we adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.¹⁰

Our search used specific keywords, including "prevalence", "potentially inappropriate medication", "database", "cohorts", "aged" and "elderly", in combination with Medical Subject Headings (see Supporting Information). We included articles involving human subjects published from January 2010 to June 2023, excluding publication types such as editorials, letters and reviews. Our complete search strategy is available in Supporting Information Data S1. We chose to begin our study in 2010 because two earlier reviews had already covered the topic. These reviews, by Tommelein et al⁶ and Guaraldo et al,⁷ focused on inappropriate medication use in older individuals in Europe and administrative databases from 1990 to 2010, respectively. These articles offered valuable insights into inappropriate medication use in older adults and were relevant to our current study. Tommelein et al systematically reviewed potentially inappropriate prescription (PIP) across Europe, emphasizing the influence of data collection methods on prevalence rates and highlighting polypharmacy, functional status and depression as risk factors. Similarly, Guaraldo et al discussed the prevalence of PIP, with a focus on administrative databases, identifying factors such as gender, age and medication count as significant influences on PIP estimates. Their methodological rigour and pertinent findings serve as a crucial reference point, enriching the context and depth of our analysis in the contemporary landscape of PIM assessment.

2.1 | Eligibility criteria

For the eligibility criteria of the selected manuscripts, we established four major criteria: (1) the study must be observational in nature, (2) it should focus on a population aged 65 years or older, (3) it must use original screening tools for the detection of PIMs validated in the literature and (4) it should utilize comprehensive healthcare databases. We considered for inclusion only those manuscripts that were published in English. Studies that were tailored to specific disease states, such as dementia, or that concentrated solely on a single

aspect of inappropriate prescribing, for instance benzodiazepine utilization, were excluded from our analysis.

2.2 | Study selection

Two authors (R.L. and E.B.) conducted the selection of papers independently. After reviewing the titles, the following categories were excluded: case studies, studies specifically focusing on a particular drug or drug subgroup, and studies involving a specific or subgroup of disease condition. The same criteria were applied to the abstracts of the selected publications. Furthermore, guidelines and studies that did not provide estimates of inappropriateness frequency, as well as those without abstracts, were excluded. The same rigorous selection strategy (criteria and selection steps) was applied to the two chosen reviews^{6,7} to ensure the coherence and reliability of our research process.

2.3 | Screening and data extraction

We conducted a detailed assessment of each paper, examining several variables, including author, publication year, country, study period, inclusion criteria, sample size, age, database type (administrative, dispensing, insurance, primary care), screening method, original screening method contents, adaptation of the original method (yes/no), adapted method contents, number of criteria considered and the prevalence of at least one PIM as a percentage.

We applied the previously mentioned exclusion criteria to the full texts during our article review. To facilitate analysis, we categorized variables such as the database type, whether the original screening method was adapted, and the contents of both the original and adapted methods (eg, medication lists, therapeutic classes with or without considering diagnosis or prescription modalities, mixed methods combining diagnosis and prescription modalities). We also carefully examined each screening method to determine the associated criteria.

2.4 | Analysis

We analysed various aspects related to the screening of PIMs. First, we presented detailed information on each study, including the country, sample size, criteria used for detecting PIMs and the prevalence of older patients receiving at least one PIM.

2.5 | Database categorization

We classified databases into five types: administrative, dispensing, insurance, primary care and combinations. This categorization provided a comprehensive view of the database, ensuring a thorough assessment of PIM prevalence and bolstering the reliability of our findings.

The definitions of the different types of healthcare databases used in this study were:

- Administrative database: records healthcare management and billing data.
- Dispensing database: tracks medication prescription and distribution details.
- Insurance database: stores insurance policy, payment and medical claim information.
- Primary care database: centres on general practitioner visits and patient medical records.

2.6 | Method categorization

Based on our expertise in this field, we created three main categories to classify screening tools for detecting PIMs. These categories are designed to reflect the varying levels of complexity and types of data they incorporate.

- Simple screening tools. This first category includes screening tools that are considered simple, such as Healthcare Effectiveness Data and Information Set (HEDIS) or Zhan criteria. These tools focus solely on the presence of a medication in the prescription, regardless of the medical context or specific aspects of the prescription like dose and duration.
- Prescription data screening tools. The second category encompasses screening tools that consider prescription conditions (such as dose and duration) but do not take into account the medical context. Examples in this category are Priscus and The Norwegian General Practice (NORGE) criteria. These tools primarily focus on prescription data, without integrating clinical aspects.
- Complex screening tools. The third category involves screening tools that are deemed complex. They incorporate not just medication lists, but also the context of the prescription and the patient's medical context. Notable examples of this category include the STOPP/START and Beers lists. These tools provide a more comprehensive assessment by combining several relevant aspects for the identification of PIMs.

This classification of screening tools into simple, prescription data and complex categories allows us to better understand and analyse the application and effectiveness of various PIM detection tools. It also helps in determining the appropriateness of each tool, depending on the type of database available and the specific information required by each tool.

2.7 | Criteria quantification approach

The methodology for calculating the number of criteria in PIMs screening methods was systematically applied as follows. For straightforward, prescription-based methods, we counted each medication

listed as an individual criterion. This direct approach was appropriate for the simpler screening methods. Conversely, for the more complex screening methods, our approach to quantifying criteria varied. We either counted each specified medication individually or considered an entire therapeutic class as a single criterion, in alignment with the guidelines specified in the original method. This method was especially chosen to accurately capture the intricate nature of these complex screening tools, ensuring a thorough and precise analysis.

2.8 | Adaptations in screening methods

We looked at how the screening methods were adapted. This involved analysing how authors explained their modifications to the original screening method. We found that incomplete prescription data created challenges, prompting researchers to adjust the original screening tools. As a result, we categorized these adaptations into four groups: methodological choice, incomplete prescription data, incomplete medical history or a combination of these categories.

In addition to these categorizations, we further explored the reasons for adaptation by considering the congruence between the country of analysis and the origin of the PIM detection method. This approach allowed us to assess whether the methods were directly applicable or required modifications to align with regional specificities, particularly in terms of medication availability and local medical practices.

2.9 | Variability in criteria utilization

To assess the concordance among different screening methods, we conducted a concordance analysis using a categorization system based on the percentage of applied criteria and the number of criteria considered. We obtained a 3×3 matrix that allowed us to visualize and analyse the concordance among the different methods concerning their suitability for the database and their detection sensitivity.

3 | RESULTS

We initially identified 472 manuscripts. After application of selection criteria on titles, abstracts and full-text, 27 references were included. Additionally, we manually identified 71 potentially suitable manuscripts from two previous literature reviews on PIM prevalence. Out of these, 37 were found eligible for further analysis. After removing duplicates ($n = 16$), we established a final sample of 48 manuscripts, representing 58 sample evaluations on PIM prevalence (Figure 1). The difference between the number of articles and samples is due to the fact that some articles conducted multiple evaluations within the same study. These studies were conducted in 20 different countries, with the majority of samples coming from Europe (30.5%) or North America (23.4%). Table 1 presents the complete list of included manuscripts, organized by country and year of publication.

3.1 | PIM prevalence

The estimated mean prevalence of PIMs was 27.8% (95% confidence interval [CI] 25.7-29.9%). The PIM prevalence ranged from 9.4%⁴⁸ to 81.0%,⁴¹ and the sample sizes from 777 to 218 383 123 patients. Out of the 48 manuscripts, seven utilized multiple screening methods or databases to assess PIM prevalence, resulting in 58 different sample screenings.

3.2 | Type of database

The two primary database types used for the screening samples were insurance databases ($n = 18$) and administrative databases ($n = 17$) (Table 1). Dispensing databases and primary care databases represented 10 and seven of the samples, respectively. Additionally, 10% ($n = 6$) of the samples were a combination of multiple databases. Specifically, three were a combination of dispensing and primary care databases, two were a combination of administrative and dispensing databases, and one was a combination of administrative and primary care databases.

3.3 | Screening methods

Twenty distinct PIM screening methods were identified. The first category, referred to as complex screening tools, comprised 12 of the identified methods. The second category, known as the prescription data screening tools, consisted of four methods. Lastly, the third category was termed simple screening tools, comprising four distinct screening methods.

The screening methods identified predominantly drew on the Beers criteria, constituting 52% of the screening method in the studied samples: 15 were based on Beers 2003 criteria,⁵⁹ seven on Beers 1997 criteria,⁶⁰ three on Beers 2015 criteria,⁶¹ two on Beers 1991 criteria,⁶² two on Beers 2012 criteria⁶³ and one on Beers 2019 criteria.⁶⁴ Moreover, six studied samples were from the Zhan criteria,⁶⁵ which are a derivation of the Beers methods. Additionally, six methods were grounded in the STOPP/START v1 criteria from 2008,⁶⁶ while four methods were based on the PRISCUS methodology.⁶⁷ Furthermore, two methods were derived from the EU(7)-PIM method⁶⁸ and another two were based on the HEDIS criteria.⁶⁹ The remaining screening tools encompassed a diverse array of approaches, including Swedish Quality Indicators (SQIs),⁷⁰ Japan criteria,⁷¹ Laroche list,⁷² Review of potentially inappropriate Medication prescribing in seniors (REMEDI[e]S),⁷³ Maio criteria,³⁹ Matavonic criteria⁷⁴ and NORGEP- criteria.⁷⁵

3.4 | Adaptation

Out of the 58 sample screenings, only eight (13.8%) utilized the original screening method without any modifications mentioned. The

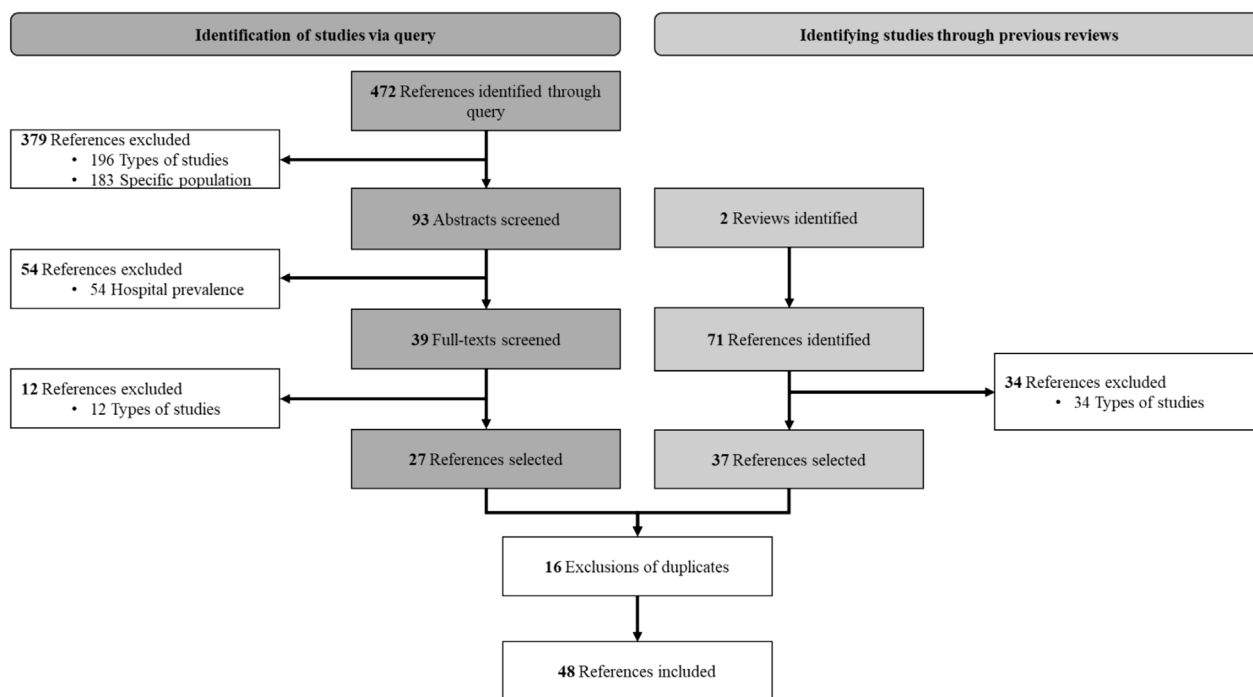


FIGURE 1 Flowchart of the literature search performed in PubMed from January 2010 to June 2023. In the end, 48 references were selected for a complete analysis.

main reason behind adapting the complex screening tools methods was the unavailability of data in the studied database. The last justification involved methodological choice and applied to eight (19.5%) screening samples. In these cases, the authors opted for methodological adaptations without providing explanations for the potential missing data.

Table 2 details the screening methods and their adaptation.

In further analysis, focusing specifically on the congruence between the screening methods' origin and the study region, we found additional reasons for adaptation. Of the 58 samples examined, 42 (72.4%) demonstrated congruence between the method's origin and the study region. Among these congruent samples, 35 were adapted for local use, reflecting regional variations in medication availability and practice. Conversely, for the 16 samples that lacked alignment between the country and the method, all were from European countries utilizing the Beers list.

3.5 | Variability in criteria utilization

The concordance analysis shows the performance of different methods for screening PIMs in terms of adequacy and detection sensitivity (Table 3). Four studies (Pugh et al,^{45,47} Carey et al²² and De Wilde et al²⁶) were excluded from the analysis because additional criteria were introduced to the original methods, not allowing the determination of the percentage of criteria.

We found that incomplete prescription data created challenges, prompting researchers to adjust the original screening tools,

evaluating 25 to 50 criteria to assess PIMs. However, 35.2% of studies applied fewer than 50% of the detection criteria, while 27.8% considered fewer than 25 criteria, potentially limiting detection sensitivity and leading to underestimations of identified PIMs. Conversely, 16.6% of studies considered over 50 criteria, indicating a comprehensive approach and enhanced sensitivity in PIM detection.

Only three studies (5.5%) applied more than 75% of the original screening tool and considered over 50 evaluation criteria, demonstrating good compliance with the reference criteria. All of them, used “insurance” type databases and original methods of prescription data screening tools (EU(7)-PIM for Selke Krulichova et al,⁵³ PRISCUS for Schubert et al⁵⁴ and Amann et al¹¹). However, these methods were adapted, and the analysis based on the data was of simple screening tools. Among the 10 screening samples with lower performance, no specific database type was identified. However, nine used original complex screening tools, and one was of simple screening tools. All of these methods were adapted, with eight as simple screening tools and two as prescription data screening tools.

4 | DISCUSSION

In our literature review, we explored the assessment of PIM prevalence in the elderly population using large databases. To the best of our knowledge, this review pioneers the discussion on data quality and methodological intricacies in detecting PIMs in epidemiological research. Our aim was to shed light on the potential risks associated

TABLE 1 Summary of the manuscripts included in the systematic review.

Authors (year published)	Country	Period studied	Sample size	Type of database	Original method	Original contents	Adaptation	Reason for adaptation	Apply contents	Criteria used (%)	Prevalence (%)
Amann et al (2012) ¹¹	Germany	2007	804 400	Insurance	PRISCUS	Prescription data	Yes	Incomplete prescription data	Simple	75/83 (90.4)	25.0
Amos et al (2015) ¹²	Italy	2012	865 324	Combination (administrative and dispensing)	Maio criteria 2011	Prescription data	No	Na	Na	26/26 (100)	27.8
Barnett et al (2006) ¹³	USA	2000-2001	VA: 123633 HMO: 157517	Administrative	Zhan criteria	Simple	Yes	Incomplete prescription data	Simple	12/33 (36.4)	21.3
Barnett et al (2011) ¹⁴	Scotland	2005-2006	65 742	Combination (dispensing and primary care)	Beers 2003	Complex	Yes	Incomplete prescription data and medical history	Simple	14/48 (29.2)	30.9
Bierman et al (2007) ¹⁵	USA	1999-2000	965 756	Administrative	Zhan criteria	Simple	No	Na	Na	33/33 (100)	24.9
Blozik et al (2013) ¹⁶	Switzerland	2008-2010	220 453	Insurance	Beers 2003	Complex	Yes	Incomplete prescription data and medical history	Complex	48/68 (70.6)	10.3
Bongue et al. ¹⁷ 2011	France	2007-2008	35 259	Insurance	Laroche list	Complex	Yes	Incomplete prescription data and medical history	Simple	20/34 (58.8)	53.5
Bradley et al. ¹⁸ 2012	Ireland	2009-2010	166 108	Combination (dispensing and primary care)	STOPP/START 2008	Complex	Yes	Methodological choices	Complex	28/87 (32.2)	34.0
Bradley et al (2014) ¹⁹	UK	2007	1 019 491	Primary care	STOPP/START 2008	Complex	Yes	Incomplete prescription data and medical history	Prescription data	52/87 (59.8)	29.0

TABLE 1 (Continued)

Authors (year published)	Country	Period studied	Sample size	Type of database	Original method	Original contents	Adaptation	Reason for adaptation	Apply contents	Criteria used (%)	Prevalence (%)
Cahir et al. ²⁰ 2010	Ireland	2007	333 801	Primary care	STOPP/ START 2008	Complex	Yes	Incomplete prescription data and medical history	Simple	28/87 (14.9)	14.9
Cahir et al. ²¹ (2014)	Ireland	2010	931	Combination (dispensing and primary care)	STOPP/ START 2008	Complex	Yes	Methodological choices	Complex	30/87 (34.5)	35.8
Carey et al. ²² (2008)	UK	2008	218 567	Primary care	Beers 2003	Complex	Yes	Incomplete prescription data and medical history	Complex and 10 drugs added	NA	28.0
Clark et al. ²³ (2020)	USA	2011-2015	218 383 123	Administrative	Beers 2019	Complex	Yes	Incomplete prescription data and medical history	Simple	33/50 (66.0)	34.4
Curtis et al. ²⁴ (2004)	USA	1999	162 370	Dispensing	Beers 2003	Complex	Yes	Methodological choices	Simple	8/63 (12.7)	21.2
Davidoff et al. ²⁵ (2015)	USA	2006-2010	18 475	Administrative	Beers 2012	Complex	Yes	Incomplete data prescription	Prescription data	36/38 (94.7)	42.6
De Wilde et al. ²⁶ (2007)	UK	2003	171 690	Primary care	Beers 2003	Complex	Yes	Incomplete prescription data	Complex and 10 drugs added	NA	32.2
Fick et al. ²⁷ (2008)	USA	2000	16 877	Administrative	Beers 2003	Complex	Yes	Incomplete medical history	Prescription data	48/68 (70.6)	40.7
Fujie et al. ²⁸ (2020)	Japan	2015	8080	Dispensing	Japan criteria 2015	Complex	Yes	Incomplete prescription data	Simple	11/27 (40.7)	26.7
	USA	1993	10 076	Administrative	Beers 1991	Complex	Yes	Methodological choices	Simple	20/30 (66.7)	12.8

(Continues)

TABLE 1 (Continued)

Authors (year published)	Country	Period studied	Sample size	Type of database	Original method	Original contents	Adaptation	Reason for adaptation	Apply contents	Criteria used (%)	Prevalence (%)
Futterman et al (1997) ²⁹		1994	10 076	Administrative	Beers 1991	Complex	Yes	Methodological choices	Simple	20/30 (66.7)	11.5
Grina and Briedis et al (2017) ³⁰	Lithuania	2015	431 625	Insurance	EU(7)-PIM	Prescription data	Yes	Incomplete prescription data	Prescription data	78/282 (27.7)	57.2
					Beers 2015	Complex	Yes	Incomplete medical history	Prescription data	36/136 (27.2)	24.1
					Beers 2003	Complex	Yes	Incomplete medical history	Prescription data	15/82 (18.3)	25.9
Goltz et al (2012) ³¹	Germany	2004	542 426	Insurance	Beers 2003	Complex	Yes	Incomplete medical history	Prescription data	43/68 (36.5)	18.2
Hedna et al (2015) ³²	Sweden	2008	813	Combination (administrative and dispensing)	STOPP/START 2008	Complex	Yes	Methodological choices	Complex	65/87 (74.2)	46.0
Howard et al (2004) ³³	Canada	1999-2000	777	Combination (administrative and primary care)	Beers 1997	Complex	Yes	Methodological choices	Prescription data	17/43 (39.5)	16.3
Johnell et al (2007) ³⁴	Sweden	2005	732 228	Dispensing	SQIs	Simple	No	Na	Na	4/4 (100)	16.5
Lai et al (2009) ³⁵	Taiwan	2001-2004	176 661 994	Administrative	Beers 2003	Complex	Yes	Incomplete prescription data and medical history	Complex	43/68 (36.5)	19.1
Leikola et al (2011) ³⁶	Finland	2007	841 509	Insurance	Beers 2003	Complex	Yes	Incomplete prescription data and medical history	Simple	20/68 (29.4)	14.7
Lund et al (2015) ³⁷	USA	2011	1 360 251	Administrative	HEDIS 2015	Simple	No	Na	Na	50/50 (100)	12.3

TABLE 1 (Continued)

Authors (year published)	Country	Period studied	Sample size	Type of database	Original method	Original contents	Adaptation	Reason for adaptation	Apply contents	Criteria used (%)	Prevalence (%)
Maio et al (2006) ³⁸	Italy	2001	849 425	Dispensing	Beers 2003	Complex	Yes	Incomplete prescription data and medical history	Simple	19/68 (27.9)	18.0
Maio et al (2010) ³⁹	Italy	2006	91 741	Primary care	Beers 2003	Complex	Yes	Incomplete prescription data and medical history	Simple	22/68 (32.4)	25.8
Mott et al (2000) ⁴⁰	USA	1996	1185	Dispensing	Beers 1997	Complex	Yes	Incomplete medical history	Complex	28/43 (65.1)	14.3
Nam et al (2016) ⁴¹	Korea	2009-2011	523 811	Insurance	Beers 2012	Complex	Yes	Incomplete medical history	Prescription data	27/38 (71.1)	81.0
Nyborg et al (2012) ⁴²	Norway	2008	445 900	Dispensing	NORGEP-criteria	Prescription data	No	Na	Na	36/36 (100)	34.8
Piccoro et al (2000) ⁴³	USA	1996	64 832	Dispensing	Beers 1997	Complex	Yes	Incomplete prescription data	Simple	25/43 (58.1)	27.0
Popović et al (2014) ⁴⁴	Croatia	2010	29 418	Insurance	Matavonic criteria 2012	Complex	Yes	Incomplete prescription data	Complex	33/138 (23.9)	62.4
Pugh et al (2005) ⁴⁵	USA	2000	1 265 434	Administrative	Zhan criteria	Simple	Yes	Add new criteria	Prescription data	33/33 (100), 7 criteria added	23
Pugh et al (2006) ⁴⁶	USA	2000	1 096 361	Administrative	HEDIS 2006	Simple	No	Na	Na	42/42 (100)	19.6
Pugh et al (2008) ⁴⁷	USA	1999-2000	850 514	Administrative	Zhan criteria	Simple	Yes	Add new criteria	Prescription data	33/33 (100), 7 criteria added	26.2

(Continues)

TABLE 1 (Continued)

Authors (year published)	Country	Period studied	Sample size	Type of database	Original method	Original contents	Adaptation	Reason for adaptation	Apply contents	Criteria used (%)	Prevalence (%)
Reich et al (2014) ⁴⁸	Switzerland	2008-2012	49 668	Insurance	Beers 2003	Complex	Yes	Incomplete prescription data and medical history	Prescription data	48/68 (70.6)	9.4
Rigler et al (2004) ⁴⁹	USA	2000-2001	A: 11163	Administrative	Beers 1997	Complex	Yes	Incomplete prescription data and medical history	Simple	25/43 (58.1)	21
			FE: 858	Administrative	Beers 1997	Complex	Yes	Incomplete prescription data and medical history	Simple	25/43 (58.1)	48
			NF: 1185	Administrative	Beers 1997	Complex	Yes	Incomplete prescription data and medical history	Simple	25/43 (58.1)	38
Roughhead et al (2007) ⁵⁰	Australia	2005	192 363	Dispensing	Beers 2003 and McLeod et al 1997	Complex	Yes	Incomplete prescription data and medical history	Simple	26/68 (38.2)	21.2
Roux et al (2020) ⁵¹	Canada	2014-2016	1 105 295	Administrative	Beers 2015	Complex	Yes	Incomplete prescription data and medical history	Simple	6/45 (13.3)	48.3
Roux et al (2022) ⁵²	France	2017	101 428	Administrative	REMEDIS	Complex	Yes	Incomplete prescription data and medical history	Prescription data	62/104 (59.6)	56.7

TABLE 1 (Continued)

Authors (year published)	Country	Period studied	Sample size	Type of database	Original method	Original contents	Adaptation	Reason for adaptation	Apply contents	Criteria used (%)	Prevalence (%)
Selke Krulichova et al (2021) ⁵³	Germany	2019	6 000 000	Insurance	EU(7)-PIM	Prescription data	Yes	Incomplete data prescription	Simple	236/282 (83.7)	45.1
Schubert et al (2013) ⁵⁴	Germany	2010	16 535	Insurance	PRISCUS	Prescription data	Yes	Incomplete prescription data	Simple	73/83 (88.0)	22.0
Simon et al (2005) ⁵⁵	USA	2000-2001	157 517	Dispensing	Beers 1997 but Zhan criteria used	Simple	Yes	Zhan criteria used	Simple	33/33 (100)	28.8
Su et al (2022) ⁵⁶	China	2016	506 214	Insurance	Beers 2015	Complex	Yes	Incomplete prescription data and medical history	Complex	41/45 (91.1)	38.1
van der Hooff et al (2005) ⁵⁷	The Netherlands	1997-2001	25 258	Primary care	Beers 1997	Complex	Yes	Incomplete prescription data	Complex	32/43 (74.4)	18.5
Zuckerman et al (2006) ⁵⁸	USA	2000-2001-2002	487 383	Insurance	Beers 2003	Complex	Yes	Incomplete prescription data	Complex	43/68 (63.2)	20.0
	USA	2000-2001-2002	487 383	Insurance	Beers 2003	Complex	Yes	Incomplete prescription data	Prescription data	48/68 (70.6)	41.9

Simple: screening tools focusing only on a medication list. Prescription data: screening tools considering prescription details as dose or duration. Complex: screening tools evaluating medication list, prescription details and medical context. For the "Criteria used" variable (%), we made a decision not to consider the percentage when authors added criteria. This choice was made to prevent any potential bias in the number of criteria considered in our analysis.

Abbreviations: A, ambulatory; FE, frail elderly; HMO, health maintenance organization; Na, Not applicable; NF, nursing facility; VA, veterans affairs.

TABLE 2 Comparison of screening methods and their application.

Original screening method	n (%)	Adaptation (%)	Reason for adaptation	n (% of adaptation)	Apply contents	n (%)			
Complex	41 (70.7)	41 (100)	Incomplete medical history	6 (14.6)	Simple	0 (0)			
					Prescription data	6 (100)			
					Complex	0 (0)			
					Simple	2 (25.0)			
			Incomplete prescription data	8 (19.5)				Prescription data	3 (37.5)
								Complex	3 (35.5)
								Simple	12 (63.2)
								Prescription data	5 (26.3)
			Incomplete medical history and Incomplete prescription data	19 (46.4)				Complex	2 (10.5)
								Simple	3 (37.5)
								Prescription data	1 (12.5)
								Complex	4 (50.0)
Methodological choice	8 (19.5)				Simple	5 (62.5)			
					Prescription data	3 (37.5)			
					Complex	0 (0)			
					Complex	0 (0)			
Prescription data	8 (13.8)	6 (75.0)	Incomplete prescription data	6 (100)	Simple	7 (77.8)			
					Prescription data	0 (0)			
					Complex	0 (0)			
Simple	9 (15.5)	3 (33.3)	Incomplete prescription data	1 (33.3)	Simple	0 (0)			
					Prescription data	2 (22.2)			
			Add new criteria	2 (66.7)				Simple	0 (0)
								Prescription data	0 (0)
								Complex	0 (0)

	% criteria apply			Total	
	<50%	50%-75%	>75%		
Number of criteria apply	<25	10	3	2	15
	25-50	8	14	8	30
	>50	1	5	3	9
	Total	19	22	13	54

TABLE 3 Concordance analysis of screening methods.

% criteria apply: corresponds to the percentage of estimated criteria applied to the sample studied.

with underestimating PIM prevalence due to the limited use of specific detection tools.

4.1 | PIM prevalence

The wide range of PIM prevalence rates, spanning from 9.4% to 81.0%, underscores significant variability among the studied populations. This variability prompts questions about the alignment between detection tools and the databases they draw from. Our findings align with similar reviews by Shade et al,⁷⁶ Hill-Taylor et al,⁷⁷ Tommelein et al⁶ and Guaraldo et al,⁷ reinforcing the reliability of our results in the broader research context. This supporting evidence strengthens the credibility of our hypothesis and emphasizes the need for further exploration in this field to

comprehensively understand inappropriate prescriptions among older adults.

4.2 | Diversity in databases

Databases play a pivotal role in epidemiology, offering a distinctive perspective into extensive health trends.⁷⁸ Our exploration of the diverse and intricate databases employed in this study has accentuated the challenges tied to their reuse for identifying PIMs in older patients—an observation previously substantiated in other studies.^{79,80} We leveraged insurance, administrative, dispensing and primary care databases, reflecting the breadth of information sources available. However, missing data within these databases or the necessity of adapting detection tools often introduced complexities into the

reuse process, particularly in complex and prescription data-screening tools. This underscores the importance of considering database limitations when using them for analysis.

Our review of various databases underscores the need for careful selection and usage in PIM detection studies. We observed that while “big data General Practitioner (GP) networks” theoretically offer the most comprehensive clinical data, other databases, such as insurance and administrative ones, although valuable, often lack over-the-counter (OTC) medication information and detailed prescribing data (dose and duration). This highlights the criticality of assessing the completeness and relevance of available data in these databases, especially when implementing complex and prescription data-screening tools.

4.3 | Method adaptations

Our review is the first to explore adaptations in evaluating inappropriate medications, reflecting the complexity of this evaluation, considering medical context and prescription conditions. While complex methods suit clinical practice, adapting them for large-scale use with extensive datasets is crucial. Eight studies (13.8%) used unadapted screening methods, while the majority (50 out of 58) required adjustments to align with database requirements or patients' medical context. The prevalence (86.2%) of adaptations toward explicit detection methods highlights the challenges posed by complex rules with multiple parameters. This underscores the need for adaptable detection methods to accurately capture data variability and prescription conditions, preventing underestimation of PIM prevalence. The importance of adaptations to account for missing data or database intricacies emphasizes the need for caution when reusing such data. Complexed detection methods, while suitable for clinical use, often require adjustments for large datasets. Overall, the prevalence of necessary adaptations underscores the complexity of rules and the necessity for more versatile approaches in assessing PIM prevalence. The lack of adaptation details in eight studies raises questions about result interpretation, affecting transparency and reproducibility.

Our analysis further extends these observations by examining the congruence between the screening method's origin and the country of application. This examination revealed a notable alignment in most of the cases. However, the necessity to adapt the Beers list in European contexts illustrates the crucial need for region-specific approaches in PIM detection. The observed discrepancy in some EU countries, due to the unavailability of certain medications listed in the Beers criteria, emphasizes the dynamic nature of medication availability and underscores the importance of contextually tailored screening tools. These findings highlight the need for adaptable and flexible methodologies that can accommodate variations in healthcare practices and medication availability across different regions. Such adaptability is vital to ensure the relevance and accuracy of PIM detection in various healthcare settings.

4.4 | Resource optimisation

Our review undertook an exhaustive evaluation to determine the optimal synergy between database types and screening tool types to heighten the detection of PIMs. Scrutinizing data from diverse studies, we unveiled a nuanced interplay between these factors influencing PIM detection efficacy. Studies demonstrating exceptional performance often leveraged “insurance” type databases and original complex type screening tools, even when adapted for prescription data screening tools analysis. This convergence points to the efficacy of databases rich in medical insights and screening tools attuned to interdependencies among medications. Conversely, methods yielding less satisfactory outcomes frequently employed original complex type screening tools, implying that while these methods incorporate diverse criteria, they may lack sensitivity in PIM detection. It is important to acknowledge that method adaptations, irrespective of their type, significantly contribute to reducing performance. Hence, aligning database attributes, screening tool types and methodological adjustments becomes paramount for optimal PIM detection outcomes. These insights offer direction for future research, facilitating the development of more precise and sensitive methods for screening PIMs and enhancing the care of older patients.

4.5 | Detection tools adapted for clinical use

Taking into account the information presented in this study, it is important to recognize that the development of PIM lists involves a balance between clinical perspectives and epidemiological data. Although these lists are primarily designed for clinical application, the underlying decisions are significantly informed by epidemiological insights. Clinical studies tend to report higher PIM prevalence rates (36.7%, 95% CI 33.4-40.0%) compared to database-driven studies, underscoring the potential for tools to be under-assessed.⁸¹ While these detection tools find utility in healthcare practice and individual patient care, their adaptation to large cohorts presents formidable challenges. Consequently, the lists generated are not always seamlessly compatible with the diverse formats of healthcare databases.

4.6 | Limitations

Our literature search was not exhaustive, focusing solely on Medline, but we augmented it by incorporating references from two other reviews. Medline's rigorous journal evaluation enhances our confidence that any missed studies are unlikely to have superior methodologies for determining PIM prevalence.

Although this is not a systematic review due to the limitation of analysing only one database, the conclusions drawn are of significant interest to the discipline. The inclusion of additional articles is unlikely to substantially alter our results, reinforcing the relevance and potential impact of our findings in the field.

In addition, we relied on databases and detection methods from the studies we included, potentially introducing biases. Variations in sample characteristics, detection criteria and method adaptations present challenges in study comparisons. Incorporating longitudinal data and recent criteria could provide a more nuanced understanding of evolving potentially inappropriate prescriptions over time.

A critical aspect highlighted by this study is the limitations of databases regarding information on OTC medications, prescription details and clinical data. This research has revealed that using PIM screening tools in incomplete databases could lead to inaccurate evaluations. It is vital to recognize that when key information is missing, the application of certain screening criteria becomes inappropriate. This limitation underscores the need to develop adaptive screening tools that consider the specificities of each database. In our future research, we plan to explore strategies to enhance the adaptability and accuracy of screening tools, considering the constraints and availability of data in various healthcare settings.

4.7 | Perspective

Our study highlights a significant gap between the detection tools used to assess potentially inappropriate prescriptions and the complexity of healthcare databases. This mismatch presents a critical challenge: how to improve the alignment between these two elements to obtain more precise estimates within the context of epidemiological studies. To address this task, several perspectives are available to us. On one hand, it is conceivable to develop advanced technologies, such as ontologies or complex algorithms, which could better adapt to the diversity of medical data and prescribing practices. On the other hand, a more specific approach could involve crafting customized detection methods designed to precisely align with the particular characteristics of a given study database. Ultimately, the goal is to enhance the relevance and accuracy of epidemiological analyses while ensuring that the tools used closely correspond to the complex and varied nature of healthcare data. This offers promising prospects for advancing research in this critical field.

5 | CONCLUSION

In summary, our findings underscore the necessity for more rigorous methodologies, enhanced data integrity and greater transparency in the algorithms used for assessing the prevalence of PIMs in the older adult population. It is crucial to develop these aspects to gain a complete understanding of PIM prevalence and its implications for health outcomes.

AUTHOR CONTRIBUTIONS

This research benefited from the expertise and dedication of several collaborators. R. Léguillon initiated the project by proposing the original idea and conducting the literature review, which laid the foundation for our study. J. Grosjean, J. Charlet and M.-L. Laroche provided

guidance and supervision for the project. Their strategic direction was crucial in defining the research objectives and ensuring alignment with academic standards. Additionally, M.-L. Laroche contributed specific expertise in the research field, significantly enriching the project. F. Roca played a key role in the methodological consolidation of our study, offering critical review and advice to strengthen our approach. E. Barat conducted a second screening of the articles included in the literature review, ensuring a rigorous and relevant selection of sources. R. Varin and S. J. Darmoni contributed through their meticulous review, providing corrections and valuable suggestions to enhance the overall quality of the manuscript. E. Lejeune and G. Kerdelhué assisted the team with the bibliographic research methodology, facilitating access to relevant sources and the organization of the literature review.

DATA AVAILABILITY STATEMENT

The data that supports the findings of this study are available in the supplementary material of this article

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CONFLICT OF INTEREST STATEMENT

None.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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