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The changing face of Australian data reforms: impact on pharmacoepidemiology research

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Abstract

Objective
A wealth of data is generated through Australia's universal health care arrangements. However, use of these data has been hampered by different federal and state legislation, privacy concerns and challenges in linking data across jurisdictions. A series of data reforms have been touted to increase population health research capacity in Australia, including pharmacoepidemiology research. Here we catalogued research leveraging Australia's Pharmaceutical Benefits Scheme (PBS) data (2014–2018) and discussed these outputs in the context of previously implemented and new data reforms.

Methods
We conducted a systematic review of population-based studies using PBS dispensing claims. Independent reviewers screened abstracts of 4,996 articles and 310 full-text manuscripts. We characterised publications according to study population, analytical approach, data sources used, aims and medicines focus.

Results
We identified 180 studies; 133 used individual-level data, 70 linked PBS dispensing claims with other health data (66 across jurisdictions). Studies using individual-level data focussed on Australians receiving government benefits (87 studies) rather than all PBS-eligible persons. 63 studies examined clinician or patient practices and 33 examined exposure-outcome relationships (27 evaluated medicines safety, 6 evaluated effectiveness). Medicines acting on the nervous and cardiovascular system account for the greatest volume of PBS medicines dispensed and were the most commonly studied (67 and 40 studies, respectively). Antineoplastic and immunomodulating agents account for approximately one third of PBS expenditure but represented only 10% of studies in this review.

Conclusions
The studies in this review represent more than a third of all population-based pharmacoepidemiology research published in the last three decades in Australia. Recent data reforms have contributed to this escalating output. However, studies are concentrated among specific subpopulations and medicines classes, and there remains a limited understanding of population benefits and harms derived from medicines use. The current draft Data Availability and Transparency legislation should further bolster efforts in population health research.

Keywords
medical record linkage; drug prescriptions; observational study; pharmacoepidemiology

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Highlights

- Australia has the potential to undertake whole-of-health care and whole-of-population research using data from its universal health care system.
- Reforms related to data availability and use in Australia have facilitated linkage of Australian Government and state health data, such as the Pharmaceutical Benefits Scheme (PBS) dispensing claims, hospitalisations, and deaths.
- Encouragingly, in the past 5 years research output in population-based pharmacoepidemiology research increased substantially. The studies catalogued in this review represent more than a third of all population-based pharmacoepidemiology studies published in the last 30 years in Australia.
- The majority of studies published in recent years used individual-level data (n = 133), 70 linked PBS dispensing claims with other health data (66 across jurisdictions). Evidence derived from these studies is concentrated among subpopulations and on medicines acting on the nervous system and cardiovascular system.
- There is still very limited evidence on the real-world safety and effectiveness of medicines in Australia.
- New legislative reform, particularly the Data Availability and Transparency Act will be formalised in the near future and will accelerate population-based research efforts in Australia, including pharmacoepidemiology.

Introduction

Worldwide population-based health administrative data are being mobilised to evaluate the quality and outcomes of care. The data collected through Australia's universal health care arrangements have the potential to advance knowledge in population health and generate timely, comprehensive clinical and policy insights. However, population-based research has been hampered by the heterogeneity in legislation, regulations and guidelines at national and state levels plus privacy concerns and the ability to link person-level data across jurisdictional boundaries [1].

The Western Australia Data Linkage System pioneered cross-jurisdictional data linkage in the late 90s, supporting a broad range of population-based research [2–6]. However, it wasn't until the mid-2000s that key initiatives enhanced the entire country's capability to leverage population-based health data for research. These include the establishment of: Australian Government approved Integrating Authorities that probabilistically link person-level data across jurisdictional boundaries (using best-practice privacy preserving protocols); and data safe havens where sensitive data can be accessed and analysed by approved researchers [7]. More recently, the 2017 Australian Productivity Commission's Data Availability and Use inquiry recommended sweeping reform to drive efficiency, safety and support decision-making [1]. The Federal government's response to the Inquiry [8] led to the establishment of the Office of the National Data Commissioner (ONDC) and the development of a legislative package to streamline the sharing of government data for service provision, policy evaluation and research, while preserving strict data privacy and confidentiality provisions. Together, these initiatives are expected to bolster Australian population health research, including the field of pharmacoepidemiology, the foundation of medicines policy research.

In Australia, it is estimated that more than 27 million individual Pharmaceutical Benefits Scheme (PBS) prescriptions are in use on any given day; more than nine million people are taking at least one prescribed medicine daily and two million are taking five or more daily [9]. PBS data linked to other administrative claims are a powerful tool to examine real-world medicines use, safety, effectiveness, and value for money in populations not typically represented in clinical trials [10, 11]. Importantly, to assess these outcomes, PBS data, under the custodianship of the Australian Government, needs to be linked at the individual-level with outcomes data such as hospitalisations, which are under the custodianship of the States and Territories. This situation has led researchers in this field to rely on publicly available aggregated data and/or stand-alone, bespoke data collections with individual-level data as the primary sources for evidence generation [1].

Our previous systematic review of population-based research leveraging PBS data over a 25 year period to 2013, documented relatively few published studies, especially compared to the pharmacoepidemiology output in the Nordic countries over a period of six years (228 versus 515 studies) [12]. We also demonstrated that output had increased substantially from 2007 to 2013, pointing to the benefits of infrastructure development in the mid-2000s and the use of Department of Veterans Affair's data collections (DVA). As a single payer, the DVA has data on a broad range of health services used by their clients that can be leveraged for quality use of medicines and outcomes research. However, we also highlighted significant blind spots in our understanding of medicine use and outcomes in Australia. In particular, we reported a paucity of published literature examining specific population sub-groups (including children and pregnant women), specific medicines (including high-cost therapies prescribed by specialists) and studies linking individual-level medicines exposure and outcomes to quantify benefits and harms [13].

Here we catalogue contemporary population-based medicines policy research leveraging Australia's PBS and other data in the period 2014–2018 and discuss these outputs in the context of Australia's data reforms.

Methods

Setting and data of interest

Australia has a universal health care system providing access to subsidised prescription medicines to citizens and eligible residents and clients of the DVA via the PBS and the Repatriation Pharmaceutical Benefits Scheme (RPBS), respectively. People contribute a co-payment towards the cost of their medicines, which varies depending on their

entitlements. Our review focusses on studies using routinely collected data on medicines dispensed through PBS and RPBS. These dispensing claims are processed by Services Australia (previously the Department of Human Services and Medicare Australia) and are provided to the Australian Government Department of Health and the DVA for monitoring, evaluation, and health service planning. These data are available to third parties, publicly or by request, for monitoring, evaluation, and research (see Supplementary Table 1).

Study identification

We searched Medline and Embase from January 2013 through December 2018 using a combination of keywords and search terms describing medicines use (e.g. prescription drugs, drug therapy, drug utilisation) with PBS dispensing data sources (see Supplementary Appendix A for search strategy). We also conducted searches on key researchers in the field of medicines policy research in Australia and screened the reference lists of all included studies (Figure 1).

Study eligibility criteria

We included full-text English-language studies using PBS and/or RPBS dispensing claims data to measure patterns of medicines use or using medicines as a proxy of a health condition or an outcome. We excluded studies: focussing exclusively on medicine expenditure or modelling; using dispensing data obtained directly from pharmacies; requiring individual informed consent to access dispensing data; or using data derived from state-based registries.

Study selection and data extraction

Two reviewers (CB, SP) screened a random 20% sample of titles and abstracts independently to identify potentially relevant studies for inclusion; one reviewer (CB) screened the remainder. Two reviewers (JOC, CB) extracted data independently from all included studies and disagreements were resolved by discussion. We extracted the following key features of each study (Box 1):

Classification of studies

We classified the broad study focus into six themes; (1) Medicine utilisation: examined trends and patterns of dispensing overall or stratified by gender, age, and medicine or additional variables; (2) Clinician practices: used individual-level data to study prescribing patterns (e.g. concomitant or inappropriate prescribing); (3) Patient practices: used individual-level data to examine patient behaviour around medicines use, such as medicine persistence or adherence; (4) Exposure and outcomes: 4A) investigated the relationship between medicine use and at least one outcome, such as death or hospital admission ('medicine use and outcomes'), OR 4B) investigated the relationship between other exposures (e.g. device use) and at least one outcome but used dispensing claims to define a cohort, comorbidities or an outcome ('other exposure and outcomes'); (5) Intervention impacts: examined the effect of one or more population-level interventions on prescribing or another outcome, classified as educational (e.g. prescriber feedback and education), policy (e.g. subsidy changes and restrictions), media (e.g. advertising campaigns), or multi-faceted (combination of the above); (6) Methods: used dispensing data to develop and refine pharmacoepidemiological techniques (e.g. validation of prescribing indicators) or study protocols reporting data based on dispensing claims.

Medicines focus of studies

We assigned WHO Anatomical Therapeutic Chemical (ATC) classifications to the medicine focus of each study [14]. We also report the proportion of studies according to their medicine focus relative to the proportion of PBS volume and spend for these classes by ATC code.

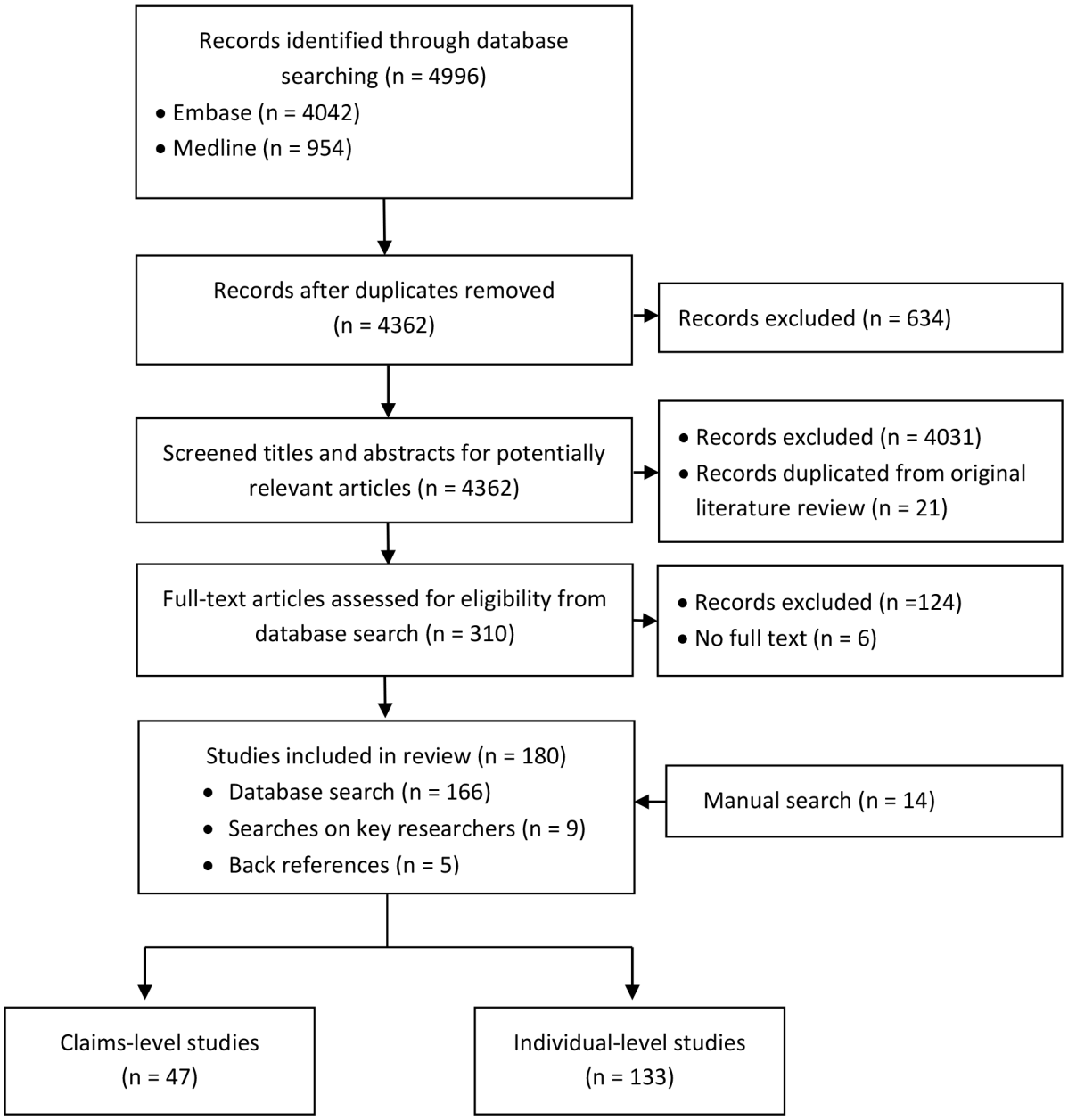
Reporting

Due to the heterogeneity of study methodology, we did not assess individual study quality. However, we extracted 23 items pertaining to the REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) checklist [15] to describe areas of underreporting. Two reviewers (JOC, CB) independently reviewed all articles published in the most recent year (2018); disagreements in extraction were resolved by discussion. For each item (see

Box 1: Features extracted from included studies

Study characteristics	Publication year, journal, study aims, funding source, and setting
Study period	Difference between the earliest and latest month and year of observation
Publication lag	The earliest month and year of publication minus last month and year of study observation
Age profile of study population	No age restrictions (entire eligible population), elderly ($\geq$ 65 years), adults ($\geq$ 18 years), women of childbearing age, or children
Beneficiary status of study population	All PBS beneficiaries, people receiving government benefits and eligible to pay lower PBS co-payments (concessional beneficiaries) or clients of the DVA
Analytical approach	Individual-level studies (track patients and/or providers over time) or claims-level studies. Studies using both approaches were classified as 'individual-level'
Data source(s)	Primary dispensing claims dataset (e.g. PBS 10% sample, RPBS data), geographic coverage (e.g. national or state level), the inclusion of other dispensing claims or data sources and individual-level linkage to other data sources.

Figure 1: Identification of studies included in the systematic review



Supplementary Appendix B) we allocated a score of 1 if studies reported the item. As some items were not applicable for some studies, we calculated the RECORD score as the percentage of items meeting the criteria in relation to the overall applicable items for each study.

We report the results of this review according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [16].

Results

We identified 4,996 studies through electronic searches and 14 through manual searches. After excluding duplicate records, we screened titles and abstracts of 4,362 articles and assessed 310 full-text manuscripts for eligibility. This review included 180 eligible studies (Figure 1) (see Supplementary Appendix C for the bibliography of included studies and Supplementary Appendix D for details of study features).

Study characteristics (Table 1 and Supplementary Figure 1)

We observed a steady increase in the number of studies published annually and a sharp rise in 2018; this last observation year accounting for nearly one-third of all studies published in the period. Most studies used individual-level data (133 studies, 74%). The time between the study observation end date and publication was up to 2-years for 58% of studies; 16% of studies had a publication lag of more than 5 years. The median lag time for claims-level studies was 29 months and for individual-level studies, 34 months.

Age profile and beneficiary status of the study population (Table 1)

Approximately half of the 180 studies did not place age restrictions on their study cohorts (91 studies, 51%). The remaining studies restricted cohorts to people aged 65 years or older (55 studies, 31%) or people aged 18 years or older (26 studies, 14%). Five studies focussed on women of childbearing age and two on children. Approximately half of the studies restricted their populations to concessional beneficiaries or DVA clients (91 studies, 51%). Approximately 90% of studies using claims-level analyses used the entire PBS-eligible population. In contrast, approximately 65% of studies using individual-level analyses restricted their cohorts to the elderly, DVA clients or concessional beneficiaries.

Data sources (Table 1, Figure 2)

Approximately two-thirds of studies leveraged dispensing claims and other health data (118 studies, 66%). Approximately 20% of studies used publicly available dispensing claims and 78% used data available by request, with a marked increase in the use of the PBS 10% sample and PBS ad hoc extracts over time.

Two-thirds of claims-level studies used publicly available data; 62% of these also included other unlinked health data. Individual-level studies used RPBS data (42%), the PBS 10% sample (29%) or ad hoc data extracts (22%). These individual-level studies were Australian-wide or restricted to residents of Western Australia and/or New South Wales. Seventy of these studies linked individual-level dispensing claims to other health data such as hospitalisation data, medical services claims, residential aged care claims, emergency department data, or cancer and perinatal registries; 66 were linked across jurisdictions (data not shown in table).

Study focus (Table 1 and Figure 3)

Approximately one-third of all studies used individual-level data to examine clinician or patient practices (47 and 16 studies, respectively). Individual and claims-level exposure-outcomes studies accounted for 21% of all studies, 27 of the 38 studies evaluated medicine safety and 6 evaluated medicine effectiveness. One-fifth of all studies used claim-level data to investigate medicine utilisation (36 studies); methodological studies and those evaluating intervention impacts each accounted for around 24% of all studies (25 and 18 studies, respectively).

Medicines focus (Table 2)

The most commonly studied medicines were those acting on the nervous system (38%) and cardiovascular system (23%), followed by those acting on the alimentary tract and metabolism (14%). In general, the most commonly studied medicines groups were also the medicines groups accounting for the greatest proportion of PBS dispensing in 2018. However, this medicine focus does not align with the proportion of PBS expenditure. For example, PBS expenditure with antineoplastic and immunomodulating agents represented 32% of the PBS spend in 2018 but less than 10% of the studies published in this review.

Reporting of the included studies – RECORD (Supplementary Figure 2)

Of the 55 studies published in 2018, we excluded seven methodological studies for which most of the RECORD items would not be applicable. From the 48 studies evaluated, the median RECORD score was 95% (interquartile range 90–100%); 13 (27%) studies scored 100%. The most underreported items were: study design, either by not reporting this item in the abstract (14 studies, 30%) or in the methods (9 studies, 19%), followed by the type of data used (14 studies, 30%), and methods of population selection (8 studies, 17%). Moreover, two-thirds of studies using linked data did not report the use of linked data in the abstract.

Discussion

The exponential growth and availability of health data has created new opportunities to generate high-quality real-world evidence in many jurisdictions across the globe, contributing to the growth in pharmacoepidemiology research. We observed a marked increase in Australian output in this field; studies identified in this 5-year systematic review represented more than one-third of all population-based pharmacoepidemiology publications in the last three decades in Australia (Supplementary Figure 3). [13] In the current review period, we also observed an increase in the use of individual-level data and studies linking dispensing claims with other data collections. These studies represented more than half of individual-level and data linkage studies in pharmacoepidemiology in the last 30 years in Australia.

There is little doubt that several initiatives, including significant investment in data linkage infrastructure in Australia, have been pivotal in the growth in data availability and pharmacoepidemiology research. Here, we highlight those initiatives specific to the PBS data collection addressing the creation and accessibility of datasets, and challenges related to data ascertainment and interpretation. We further discuss the pharmacoepidemiology outputs in the context of Australia's data current and future reforms.

Initiatives improving availability and ascertainment of dispensing claims data

First, the availability of a standardised data collection of person-level dispensing claims for a 10% sample of PBS-eligible people ("PBS 10%") has contributed to the rapid increase in the number of studies using individual-level dispensing claims over time. The PBS 10% sample dataset, established in 2005, contains the entire PBS-claims history for a 10% random selection of PBS-eligible Australians. To minimise the risk of re-identification, the data is limited to a population sample, offset dates of dispensing by up to 14 days (but identically for each person), and it is not permitted to be linked to any other dataset. The collection is provided to approved third parties on a fee-for-service basis, has a streamlined governance process and approved organisations

Table 1: Study characteristics

Characteristic	All studies, n (%) N = 180	Claims-level studies, n (%) n = 47	Individual-level studies, n (%) n = 133
Publication Year			
2014‡	20 (11.1)	4 (8.5)	16 (12.1)
2015	33 (18.3)	10 (21.3)	23 (17.3)
2016	35 (19.4)	11 (23.4)	24 (18.0)
2017	37 (20.6)	9 (19.1)	28 (21.1)
2018	55 (30.6)	13 (27.7)	42 (31.6)
Publication lag (time between last observation year and publication year)			
<1 year	18 (10.0)	5 (10.6)	13 (9.8)
1–2 years	86 (47.8)	28 (59.6)	58 (43.6)
3–5 years	47 (26.1)	10 (21.3)	37 (27.8)
>5 years	29 (16.1)	4 (8.5)	25 (18.8)
Median publication lag, months (IQR)	32.5 (22.0; 49.0)	29.0 (19.0; 40.0)	34.0 (23.0; 50.0)
Study Population: Age profile			
No age restrictions	91 (50.6)	44 (93.6)	47 (35.3)
Elderly (≥ 65 years)	55 (30.6)	0 (0.0)	55 (41.4)
Adults (≥ 18 years)	26 (14.4)	1 (2.1)	25 (18.8)
Women of childbearing age	6 (3.3)	2 (4.3)	4 (3.0)
Children	2 (1.1)	0 (0.0)	2 (1.5)
Study population: Beneficiary status			
All PBS beneficiaries	89 (49.5)	43 (91.5)	46 (34.6)
Concessional PBS beneficiaries†	35 (19.4)	4 (8.5)	31 (23.3)
Clients of the DVA	56 (31.1)	0 (0.0)	56 (42.1)
Data sources			
Dispensing claims only	62 (34.4)	18 (38.3)	44 (33.1)
Dispensing claims & other health data	118 (65.6)	29 (61.7)	89 (66.9)
Primary dispensing claims data			
Publicly available	30 (16.7)	29 (61.7)	1 (0.8)
Medicare Statistics Online	18 (10.0)	18 (38.3)	0 (0.0)
Australian Statistics on Medicines	9 (5.0)	9 (19.1)	0 (0.0)
Section 85 extract	2 (1.1)	2 (4.3)	0 (0.0)
10% MBS-PBS sample	1 (0.6)	0 (0.0)	1 (0.8)
Available by request	141 (78.3)	14 (29.8)	127 (95.5)
PBS ad hoc extracts	38 (21.1)	8 (17.0)	30 (21.8)
RPBS	56 (31.1)	0 (0.0)	56 (42.1)
PBS 10% sample	39 (21.7)	1 (2.1)	38 (28.6)
DUSC	8 (4.4)	5 (10.6)	3 (2.3)
Not specified	9 (5.0)	4 (8.5)	5 (3.7)
Geographic coverage of primary dispensing data*			
National	153 (85.0)	41 (87.2)	111 (83.5)
Western Australia	12 (6.7)	0 (0.0)	12 (9.0)
New South Wales	14 (7.8)	2 (4.3)	12 (9.0)
Other states/territories	5 (2.8)	5 (10.6)	0 (0.0)
Study focus			
Medicine utilisation	36 (20.0)	36 (76.6)	0 (0.0)
Clinician practices	47 (26.1)	0 (0.0)	47 (35.3)
Patient practices	16 (8.9)	0 (0.0)	16 (12.0)
Intervention impacts	18 (10.0)	5 (10.6)	13 (9.8)
Exposure and outcomes	38 (21.1)	5 (10.6)	33 (24.8)
Medicine use and outcomes	33 (18.3)	4 (8.5)	29 (21.8)
Other exposures and outcomes	5 (2.8)	1 (2.1)	4 (3.0)
Methods	25 (13.9)	1 (2.1)	24 (18.0)
Funding*			
No funding	23 (12.8)	17 (36.2)	6 (4.5)

Continued

Table 1: Continued

Characteristic	All studies, n (%) N = 180	Claims-level studies, n (%) n = 47	Individual-level studies, n (%) n = 133
Not reported	18 (10.0)	11 (23.4)	7 (5.2)
One or more			
Government	122 (67.8)	12 (25.5)	110 (82.7)
University	22 (12.2)	4 (8.5)	18 (13.5)
Industry	14 (7.8)	1 (2.1)	13 (9.8)
Other	25 (13.9)	8 (17.0)	17 (12.8)

♯Includes 3 studies not identified in the previous review.
†People receiving government benefits and eligible to pay lower PBS co-payment thresholds.
*Percentages may not add up to 100% (studies could report multiple options).
IQR = interquartile range.
DUSC = Drug Utilisation Sub-Committee, DVA: Department of Veterans' Affairs, PBS = Pharmaceutical Benefits Scheme, RPBS = Repatriation Pharmaceutical Benefits Scheme, MBS = Medicare Benefits Scheme.

can hold longitudinal data that is updated at least quarterly. The earliest research studies using this collection were published between 2008–2013 [17–22]. In the period of the current review, 39 studies have been published using this collection. The governance arrangements allow relatively rapid turnaround for approval of studies using contemporary data. This is a model that should be replicated across other data collections, including those with PBS dispensing claims linked to other health datasets.

Second, individual-level studies using PBS data prior to 2012 were often restricted to people receiving government entitlements to ensure complete capture of dispensing records [23]. The 2012 reform allowing the capture of all PBS dispensings (irrespective of whether they attracted

Figure 2: Number of publications (cumulative) according to primary dispensing claims data

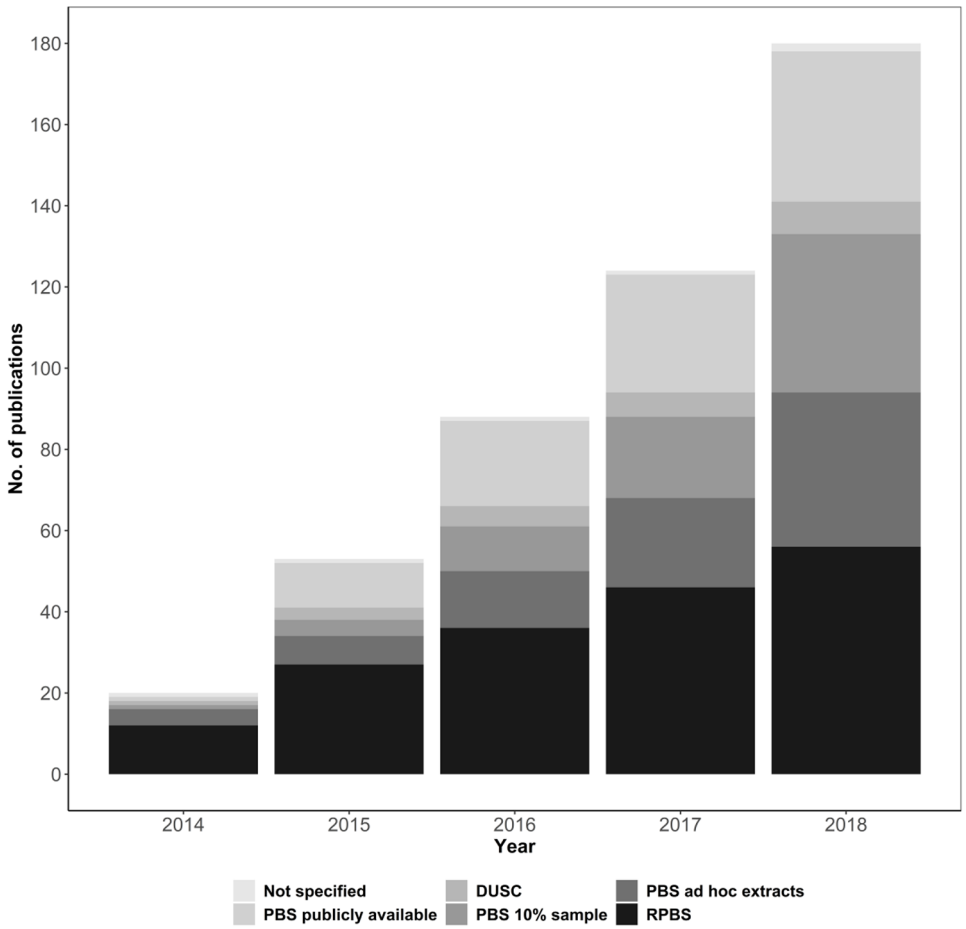
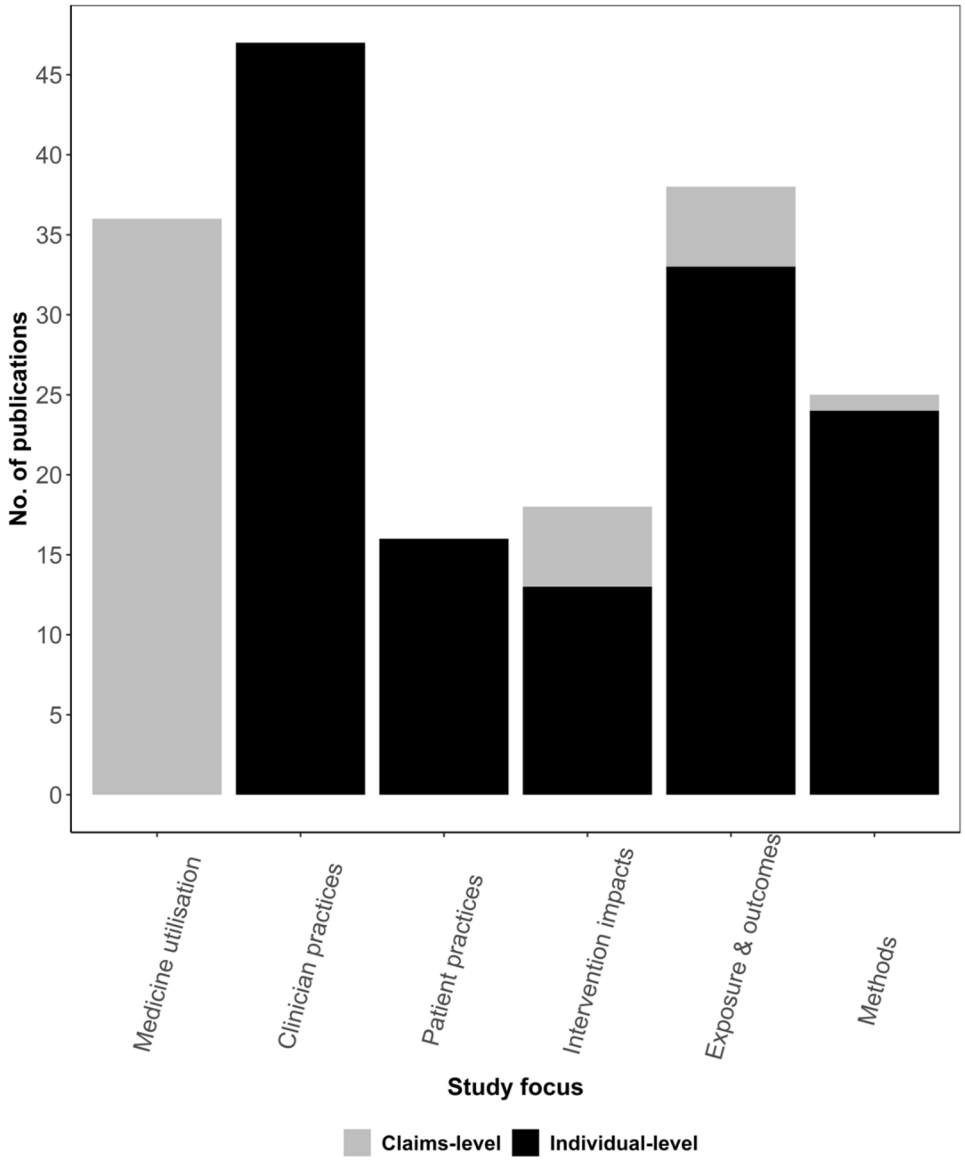


Figure 3: Number of studies according to study focus and analytical approach



a government subsidy) led to an increase in individual-level studies conducted across the entire eligible Australian population, not just in people receiving government benefits [13]. However, the collection does not contain information on private prescriptions, has limited capture of highly specialised medicines dispensed in public hospitals prior to 2013 and no information on prescription indication, prescribed daily dosage, and treatment duration. These limitations are not uncommon in community-based dispensing claims data, but it is important to consider these in pharmacoepidemiological study designs [23, 24].

With respect to undertaking exposure-outcomes studies, the Australian Institute of Health and Welfare's development of multi-source enduring linked data assets (MELDAs) comprising continuing cross-jurisdictional, person-level linkages of medicines exposure with hospitalisation and mortality data show strong potential to further accelerate national population-based research capacity [25, 26]. At the time of writing, there were no formal policies around third-party access (including to academic researchers) to the current suite of MELDAs; this should be considered an immediate priority to realise this significant investment in public money [27].

Future directions

In July 2019, quality use of medicines and medicines safety was announced as Australia's tenth national health priority [28, 29]. Studies catalogued in this systematic review provide contemporary evidence assessing quality use of medicines including the impact of medicines policy interventions, [30–32] medicine use in populations not always represented in clinical trials, [33, 34] and adherence with current treatment guidelines [35–37]. However, there is a need for greater focus on outcomes studies, especially pertaining to medicine safety, and with greater attention to vulnerable population sub-groups [38].

Despite advances, studies examining clinician and patient practices, as well as medicines utilisation studies, still represented a large proportion of the body of literature (Supplementary Figure 3) [13]. Further, the evidence base is still dominated by studies on cardiovascular medicines and

Table 2: Number and proportion of studies by pharmacological group compared to PBS volume and PBS expenditure (2014–2018). Study could be classified under more than one pharmacological group (N = 176*)

Anatomical therapeutic classification first level grouping		Claims-level studies n	Individual-level studies n	All studies n	%	PBS volume 2018# %	PBS cost 2018# %
A	Alimentary tract and metabolism	7	17	24	13.6	15.5	8.6
B	Blood and blood forming organs	–	17	17	9.7	4.6	5.6
C	Cardiovascular system	6	34	40	22.7	31.5	8.4
G	Genito-urinary system and sex hormones	3	9	12	6.8	1.9	2.0
H	Systemic hormonal preparations	1	4	5	2.8	1.8	1.4
J	Anti-infectives for systemic use	5	6	11	6.3	6.3	16.4
L	Antineoplastic & immunomodulating agents	1	14	17	9.7	1.9	32.0
M	Musculoskeletal system	1	14	15	8.5	3.4	2.9
N	Nervous system	20	47	67	38.1	22.1	11.2
R	Respiratory system	6	8	14	8.0	5.9	4.8
	Other ATC groups**	0	6	6	3.4	5.2	6.7
	All ATC groupings	1	21	22	12.5	–	–

*4 studies were removed from the analysis. These studies used individual-level drug data to define their cohort, only.
**Other ATC groups: D, dermatologicals; S, sensory organs; V, various.
#Data derived from the PBS: Expenditure and prescriptions twelve months to 30 June 2018. Canberra; 2013. http://www.pbs.gov.au/info/statistics/expenditure-prescriptions/expenditure-prescriptions-twelve-months-to-30-june-2018. The figures include prescriptions on the general Section 85 and Section 100; excluding under co-payment prescriptions.

those acting on the nervous system and in elderly Australians. Significant blind spots remain in our understanding of real-world medicine effectiveness and safety, particularly in Australians who do not receive government benefits and in populations consistently excluded from clinical trials, such as women of childbearing age and children. In this context, individual-level dispensing claims linked to health outcomes data, would provide a deeper understanding of the benefits and harms derived from medicine use, including indications for prescribing, clinical diagnoses, and other patient risk factors.

Historically, researchers have faced trade-offs between the ease of using readily available individual-level data, such as stand-alone PBS dispensing claims with limited clinical information (comprising the majority of individual-level studies in our review) or investing in the long process of gaining approvals and access to linked data [39, 40]. Encouragingly, we observed an increasing number of studies based on dispensing claims linked at the individual level to other data sources and we anticipate a further upswing in these types of studies in light of the major reforms underway in Australia. Particularly the new Data Availability and Transparency legislation, designed to maximise the value of Australian Government public sector data for service delivery and research. The legislation creates roles and responsibilities to data sharing. It adopts a guidance package to allow consistent practices across jurisdictions and safe sharing of data for public good purposes, including research and development, overriding secrecy provisions [41].

Other Commonwealth countries with similar health care systems and political structures, such as Canada and the United Kingdom, have bolstered their research capability by establishing independent centres serving the specific needs of the research community and closing the gap between linkage and analysis [42, 43]. Australia would benefit from adopting a similar model to harness data from its health care system covering over 25 million citizens and residents.

Limitations of this review

Our systematic review is not without limitations. We have focussed on studies using only routinely collected data and did not include studies using PBS data that required specific individual consent. We developed an arbitrary classification to classify studies by their main focus and given the high degree of variability both within and across studies, many could have been classified under alternative categories. Finally, we only addressed the reporting quality of studies published in 2018, identifying key elements that future studies should consider increasing their transparency and reproducibility and did not assess the methodological quality or relevance of included studies.

Conclusion

Here we used pharmacoepidemiology research as an exemplar to demonstrate the way in which data reforms have supported population health research in Australia. While our findings are encouraging in that we have observed significant growth in output in a five-year period, there is still some way to go before we realise the full potential of Australia's administrative data in population-based research. Major legislative reform currently in place is likely to further break down barriers to facilitate more timely and comprehensive research to support clinical and policy decision-making.

Conflicts of interest

The authors report no actual, potential, or perceived conflict of interest with regard to the submission of this manuscript. The Centre for Big Data Research in Health, UNSW Sydney has received funding from AbbVie to conduct research, unrelated

to the present study. AbbVie did not have any knowledge of, or involvement in, this study.

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Ethics statement

This study used only published data and did not require Ethics Approval.

References

1. Productivity Commission 2017. *Data availability and use*, Report No. 82,. Canberra. Available at: http://www.pc.gov.au/inquiries/completed/data-access/report

2. Kelman CW, Bass AJ, Holman CD. Research use of linked health data–a best practice protocol. Aust N Z J Public Health. 2002;26(3):251–5. https://doi.org/10.1111/j.1467-842x.2002.tb00682.x

3. Price SD, Holman CD, Sanfilippo FM, Emery JD. Are older Western Australians exposed to potentially inappropriate medications according to the Beers Criteria? A 13-year prevalence study. Australas J Ageing. 2014;33(3):E39–48. https://doi.org/10.1111/ajag.12136

4. Gunnell AS, Hung J, Knuiman MW, Nedkoff L, Gillies M, Geelhoed E, et al. Secondary preventive medication use in a prevalent population-based cohort of acute coronary syndrome survivors. Cardiovascular Therapeutics. 2016;34(6):423–30. https://doi.org/10.1111/1755-5922.12212

5. Colvin L, Gill AW, Slack-Smith L, Stanley FJ, Bower C. Off-Label Use of Ondansetron in Pregnancy in Western Australia. Biomed Research International. 2013;909860. https://doi.org/10.1155/2013/909860

6. Price SD, Holman CDAJ, Sanfilippo FM, Emery JD. Use of case–time–control design in pharmacovigilance applications: exploration with high-risk medications and unplanned hospital admissions in the Western Australian elderly. Pharmacoepidemiology and Drug Safety 2013;22:1159–70. https://doi.org/10.1002/pds.3469

7. Flack F, Smith M. The Population Health Research Network - Population Data Centre Profile. Int J Popul Data Sci. 2019;4(2):1130. https://doi.org/10.23889/ijpds.v4i2.1130

8. Department of the Prime Minister Cabinet, 2018. *The Australian Government's Response to the Productivity Commission Data Availability and Use Inquiry.* Available at: https://dataavailability.pmc.gov.au/sites/default/files/govt-response-pc-dau-inquiry.pdf

9. Wylie C DB, Brett J, Pearson SA, Buckley NA. A national study on prescribed medicine in Australia on a typical day. Pharmacoepidemiology & Drug Safety. 2020; 29(9):1046–1053. https://doi.org/10.1002/pds.5093

10. World Health Organization. (1988). Guidelines for developing national drug policies. World Health Organization. https://apps.who.int/iris/handle/10665/40427

11. Kaplan W, Mathers C. The World Medicines Situation 2011. Global Health Trends: Global Burden of Disease and Health Trends. 3rd ed. Geneva, Switzerland: WHO Press, World Health Organization, 2011. Available at: https://www.who.int/medicines/areas/policy/world_medicines_situation/en/

12. Wettermark B, Zoëga H, Furu K, Korhonen M, Hallas J, Nørgaard M, et al. The Nordic prescription databases as a resource for pharmacoepidemiological research–a literature review. Pharmacoepidemiol Drug Saf. 2013;22(7):691–9. https://doi.org/10.1002/pds.3457

13. Pearson SA, Pesa N, Langton JM, Drew A, Faedo M, Robertson J. Studies using Australia's Pharmaceutical Benefits Scheme data for pharmacoepidemiological research: a systematic review of the published literature (1987–2013). Pharmacoepidemiol Drug Saf. 2015;24(5):447-55. https://doi.org/10.1002/pds.3756

14. WHO Collaborating Centre for Drug Statistics and Methodology. Structure and principles Oslo, Norway. 2011. Available from: http://www.whocc.no/atc/structure_and_principles/.

15. Benchimol EI, Smeeth L, Guttmann A, Harron K, Moher D, Petersen I, et al. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) statement. PLoS Med. 2015;12(10):e1001885. https://doi.org/10.1371/journal.pmed.1001885

16. Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med. 2009;6(7):e1000097. https://doi.org/10.1371/journal.pmed.1000097

17. Simons LA, Ortiz M, Calcino G. Long term persistence with statin therapy Experience in Australia 2006–2010. Aust Fam Physician 2011;40(5):319–22. PMID: 21597553

18. Ortiz M, Simons LA, Calcino G. Generic substitution of commonly used medications: Australia-wide experience, 2007-2008. MedJ Aust. 2010;192(7):370–3. https://doi.org/10.5694/j1326-5377.2010.tb03556.x

19. Simons LA, Ortiz M, Calcino G. Persistence with antihypertensive medication: Australia-wide experience, 2004–2006. Med JAust. 2008;188(4):224–7. https://doi.org/10.5694/j.1326-5377.2008.tb01589.x

20. Simons LA, Ortiz M, Calcino G. Persistence with a single pill versus two pills of amlodipine and atorvastatin: the Australian experience, 2006-2010. MJAust. 2011;195(3):134–7. https://doi.org/10.5694/j.1326-5377.2011.tb03240.x

21. Simons LA, Ortiz M, Calcino G. Statin-fibrate co-prescription: Australia-wide experience 2007–2010. Australian Journal of Pharmacy. 2011;92(1099):8+10.

22. Simons LA, Ortiz M, Germanos P, Calcino G. Persistence on warfarin in patients with atrial fibrillation: experience in Australia 2006–2009. Aust Fam Physician. 2013;42(9):659–61. PMID: 24024228

23. Mellish L, Karanges EA, Litchfield MJ, Schaffer AL, Blanch B, Daniels BJ, et al. The Australian Pharmaceutical Benefits Scheme data collection: a practical guide for researchers. BMC Research Notes. 2015;8:634. https://doi.org/10.1186/s13104-015-1616-8

24. Paige E, Kemp-Casey A, Korda R, Banks E. Using Australian Pharmaceutical Benefits Scheme data for pharmacoepidemiological research: challenges and approaches. Public Health Res Pract. 2015;25(4): e2541546. https://doi.org/10.17061/phrp2541546

25. Briffa TG, Jorm L, Jackson RT, Reid C, Chew DP. Nationally linked data to improve health services and policy. Med J Aust. 2019;211(9):397–8.e1. https://doi.org/10.5694/mja2.50368

26. Schaffer AL, Falster MO, Brieger D, Jorm LR, Wilson A, Hay M, et al. Evidence-Practice Gaps in Postdischarge Initiation With Oral Anticoagulants in Patients With Atrial Fibrillation. J Am Heart Assoc. 2019;8(24):e014287. https://doi.org/10.1161/JAHA.119.014287

27. Australian Government Department of the Prime Minister and Cabinet. *Data Sharing and Release Legislative Reforms Discussion Paper* (2019). [cited 05/05/2020]. Available from: https://www.datacommissioner.gov.au/sites/default/files/2019-09/Data%20Sharing%20and%20Release%20Legislative%20Reforms%20Discussion%20Paper%20-%20Accessibility.pdf.

28. Pharmaceutical Society of Australia. Medicine Safety to be the 10th National Health Priority Area [media release] (2019 November 1). Available from: https://www.psa.org.au/medicine-safety-to-be-the-10th-national-health-priority-area/

29. Minister for Health, The Hon Greg Hunt MP *Health ministers unite in response to Aged Care Royal Commission Interim Report* [media release]. Canberra: Federal Department of Health; November 2019. Available from: https://www.health.gov.au/ministers/the-hon-greg-hunt-mp/media/health-ministers-unite-in-response-to-aged-care-royal-commission-interim-report

30. Roughead EE, Kim DS, Ong B, Kemp-Casey A. Pricing policies for generic medicines in Australia, New Zealand, the Republic of Korea and Singapore: patent expiry and influence on atorvastatin price. WHO South-East Asia J of Public Health. 2018;7(2):99–106. https://doi.org/10.4103/2224-3151.239421

31. Schaffer AL, Buckley NA, Cairns R, Pearson SA. Interrupted time series analysis of the effect of rescheduling alprazolam in Australia: Taking control of prescription drug use. JAMA Intern Med. 2016;176(8):1223–5. https://doi.org/10.1001/jamainternmed.2016.2992

32. Brett J, Schaffer A, Dobbins T, Buckley NA, Pearson SA. The impact of permissive and restrictive pharmaceutical policies on quetiapine dispensing: Evaluating a policy pendulum using interrupted time series analysis. Pharmacoepidemiology and Drug Safety. 2018;27(4):439–46. https://doi.org/10.1002/pds.4408

33. Daniels B, Kiely BE, Houssami N, Lord SJ, Dobbins T, Lu CY, et al. Survival outcomes for Australian women receiving trastuzumab for HER2-positive metastatic breast cancer following (neo)adjuvant trastuzumab: A national population-based observational study (2006–2014). Br JCancer. 2018;118(3):441–7. https://doi.org/10.1038/bjc.2017.405

34. Ahmed B, Tran DT, Zoega H, Kennedy SE, Jorm LR, Havard A. Maternal and perinatal outcomes associated with the use of renin-angiotensin system (RAS) blockers for chronic hypertension in early pregnancy. Pregnancy Hypertension. 2018;14:156–61. https://doi.org/10.1016/j.preghy.2018.09.010

35. Daniels B, Girosi F, Tervonen H, Kiely BE, Lord SJ, Houssami N, et al. Adherence to prescribing restrictions for HER2-positive metastatic breast cancer in Australia: A national population-based observational study (2001-2016). PLoS ONE. 2018;13(7):e0198152. https://doi.org/10.1371/journal.pone.0198152

36. Lim R, Kerr M, Roughead EE. Use of medicines and health services for chronic obstructive pulmonary disease among a cohort of Australians over 50 years. Int JChron Obstruct Pulmon Dis. 2018;13:3085–93. https://doi.org/10.2147/COPD,S172495

37. Simons LA, Chung E. Are high coronary risk patients missing out on lipid-lowering drugs in Australia? Med J Aust. 2014;201(4):213–6. https://doi.org/10.5694/mja14.00249

38. McLachlan AJ, Aslani P. National Medicines Policy 2.0: a vision for the future. Aust Prescr. 2020;43(1):24–6. https://doi.org/10.18733/austprecr.2020.007

39. Srinivasan U, Rao S, Ramachandran D, Jonas D. 2016, *Flying blind: Australian consumers and digital health, Volume 1: Australian health data series*, Health Market Quality Research Program, CMCRC, Sydney. Available from: https://flyingblind.cmcrc.com/consumers-digital-health

40. Mitchell RJ, Cameron CM, McClure RJ, Williamson AM. Data linkage capabilities in Australia: practical issues identified by a Population Health Research Network 'Proof of Concept project'. Aust N Z J Public Health. 2015;39(4):319–25. https://doi.org/10.1111/1753-6405.12310

41. Office of the National Data Commissioner. Data legislation: Australian Government; 2020 [Available from: https://www.datacommissioner.gov.au/data-legislation.

42. Katz A, Enns J, Smith M, Burchill C, Turner K, Towns IJPDS. Population Data Centre Profile: The Manitoba Centre for Health Policy. 2019;4(2). http://orcid.org/0000-0001-7805-7582

43. Jones KH, Ford DV, Thompson S, Lyons R IJPDS. A profile of the Sail Databank on the UK secure research platform. 2019;4(2). https://doi.org/10.23889/ijpds.v4i2.1130

Supplementary Table 1: Sources of dispensing claims data available to third parties for monitoring, surveillance, and research

Data source	Description	PBS data	RPBS data	Level of data	Data custodian
Publicly available					
Medicare Statistics Online[1]	Reports by PBS Item and Group. Reports do not include data on under co-payment (i.e., PBS-medicines priced below the co-payment threshold) or private prescriptions	√		Aggregated claims	Services Australia
Section 85 extract[2]	Reports on PBS and RPBS claims updated monthly and only available for most recent 5 years. Includes under co-payment medicines	√	√	Aggregated claims	Department of Health
Australian Statistics on Medicines (ASM)[3]	Annual publication produced by the Drug Utilisation Sub-Committee (DUSC) of the Pharmaceutical Benefits Advisory Committee, Combining PBS/RPBS data with estimates of non-subsidised (under co-payment and private) prescription medicines use obtained from a panel survey of Australian pharmacies.	√	√	Aggregated claims	Department of Health
Under co-payment extract[4]	Extract of both PBS and RPBS under co-payment data. Available from July 2012-onward.	√	√	Aggregated claims	Department of Health
10% Medicare Benefits Scheme (MBS)/PBS dataset[5]	10% random sample of people claiming Medicare Benefits since 1984, or Pharmaceutical Benefits since 2003. Included individual-level linked PBS-MBS data (2003–2014). Data was withdrawn from the public domain in 2016.	√		Individual-level, unit record data	Department of Health
Available to third parties by request					
PBS 10% sample	Standardised, longitudinal, unit-record extract containing all PBS medicine dispensing data for a random 10% sample of PBS-eligible persons.	√		Individual-level, unit record data	Services Australia
PBS ad hoc extracts	Longitudinal data for all PBS-eligible Australians to address specific questions.	√		Individual-level, unit record data or aggregated claims	Services Australia, Department of Health
RPBS	Longitudinal data for all eligible veterans and dependents to address specific questions.		√	Individual-level, unit record data	Department of Veteran's Affairs
DUSC	Customised extracts from data underlying the ASM (see above) since 1987.	√	√	Aggregated claims	Department of Health

Source: Adapted from Mellish L, Karanges EA, Litchfield MJ, Schaffer AL, Blanch B, Daniels BJ, et al. The Australian Pharmaceutical Benefits Scheme data collection: a practical guide for researchers. BMC Research Notes. 2015;8:634.

[1] http://medicarestatistics.humanservices.gov.au/statistics/pbs_item.jsp

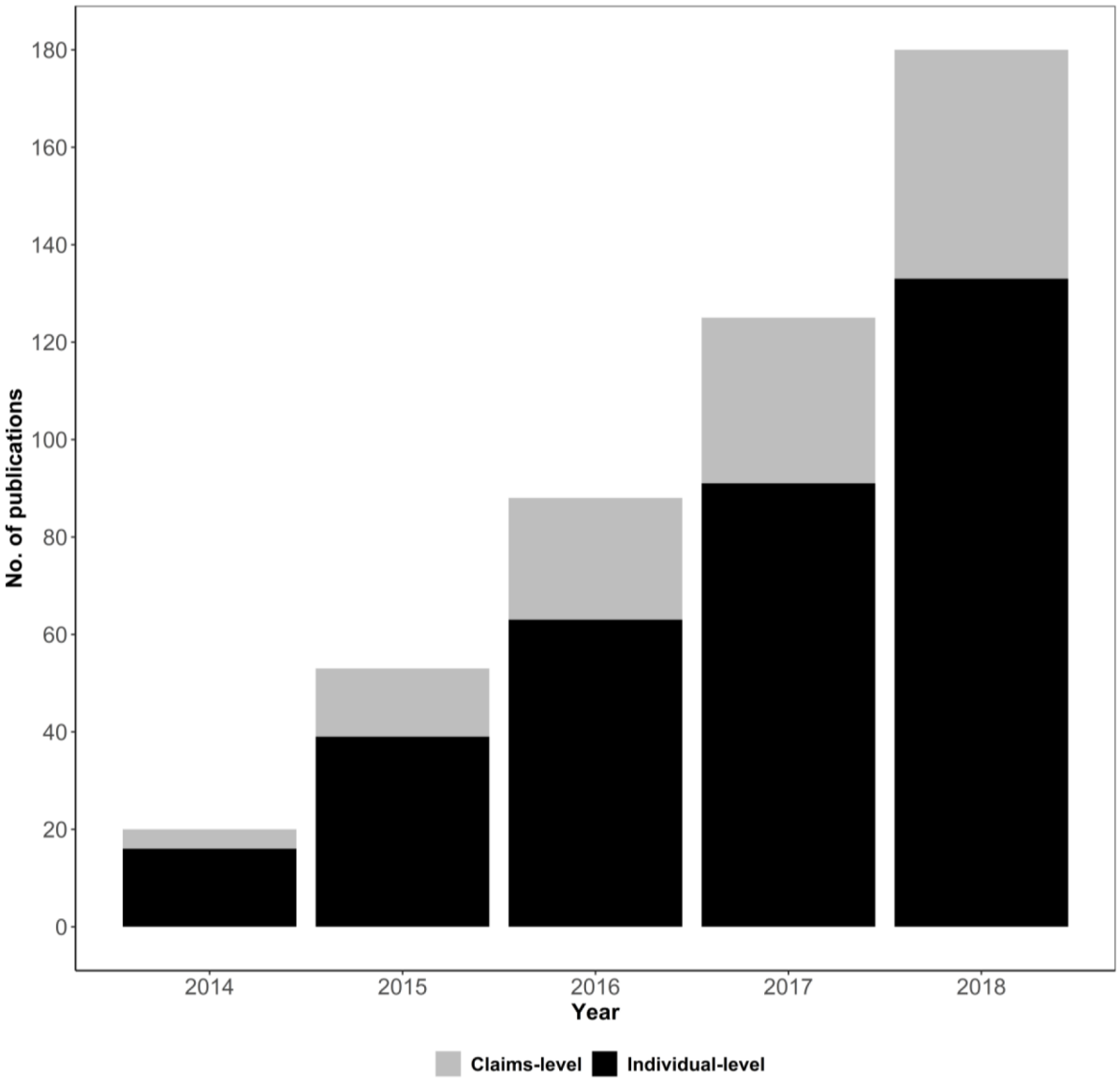
[2] http://www.pbs.gov.au/info/statistics/dos-and-dop/dos-and-dop

[3] http://www.pbs.gov.au/info/statistics/asm/australian-statistics-on-medicines

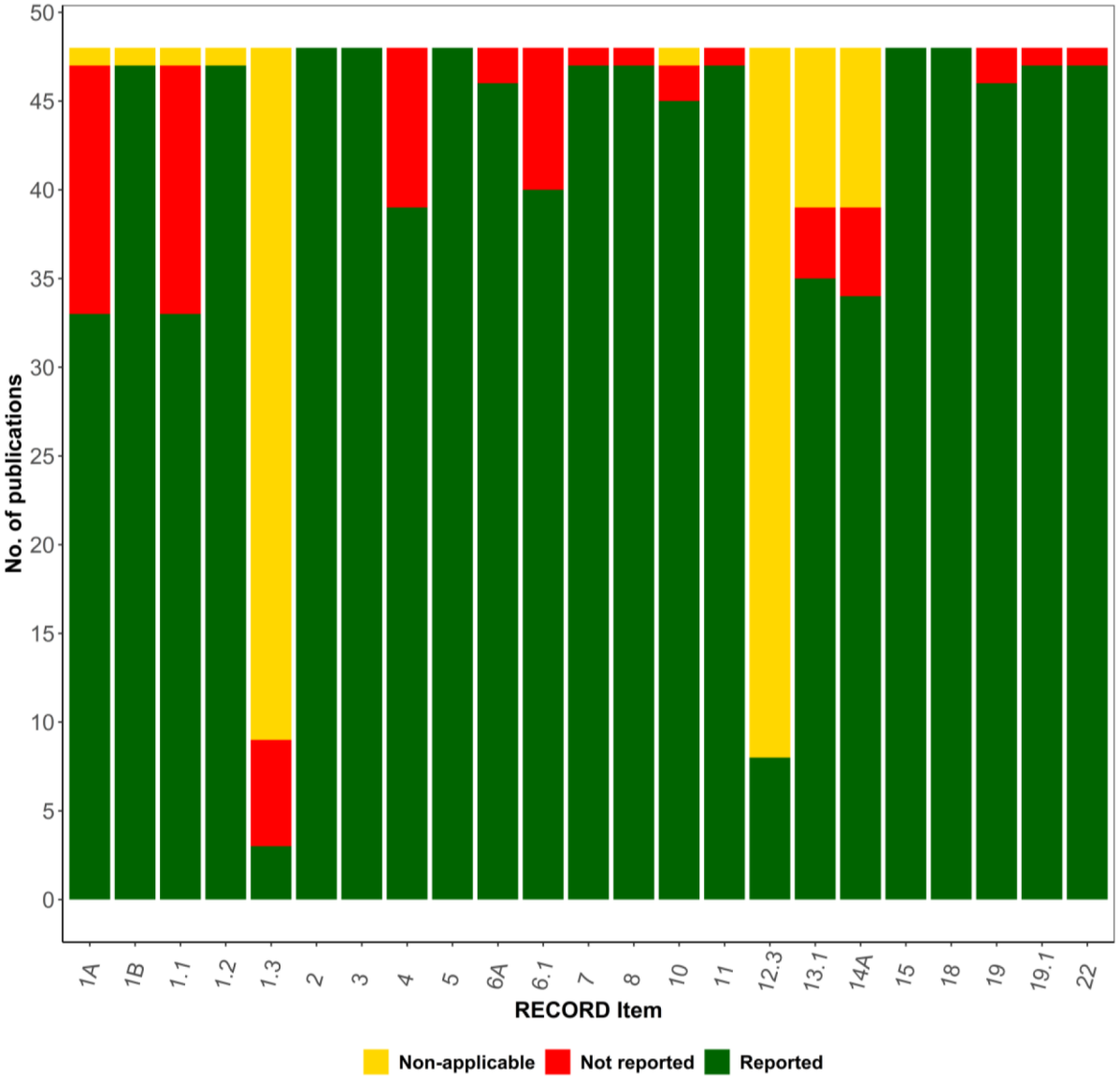
[4] http://www.pbs.gov.au/info/statistics/under-co-payment/ucp-data-report

[5] www.data.gov.au

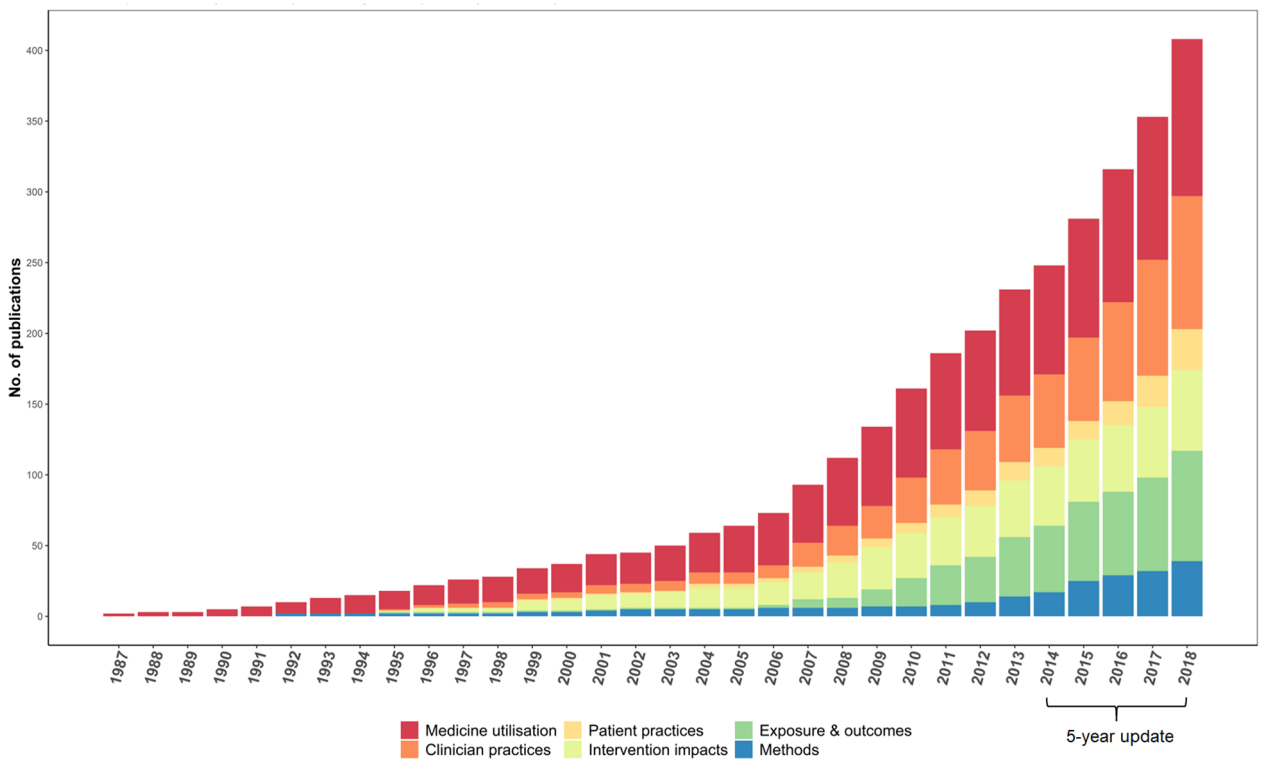
Supplementary Figure 1: Number of publications (cumulative) according to analytical approach (n = 180)



Supplementary Figure 2: RECORD classification of studies published in 2018 per evaluated item (n = 48)



Supplementary Figure 3: Number of publications (cumulative) according to study focus (1987–2018)



Supplementary Appendix A: Search strategy

Medline search

Database: OVID MEDLINE 1946 to May Week 4 2019
Search strategy:

S. No.	Search terms
1	drug utilization/
2	drug utilisation.mp.
3	drug utilization.mp.
4	drug prescriptions/
5	prescription drugs/
6	drug therapy/
7	pharmaceutical preparations/
8	health insurance commission.mp.
9	pharmaceutical benefits scheme.mp.
10	pbs.mp.
11	pharmacoepidemiolog$.mp.
12	dispens$.mp.
13	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12
14	Australia?.mp.
15	13 and 14
16	mcmanus p.au.
17	roughead ee.au.
18	colvin l.au.
19	gilbert al.au.
20	(henry or henry da).au.
21	preen db.au.
22	tett se.au.
23	ortiz m.au.
24	16 or 17 or 18 or 19 or 20 or 21 or 22 or 23
25	15 or 24
26	limit 25 to yr="2013–2018"
27	remove duplicates from 26

EMBASE search

Database: EMBASE 1974 to 2019 June 03
Search Strategy:

S. No.	Search terms
1	drug utilization/
2	drug utilisation.mp.
3	drug utilization.mp.
4	drug prescriptions/
5	prescription drugs/
6	drug therapy/
7	pharmaceutical preparations/
8	health insurance commission.mp.
9	pharmaceutical benefits scheme.mp.
10	pbs.mp.
11	pharmacoepidemiolog$.mp.
12	dispens$.mp.
13	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12
14	Australia?.mp.
15	13 and 14
16	mcmanus p.au.
17	roughead ee.au.
18	colvin l.au.
19	gilbert al.au.
20	(henry or henry da).au.
21	preen db.au.
22	tett se.au
23	ortiz m.au.
24	16 or 17 or 18 or 19 or 20 or 21 or 22 or 23
25	15 or 24
26	limit 25 to yr="2013–2018"
27	remove duplicates from 26

Supplementary Appendix B: Selected STROBE and RECORD items from the RECORD statement tool

	Item No.	STROBE items	RECORD items
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found	RECORD 1.1: The type of data used should be specified in the title or abstract. When possible, the name of the databases used should be included. RECORD 1.2: If applicable, the geographic region and timeframe within which the study took place should be reported in the title or abstract. RECORD 1.3: If linkage between databases was conducted for the study, this should be clearly stated in the title or abstract.
Introduction			
Background rationale	2	Explain the scientific background and rationale for the investigation being reported	
Objectives	3	State specific objectives, including any prespecified hypotheses	
Methods			
Study Design	4	Present key elements of study design early in the paper	
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	
Participants	6	Give the eligibility criteria, and the sources and methods of selection of participants	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable.	
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	
Linkage		..	RECORD 12.3: State whether the study included person-level, institutional-level, or other data linkage across two or more databases. The methods of linkage and methods of linkage quality evaluation should be provided.
Results			
Participants	13	(a) Report the numbers of individuals at each stage of the study (*e.g.*, numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed)	
Descriptive data	14	(a) Give characteristics of study participants (*e.g.*, demographic, clinical, social) and information on exposures and potential confounders	

Continued

Supplementary Appendix B: Continued

	Item No.	STROBE items	RECORD items
Outcome data	15	*Cohort study* - Report numbers of outcome events or summary measures over time *Case-control study* - Report numbers in each exposure category, or summary measures of exposure *Cross-sectional study* - Report numbers of outcome events or summary measures	
Discussion			
Key results	18	Summarise key results with reference to study objectives	
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	RECORD 19.1: Discuss the implications of using data that were not created or collected to answer the specific research question(s). Include discussion of misclassification bias, unmeasured confounding, missing data, and changing eligibility over time, as they pertain to the study being reported.
Other Information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	

Source: Benchimol EI, Smeeth L, Guttmann A, Harron K, Moher D, Petersen I, Sørensen HT, von Elm E, Langan SM, the RECORD Working Committee. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement. *PLoS Medicine* 2015; in press.

Supplementary Appendix C: List of studies included in the systematic review

1. Acar M, Juneja P, Handel M. Treatment persistence of subcutaneous TNF inhibitors among Australian patients with immune-mediated rheumatic disease (IMRD). Open Access Rheumatology: Research and Reviews. 2018; Volume 10:151–60. https://doi.org/10.2147/oarrr.s179704
2. Ahmed B, Tran DT, Zoega H, Kennedy SE, Jorm LR, Havard A. Maternal and perinatal outcomes associated with the use of renin-angiotensin system (RAS) blockers for chronic hypertension in early pregnancy. Pregnancy Hypertension. 2018;14:156–61. https://doi.org/10.1016/j.preghy.2018.09.010
3. Allard NL, MacLachlan JH, Cowie BC. The cascade of care for Australians living with chronic hepatitis B: measuring access to diagnosis, management and treatment. Australian & New Zealand Journal of Public Health. 2015;39(3):255–9. https://doi.org/10.1111/1753-6405.12345
4. Arnet I, Greenland M, Knuiman MW, Rankin JM, Hung J, Nedkoff L, et al. Operationalization and validation of a novel method to calculate adherence to polypharmacy with refill data from the australian pharmaceutical benefits scheme (Pbs) database. Clinical Epidemiology. 2018;10:1181–94. https://doi.org/10.2147/CLEP.S153496
5. Baker D, Wilsmore B, Narasimhan S. Adoption of direct oral anticoagulants for stroke prevention in atrial fibrillation. Internal Medicine Journal. 2016;46(7):792–7. https://doi.org/10.1111/imj.13088
6. Barozzi N, Peeters GM, Tett SE. Actions following adverse drug events - how do these influence uptake and utilisation of newer and/or similar medications? BMC Health Services Research. 2015;15:498. https://doi.org/10.1186/s12913-015-1165-9
7. Bartlett LE, Pratt N, Roughead EE. Does tablet formulation alone improve adherence and persistence: a comparison of ezetimibe fixed dose combination versus ezetimibe separate pill combination? British Journal of Clinical Pharmacology. 2017;83(1):202–10. https://doi.org/10.1111/bcp.13088
8. Bartlett LE, Pratt N, Roughead EE. Does a fixed-dose combination of amlodipine and atorvastatin improve persistence with therapy in the Australian population? Current Medical Research and Opinion. 2018;34(2):305–11. https://doi.org/10.1080/03007995.2017.1384375
9. Bartlett LE, Pratt NL, Roughead EE. Prior experience with cardiovascular medicines predicted longer persistence in people initiated to combinations of antihypertensive and lipid-lowering therapies: Findings from two australian cohorts. Patient Preference and Adherence. 2018;12:835–43. https://doi.org/10.2147/PPA.S150142
10. Berecki-Gisolf J, Hassani-Mahmooei B, Clapperton A, McClure R. Prescription opioid dispensing and prescription opioid poisoning: Population data from Victoria, Australia 2006 to 2013. Australian and New Zealand journal of public health. 2017;41(1):85–91. https://doi.org/10.1111/1753-6405.12568
11. Berling I, Buckley NA, Isbister GK. The antipsychotic story: Changes in prescriptions and overdose without better safety. British Journal of Clinical Pharmacology. 2016. https://doi.org/10.1111/bcp.12927
12. Bingham AL, Garrett CC, Bayly C, Kavanagh AM, Keogh LA, Bentley RJ, et al. The levonorgestrel intrauterine device in Australia: analysis of prescribing data 2008–2012. BMC Women's Health. 2018;18(1):194. https://doi.org/10.1186/s12905-018-0680-3
13. Bingham AL, Garrett CC, Kavanagh AM, Keogh LA, Bentley RJ, Hocking JS. Prescription rates of the contraceptive implant in Australia 2008–2012: Impact of patient age and area of residence. Sexual Health. 2016;13(1):87–90. https://doi.org/10.1071/SH15141
14. Blanch B, Daniels B, Litchfield M, Pearson SA. Looking forward and looking back: the balancing act in new drug user designs for pharmacoepidemiological research. Pharmacoepidemiology & Drug Safety. 2015;24(10):1117–9. https://doi.org/10.1002/pds.3848
15. Blanch B, Degenhardt L, Buckley NA, Gisev N, Dobbins T, Karanges EA, et al. Prescription Opioid Access Patterns and Factors Associated with Increasing Number of Prescribers, Pharmacies, and Dispensings: An Observational Study Using Pharmaceutical Claims. Pain Medicine. 2018;19(6):1170–83. https://doi.org/10.1093/pm/pnx035
16. Blanch B, Gladstone E, Smolina K, Buckley NA, Karanges EA, Morgan SG, et al. Benchmarking prescription drug access patterns in pharmaceutical claims: a method for identifying high and potentially harmful opioid use in Australia and Canada? Journal of Pharmaceutical Health Services Research. 2017;8(1):23–30. https://doi.org/10.1111/jphs.12165
17. Blanch B, Pearson SA, Haber PS. An overview of the patterns of prescription opioid use, costs and related harms in Australia. British Journal of Clinical Pharmacology. 2014;78(5):1159–66. https://doi.org/10.1111/bcp.12446
18. Brett J, Daniels B, Karanges EA, Buckley NA, Schneider C, Nassir A, et al. Psychotropic polypharmacy in Australia, 2006 to 2015: a descriptive cohort study. British Journal of Clinical Pharmacology. 2017;83(11):2581–8. https://doi.org/10.1111/bcp.13369
19. Brett J, Karanges EA, Daniels B, Buckley NA, Schneider C, Nassir A, et al. Psychotropic medication use in Australia, 2007 to 2015: Changes in annual incidence, prevalence and treatment exposure. Australian & New Zealand Journal of Psychiatry. 2017;51(10):990–9. https://doi.org/10.1177/0004867417721018
20. Brett J, Maust DT, Bouck Z, Ignacio RV, Mecredy G, Kerr EA, et al. Benzodiazepine Use in Older Adults in the United States, Ontario, and Australia from 2010 to 2016. Journal of the American Geriatrics Society. 2018;66(6):1180–5. https://doi.org/10.1111/jgs.15292
21. Brett J, Schaffer A, Dobbins T, Buckley NA, Pearson SA. The impact of permissive and restrictive pharmaceutical policies on quetiapine dispensing: Evaluating a policy pendulum using interrupted time series analysis. Pharmacoepidemiology and Drug Safety. 2018;27(4):439–46. https://doi.org/10.1002/pds.4408
22. Brett J, Zoega H, Buckley NA, Daniels BJ, Elshaug AG, Pearson SA. Choosing wisely? Quantifying the extent of three low value psychotropic prescribing practices in Australia. BMC health services research. 2018;18(1):1009. https://doi.org/10.1186/s12913-018-3811-5
23. Buckley NA, Whyte IM, Dawson AH, Isbister GK. A prospective cohort study of trends in self-poisoning, Newcastle, Australia, 1987-2012: plus ca change, plus c'est la meme

chose. The Medical journal of Australia. 2015;202(8):438–42. https://doi.org/10.5694/mja14.01116
24. Cairns R, Daniels B, Wood DA, Brett J. ADHD medication overdose and misuse: the NSW Poisons Information Centre experience, 2004-2014. Medical Journal of Australia. 2016;204(4):154. https://doi.org/10.5694/mja15.00791
25. Castle DJ, Chung E. Cardiometabolic comorbidities and life expectancy in people on medication for schizophrenia in Australia. Current Medical Research and Opinion. 2018;34(4):613–8. https://doi.org/10.1080/03007995.2017.1419946
26. Caughey GE, Barratt JD, Shakib S, Kemp-Casey A, Roughead EE. Medication use and potentially high-risk prescribing in older patients hospitalized for diabetes: a missed opportunity to improve care? Diabetic Medicine. 2017;34(3):432–9. https://doi.org/10.1111/dme.13148
27. Caughey GE, Kalisch Ellett LM, Goldstein S, Roughead EE. Suboptimal medication-related quality of care preceding hospitalisation of older patients. Medical Journal of Australia. 2015;203(5):220.e1–7. https://doi.org/10.5694/mja14.01479
28. Caughey GE, Pratt NL, Barratt JD, Shakib S, Kemp-Casey AR, Roughead EE. Understanding 30-day re-admission after hospitalisation of older patients for diabetes: Identifying those at greatest risk. Medical Journal of Australia. 2017;206(4):170–5. https://doi.org/10.5694/mja16.00671
29. Caughey GE, Vitry AI, Ramsay EN, Gilbert AL, Shakib S, Ryan P, et al. Effect of a general practitioner management plan on health outcomes and hospitalisations in older patients with diabetes. Internal Medicine Journal. 2016;46(12):1430–6. https://doi.org/10.1111/imj.13286
30. Daniels B, Girosi F, Tervonen H, Kiely BE, Lord SJ, Houssami N, et al. Adherence to prescribing restrictions for HER2-positive metastatic breast cancer in Australia: A national population-based observational study (2001-2016). PLOS ONE. 2018;13(7):e0198152. https://doi.org/10.1371/journal.pone.0198152
31. Daniels B, Kiely BE, Houssami N, Lord SJ, Dobbins T, Lu CY, et al. Survival outcomes for Australian women receiving trastuzumab for HER2-positive metastatic breast cancer following (neo)adjuvant trastuzumab: A national population-based observational study (2006-2014). British Journal of Cancer. 2018;118(3):441–7. https://doi.org/10.1038/bjc.2017.405
32. Daniels B, Kiely BE, Lord SJ, Houssami N, Lu CY, Ward RL, et al. Trastuzumab for metastatic breast cancer: Real world outcomes from an Australian whole-of-population cohort (2001–2016). The Breast. 2018;38:7–13. https://doi.org/10.1016/j.breast.2017.11.007
33. Daniels B, Kiely BE, Lord SJ, Houssami N, Lu CY, Ward RL, et al. Long-term survival in trastuzumab-treated patients with HER2-positive metastatic breast cancer: real-world outcomes and treatment patterns in a whole-of-population Australian cohort (2001-2016). Breast Cancer Research and Treatment. 2018;171(1):151–9. https://doi.org/10.1007/s10549-018-4804-0
34. Daniels B, Lord SJ, Kiely BE, Houssami N, Haywood P, Lu CY, et al. Use and outcomes of targeted therapies in early and metastatic HER2-positive breast cancer in Australia: protocol detailing observations in a whole of population cohort. BMJ Open. 2017;7(1):e014439. https://doi.org/10.1136/bmjopen-2016-014439
35. de Graaff B, Yee KC, Clarke P, Palmer A. Uptake of and Expenditure on Direct-Acting Antiviral Agents for Hepatitis C Treatment in Australia. Applied Health Economics and Health Policy. 2018;16(4):495–502. https://doi.org/10.1007/s40258-018-0392-8
36. Degenhardt L, Gisev N, Cama E, Nielsen S, Larance B, Bruno R. The extent and correlates of community-based pharmaceutical opioid utilisation in Australia. Pharmacoepidemiology & Drug Safety. 2016;25(5):521-38. https://doi.org/10.1002/pds.3931
37. Eyre BLKD, Eadie MJ, van Driel ML, Ross-Lee L, Hollingworth SA. Triptan use in Australia 1997-2015: A pharmacoepidemiological study. Acta Neurologica Scandinavica. 2017;136(2):155–9. https://doi.org/10.1111/ane.12727
38. Finger RP, Xie J, Fotis K, Parikh S, Cummins R, Mitchell P, et al. Disparities in access to anti-vascular endothelial growth factor treatment for neovascular age-related macular degeneration. Clinical and Experimental Ophthalmology. 2017;45(2):143–51. https://doi.org/10.1111/ceo.12804
39. Ford PJ, Saladine C, Zhang K, Hollingworth SA. Prescribing patterns of dental practitioners in Australia from 2001 to 2012. Antimicrobials. Australian dental journal. 2017;62(1):52–7. https://doi.org/10.1111/adj.12427
40. Forrester T, Siskind D, Winckel K, Wheeler A, Hollingworth S. Increasing Clozapine Dispensing Trends in Queensland, Australia 2004-2013. Pharmacopsychiatry. 2015;48(4-5):164–9. https://doi.org/10.1055/s-0035-1554713
41. Gadzhanova S, Roughead E. Use of prescription medicines in Australian women of child-bearing age. BMC Pharmacology & Toxicology. 2015;16:33. https://doi.org/10.1186/s40360-015-0033-x
42. Gadzhanova S, Roughead E. Prescribed antibiotic use in Australian children aged 0-12 years. Australian Family Physician. 2016;45(3):134–8.
43. Gadzhanova S, Roughead E, Robinson M. Use of Medicines with Anticholinergic and Sedative Effect Before and After Initiation of Anti-Dementia Medications. Drugs - Real World Outcomes. 2015;2(1):53–60. https://doi.org/10.1007/s40801-015-0012-y
44. Gadzhanova S, Roughead EE, Bartlett LE. Long-term persistence to mono and combination therapies with angiotensin converting enzymes and angiotensin II receptor blockers in Australia. European Journal of Clinical Pharmacology. 2016;72(6):765–71. https://doi.org/10.1007/s00228-016-2037-x
45. Gardiner KM, Tett SE, Staatz CE. Multinational Evaluation of Mycophenolic Acid, Tacrolimus, Cyclosporin, Sirolimus, and Everolimus Utilization. Annals of Transplantation. 2016;21:1–11. https://doi.org/10.12659/aot.895664
46. Gillam MH, Pratt NL, Inacio MCS, Roughead EE, Shakib S, Nicholls SJ, et al. Heart failure after conventional metal-on-metal hip replacements: A retrospective cohort study. Acta Orthopaedica. 2017;88(1):2–9. https://doi.org/10.1080/17453674.2016.1246276
47. Gillam MH, Pratt NL, Inacio MCS, Shakib S, Sanders P, Lau DH, et al. Rehospitalizations for complications and mortality following pacemaker implantation: A retrospective cohort study in an older population. Clinical Cardiology. 2018;41(11):1480–6. https://doi.org/10.1002/clc.23091

48. Gisev N, Pearson SA, Blanch B, Larance B, Dobbins T, Larney S, et al. Initiation of strong prescription opioids in Australia: cohort characteristics and factors associated with the type of opioid initiated. British Journal of Clinical Pharmacology. 2016;82:1123–33. https://doi.org/10.1111/bcp.13026
49. Gisev N, Pearson SA, Karanges EA, Larance B, Buckley NA, Larney S, et al. To what extent do data from pharmaceutical claims under-estimate opioid analgesic utilisation in Australia? Pharmacoepidemiology and Drug Safety. 2018;27(5):550–5. https://doi.org/10.1002/pds.4329
50. Gunnell AS, Hung J, Knuiman MW, Nedkoff L, Gillies M, Geelhoed E, et al. Secondary preventive medication use in a prevalent population-based cohort of acute coronary syndrome survivors. Cardiovascular Therapeutics. 2016;34(6):423–30. https://doi.org/10.1111/1755-5922.12212
51. Gunnell AS, Knuiman MW, Geelhoed E, Hobbs MST, Katzenellenbogen JM, Hung J, et al. Long-term use and cost-effectiveness of secondary prevention drugs for heart disease in Western Australian seniors (WAMACH): A study protocol. BMJ Open. 2014;4(9). https://doi.org/10.1136/bmjopen-2014-006258
52. Hajarizadeh B, Grebely J, Matthews GV, Martinello M, Dore GJ. Uptake of direct-acting antiviral treatment for chronic hepatitis C in Australia. Journal of Viral Hepatitis. 2018;25(6):640–8. https://doi.org/10.1111/jvh.12852
53. Hajarizadeh B, Grebely J, McManus H, Estes C, Razavi H, Gray RT, et al. Chronic hepatitis C burden and care cascade in Australia in the era of interferon-based treatment. Journal of Gastroenterology and Hepatology. 2017;32(1):229–36. https://doi.org/10.1111/jgh.1345354
54. Hajati F, Atlantis E, Bell KJL, Girosi F. Patterns and trends of potentially inappropriate high-density lipoprotein cholesterol testing in Australian adults at high risk of cardiovascular disease from 2008 to 2014: analysis of linked individual patient data from the Australian Medicare Benefits S. BMJ Open. 2018;8(3):e019041. https://doi.org/10.1136/bmjopen-2017-019041
55. Hálfdánarson Ó, Zoëga H, Aagaard L, Bernardo M, Brandt L, Fusté AC, et al. International trends in antipsychotic use: A study in 16 countries, 2005–2014. European Neuropsychopharmacology. 2017;27(10):1064–76. https://doi.org/10.1016/j.euroneuro.2017.07.001
56. Handelsman DJ. Pharmacoepidemiology of testosterone: Curbing off-label prescribing. Pharmacoepidemiology and Drug Safety. 2017;26(10):1248–55. https://doi.org/10.1002/pds.4284
57. Hansen CA, Inacio MCS, Pratt NL, Roughead EE, Graves SE. Chronic Use of Opioids Before and After Total Knee Arthroplasty: A Retrospective Cohort Study. The Journal of Arthroplasty. 2017;32(3):811–7.e1. https://doi.org/10.1016/j.arth.2016.09.040
58. Hasan SS, Clavarino AM, Mamun AA, Kairuz T. A comparative drug utilisation study of the treatment of diabetes in Malaysia and Australia. Australasian Medical Journal. 2015;8(6):179–88. https://doi.org/10.4066/AMJ.2015.2330
59. Hawke KL, McGuire TM, Ranmuthugala G, Van Driel ML. What do consumers want to know about antibiotics? Analysis of a medicines call centre database. Family Practice. 2016;33(1):75–81. https://doi.org/10.1093/fampra/cmv083
60. Hoang T, Liu J, Roughead E, Pratt N, Li J. Supervised signal detection for adverse drug reactions in medication dispensing data. Computer Methods and Programs in Biomedicine. 2018;161:25–38. https://doi.org/10.1016/j.cmpb.2018.03.021
61. Hollingworth SA, Chan R, Pham J, Shi S, Ford PJ. Prescribing patterns of analgesics and other medicines by dental practitioners in Australia from 2001 to 2012. Community dentistry and oral epidemiology. 2017;45(4):303–9. https://doi.org/10.1111/cdoe.12291
62. Hollingworth SA, Gray PD, Hall WD, Najman JM. Opioid analgesic prescribing in Australia: a focus on gender and age. Pharmacoepidemiology & Drug Safety. 2015;24(6):628–36. https://doi.org/10.1002/pds.3767
63. Hollingworth SA, McGuire TM, Pache D, Eadie MJ. Dopamine Agonists: Time Pattern of Adverse Effects Reporting in Australia. Drugs - Real World Outcomes. 2015;2(3):199–203. https://doi.org/10.1007/s40801-015-0028-3
64. Hollingworth SA, Ostino R, David MC, Martin JH, Tett SE. Ezetimibe: Use, costs, and adverse events in Australia. Cardiovascular Therapeutics. 2017;35(1):40–6. https://doi.org/10.1111/1755-5922.12236
65. Hopkins AM, Proudman SM, Vitry AI, Sorich MJ, Cleland LG, Wiese MD. Ten years of publicly funded biological disease-modifying antirheumatic drugs in Australia. Medical Journal of Australia. 2016;204(2):64–8.e1. https://doi.org/10.5694/mja15.00716
66. Hopkins AM, Vitry AI, O'Doherty CE, Proudman SM, Wiese MD. Changes to the Australian Pharmaceutical Benefit Scheme restrictions for biological disease-modifying antirheumatic drugs have influenced the use of leflunomide. International Journal of Rheumatic Diseases. 2017;20(11):1795–7. https://doi.org/10.1111/1756-185X.12717
67. Huang R, Petoumenos K, Gray RT, McManus H, Dharan N, Guy R, et al. National characteristics and trends in antiretroviral treatment in Australia can be accurately estimated using a large clinical cohort. Journal of Clinical Epidemiology. 2018;100:82–91. https://doi.org/10.1016/j.jclinepi.2018.04.015
68. Huang W, Castelino RL, Peterson GM. Adverse event notifications implicating metformin with lactic acidosis in Australia. Journal of diabetes and its complications. 2015;29(8):1261–5. https://doi.org/10.1016/j.jdiacomp.2015.06.001
69. I AW, Pratt NL, Kalisch LM, Roughead EE. Comparing time to adverse drug reaction signals in a spontaneous reporting database and a claims database: a case study of rofecoxib-induced myocardial infarction and rosiglitazone-induced heart failure signals in Australia. Drug safety. 2014;37(1):53–64. https://doi.org/10.1007/s40264-013-0124-9
70. Inacio MC, Hansen C, Pratt NL, Graves SE, Roughead EE. Risk factors for persistent and new chronic opioid use in patients undergoing total hip arthroplasty: a retrospective cohort study. BMJ Open. 2016;6(4):e010664. https://doi.org/10.1136/bmjopen-2015-010664
71. Inacio MC, Pratt NL, Roughead EE, Graves SE. Using Medications for Prediction of Revision after Total Joint Arthroplasty. Journal of Arthroplasty. 2015;30(12):2061–70. https://doi.org/10.1016/j.arth.2015.06.009

72. Inacio MC, Pratt NL, Roughead EE, Graves SE. Comparing co-morbidities in total joint arthroplasty patients using the RxRisk-V, Elixhauser, and Charlson Measures: a cross-sectional evaluation. BMC Musculoskeletal Disorders. 2015;16:385. https://doi.org/10.1186/s12891-015-0835-4
73. Inacio MC, Pratt NL, Roughead EE, Graves SE. Predicting Infections After Total Joint Arthroplasty Using a Prescription Based Comorbidity Measure. Journal of Arthroplasty. 2015;30(10):1692-8. https://doi.org/10.1016/j.arth.2015.05.004
74. Inacio MC, Pratt NL, Roughead EE, Paxton EW, Graves SE. Opioid use after total hip arthroplasty surgery is associated with revision surgery. BMC Musculoskeletal Disorders. 2016;17:122. https://doi.org/10.1186/s12891-016-0970-6
75. Inacio MCS, Cashman K, Pratt NL, Gillam MH, Caughey G, Graves SE, et al. Prevalence and changes in analgesic medication utilisation 1 year prior to total joint replacement in an older cohort of patients. Osteoarthritis and Cartilage. 2018;26(3):356–62. https://doi.org/10.1016/j.joca.2017.11.016
76. Inacio MCS, Pratt NL, Roughead EE, Graves SE. Evaluation of three co-morbidity measures to predict mortality in patients undergoing total joint arthroplasty. Osteoarthritis and Cartilage. 2016;24(10):1718–26. https://doi.org/10.1016/j.joca.2016.05.006
77. Islam M, Wollersheim D. Variation in Prescription Opioid Dispensing across Neighborhoods of Diverse Socioeconomic Disadvantages in Victoria, Australia. Pharmaceuticals. 2018;11(4):116. https://doi.org/10.3390/ph11040116
78. Islam MM, Conigrave KM, Day CA, Nguyen Y, Haber PS. Twenty-year trends in benzodiazepine dispensing in the Australian population. Internal Medicine Journal. 2014;44(1):57-64. https://doi.org/10.1111/imj.12315
79. Islam MM, McRae IS, Mazumdar S, Simpson P, Wollersheim D, Fatema K, et al. Prescription opioid dispensing in New South Wales, Australia: spatial and temporal variation. BMC Pharmacology and Toxicology. 2018;19(1). https://doi.org/10.1186/s40360-018-0219-0
80. Islam MM, McRae IS, Mazumdar S, Taplin S, McKetin R. Prescription opioid analgesics for pain management in Australia: 20years of dispensing.[Erratum appears in Intern Med J. 2016 Aug;46(8):963; PMID: 27553995]. Internal Medicine Journal. 2016;46(8):955–63. https://doi.org/10.1111/imj.12966
81. Jamolowicz AI, Chen HY, Panegyres PK. Statins and memory loss: An Australian experience. Australasian Medical Journal. 2015;8(3):73–9. https://doi.org/10.4066/AMJ.2015.2014
82. Jones G, Hall S, Bird P, Littlejohn G, Tymms K, Youssef P, et al. A retrospective review of the persistence on bDMARDs prescribed for the treatment of rheumatoid arthritis in the Australian population. International Journal of Rheumatic Diseases. 2018;21(8):1581–90. https://doi.org/10.1111/1756-185X.13243
83. Kalisch Ellett LM, Lim R, Pratt NL, Kerr M, Ramsay EN, LeBlanc TV, et al. Reducing hypnotic use in insomnia management among Australian veterans: results from repeated national interventions. BMC health services research. 2018;18(1):626. https://doi.org/10.1186/s12913-018-3443-9
84. Kalisch Ellett LM, Pratt NL, Barratt JD, Rowett D, Roughead EE. Risk of medication-associated initiation of oxybutynin in elderly men and women. Journal of the American Geriatrics Society. 2014;62(4):690–5. https://doi.org/10.1111/jgs.12741
85. Kalisch Ellett LM, Pratt NL, Kerr M, Roughead EE. Antipsychotic polypharmacy in older Australians. International Psychogeriatrics. 2018;30(4):539–46. https://doi.org/10.1017/S1041610217001934
86. Kalisch Ellett LM, Pratt NL, Le Blanc VT, Westaway K, Roughead EE. Increased risk of hospital admission for dehydration or heat-related illness after initiation of medicines: a sequence symmetry analysis. Journal of Clinical Pharmacy & Therapeutics. 2016;41(5):503–7. https://doi.org/10.1111/jcpt.12418
87. Kalisch Ellett LM, Pratt NL, Ramsay EN, Barratt JD, Roughead EE. Multiple anticholinergic medication use and risk of hospital admission for confusion or dementia. Journal of the American Geriatrics Society. 2014;62(10):1916–22. https://doi.org/10.1111/jgs.13054
88. Kalisch Ellett LM, Pratt NL, Ramsay EN, Sluggett JK, Barratt JD, Roughead EE. Central Nervous System-Acting Medicines and Risk of Hospital Admission for Confusion, Delirium, or Dementia. Journal of the American Medical Directors Association. 2016;17(6):530–4. https://doi.org/10.1016/j.jamda.2016.02.008
89. Kalisch Ellett LM, Pratt NL, Sluggett JK, Ramsay EN, Kerr M, Leblanc VT, et al. Sustaining practice change in health care: the impact of a national quality improvement program on the uptake of collaborative medicines reviews. Journal of Pharmacy Practice and Research. 2018;48(3):222–30. https://doi.org/10.1002/jppr.1379
90. Kalisch Ellett LM, Pratt NL, Sluggett JK, Ramsay EN, Kerr M, Leblanc VT, et al. Patient-specific prescriber feedback can increase the rate of osteoporosis screening and treatment: results from two national interventions. Archives of Osteoporosis. 2017;12(1). https://doi.org/10.1007/s11657-017-0309-4
91. Karanges EA, Blanch B, Buckley NA, Pearson SA. Twenty-five years of prescription opioid use in Australia: a whole-of-population analysis using pharmaceutical claims. British Journal of Clinical Pharmacology. 2016;82:255–67. https://doi.org/10.1111/bcp.12937
92. Karanges EA, Buckley NA, Brett J, Blanch B, Litchfield M, Degenhardt L, et al. Trends in opioid utilisation in Australia, 2006-2015: Insights from multiple metrics. Pharmacoepidemiology and Drug Safety. 2018;27(5):504–12. https://doi.org/10.1002/pds.4369
93. Karanges EA, Stephenson CP, McGregor IS. Longitudinal trends in the dispensing of psychotropic medications in Australia from 2009-2012: Focus on children, adolescents and prescriber specialty. Australian and New Zealand Journal of Psychiatry. 2014;48(10):917–31.
94. Keen P, Gray RT, Telfer B, Guy R, Schmidt H-M, Whittaker B, et al. The 2016 HIV diagnosis and care cascade in New South Wales, Australia: meeting the UNAIDS 90-90-90 targets. Journal of the International AIDS Society. 2018;21(4):e25109. https://doi.org/10.1002/jia2.25109
95. Kelly E, Lu CY, Albertini S, Vitry A. Longitudinal trends in utilization of endocrine therapies for breast cancer: an international comparison. Journal of Clinical Pharmacy

& Therapeutics. 2015;40(1):76–82. https://doi.org/10.1177/0004867414538675
96. Kemp-Casey A, Pratt N, Ramsay E, Roughead EE. Using Post-market Utilisation Analysis to Support Medicines Pricing Policy: An Australian Case Study of Aflibercept and Ranibizumab Use. Applied Health Economics and Health Policy. 2019;17(3):411–7. https://doi.org/10.1007/s40258-018-0440-4
97. Khan I, Patel HC, Nanayakkara S, Raju H, Voskoboinik A, Mariani JA. Trends in outpatient anti-arrhythmic prescriptions for atrial fibrillation and left atrial ablation in Australia: 1997-2016. Internal Medicine Journal. 2018;48(4):427–32. https://doi.org/10.1111/imj.13706
98. Kjosavik SR, Gillam MH, Roughead EE. Average duration of treatment with antidepressants among concession card holders in Australia. Australian & New Zealand Journal of Psychiatry. 2016;50(12):1180–5. https://doi.org/10.1177/0004867415621392
99. Kjosavik SR, Gillam MH, Roughead EE. Average duration of treatment with antipsychotics among concession card holders in Australia. Australian & New Zealand Journal of Psychiatry. 2017;51(7):719–26. https://doi.org/10.1177/0004867417691851
100. Kumar SS, McManus H, Radovich T, Greenfield JR, Viardot A, Williams KM, et al. Interrogation of a longitudinal, national pharmacy claims dataset to explore factors that predict the need for add-on therapy in older and socioeconomically disadvantaged Australians with type 2 diabetes mellitus patients (T2DM). European Journal of Clinical Pharmacology. 2018;74(10):1327–32. https://doi.org/10.1007/s00228-018-2506-5
101. Lai ECC, Shin JY, Kubota K, Man KKC, Park BJ, Pratt N, et al. Comparative safety of NSAIDs for gastrointestinal events in Asia-Pacific populations: A multi-database, international cohort study. Pharmacoepidemiology and Drug Safety. 2018;27(11):1223–30. https://doi.org/10.1002/pds.4663
102. Lalic S, Gisev N, Bell JS, Korhonen MJ, Ilomaki J. Predictors of persistent prescription opioid analgesic use among people without cancer in Australia. British Journal of Clinical Pharmacology. 2018;84(6):1267–78. https://doi.org/10.1111/bcp.13556
103. Langton JM, Goldsbury D, Srasuebkul P, Ingham JM, O'Connell DL, Pearson SA. Insights from linking routinely collected data across Australian health jurisdictions: a case study of end-of-life health service use. Public health research & practice. 2018;28(1). https://doi.org/10.17061/phrp2811806
104. Langton JM, Reeve R, Srasuebkul P, Haas M, Viney R, Currow D, et al. Health service use and costs in the last 6 months of life in elderly decedents with a history of cancer: a comprehensive analysis from a health payer perspective. British journal of cancer. 2016;114(11):1293–302. https://doi.org/10.1038/bjc.2016.75
105. Langton JM, Srasuebkul P, Reeve R, Parkinson B, Gu Y, Buckley NA, et al. Resource use, costs and quality of end-of-life care: observations in a cohort of elderly Australian cancer decedents. Implementation Science. 2015;10(1):25. https://doi.org/10.1186/s13012-014-0148-2
106. Leach MJ, Pratt NL, Roughead EE. Medicine use among older Australians before and after hip fracture. Journal of Pharmacy Practice and Research. 2013;43(4):265–8. https://doi.org/10.1002/j.2055-2335.2013.tb00271.x
107. Leach MJ, Pratt NL, Roughead EE. Psychoactive medicine use and the risk of hip fracture in older people: a case-crossover study. Pharmacoepidemiology & Drug Safety. 2015;24(6):576–82. https://doi.org/10.1002/pds.3785
108. Leach MJ, Pratt NL, Roughead EE. The Risk of Hip Fracture Due to Mirtazapine Exposure When Switching Antidepressants or Using Other Antidepressants as Add-On Therapy. Drugs - Real World Outcomes. 2017;4(4):247–55. https://doi.org/10.1007/s40801-017-0120-y
109. Leach MJ, Pratt NL, Roughead EE. Risk of Hip Fracture in Older People Using Selective Serotonin Reuptake Inhibitors and Other Psychoactive Medicines Concurrently: A Matched Case-Control Study in Australia. Drugs - Real World Outcomes. 2017;4(2):87–96. https://doi.org/10.1007/s40801-017-0107-8
110. Lee J, Pilgrim J, Gerostamoulos D, Robinson J, Wong A. Increasing rates of quetiapine overdose, misuse, and mortality in Victoria, Australia. Drug and Alcohol Dependence. 2018;187:95–9. https://doi.org/10.1016/j.drugalcdep.2018.03.002
111. Lim R, Kerr M, Roughead EE. Use of medicines and health services for chronic obstructive pulmonary disease among a cohort of Australians over 50 years. International Journal of COPD. 2018;13:3085–93. https://doi.org/10.2147/COPD.S172495
112. MacIntyre R, Stein A, Harrison C, Britt H, Mahimbo A, Cunningham A. Increasing trends of herpes zoster in Australia.[Erratum appears in PLoS One. 2015;10(6):e0129872; PMID: 26038831]. PLoS ONE [Electronic Resource]. 2015;10(4):e0125025. https://doi.org/10.1371/journal.pone.0125025
113. Mellish L, Karanges EA, Litchfield MJ, Schaffer AL, Blanch B, Daniels BJ, et al. The Australian Pharmaceutical Benefits Scheme data collection: a practical guide for researchers. BMC Research Notes. 2015;8:634. https://doi.org/10.1186/s13104-015-1616-8
114. Meumann EM, Mitchell BG, McGregor A, McBryde E, Cooley L. Urinary Escherichia coli antimicrobial susceptibility profiles and their relationship with community antibiotic use in Tasmania, Australia. International Journal of Antimicrobial Agents. 2015;46(4):389–93. https://doi.org/10.1016/j.ijantimicag.2015.05.015
115. Moon J, Kumar SS, Graham GG, Baysari MT, Williams KM, Chen W, et al. Trends in metformin utilisation and dose appropriateness in Australia. European Journal of Clinical Pharmacology. 2016;72(12):1489–96. https://doi.org/10.1007/s00228-016-2117-y
116. Morgan A, Joshy G, Schaffer A, Laba T-L, Litchfield M, Pearson S, et al. Rapid and substantial increases in anticoagulant use and expenditure in Australia following the introduction of new types of oral anticoagulants. PLOS ONE. 2018;13(12):e0208824. https://doi.org/10.1371/journal.pone.0208824
117. Morley KC, Logge W, Pearson SA, Baillie A, Haber PS. National trends in alcohol pharmacotherapy: Findings from an Australian claims database. Drug and Alcohol Dependence. 2016;166:254–7. https://doi.org/10.1016/j.drugalcdep.2016.06.027

118. Morley KC, Logge W, Pearson S-A, Baillie A, Haber PS. Socioeconomic and geographic disparities in access to pharmacotherapy for alcohol dependence. Journal of Substance Abuse Treatment. 2017;74:23–5. https://doi.org/10.1016/j.jsat.2016.12.004
119. Ng HS, Koczwara B, Roder D, Vitry A. Development of comorbidities in men with prostate cancer treated with androgen deprivation therapy: an Australian population-based cohort study. Prostate Cancer and Prostatic Diseases. 2018;21(3):403–10. https://doi.org/10.1038/s41391-018-0036-y
120. Ng HS, Koczwara B, Roder DM, Niyonsenga T, Vitry AI. Comorbidities in Australian women with hormone-dependent breast cancer: A population-based analysis. Medical Journal of Australia. 2018;208(1):24–8. https://doi.org/10.5694/mja17.00006
121. Nguyen TA, Caughey G, Pratt N, Shakib S, Kemp A, Roughead E. Hospitalization for drug-induced hepatotoxicity: linking Y-codes with pharmaceutical claims data to identify implicated medicines. Journal of Clinical Pharmacy & Therapeutics. 2015;40(2):213–9. https://doi.org/10.1111/jcpt.12249
122. Niyomnaitham S, Page A, La Caze A, Whitfield K, Smith AJ. Utilisation trends of rosiglitazone and pioglitazone in Australia before and after safety warnings. BMC health services research. 2014;14:151. https://doi.org/10.1186/1472-6963-14-151
123. Ofori-Asenso R, Ilomaki J, Curtis A, Zomer E, Zoungas S, Liew D. Patterns of Medication Dispensation for Multiple Comorbidities among Older Adults in Australia. Pharmacy. 2018;6(4):134. https://doi.org/10.3390/pharmacy6040134
124. Ofori-Asenso R, Ilomaki J, Tacey M, Zomer E, Curtis AJ, Bell JS, et al. Patterns of statin use and long-term adherence and persistence among older adults with diabetes. Journal of Diabetes. 2018;10(9):699–707. https://doi.org/10.1111/1753-0407.12769
125. Ofori-Asenso R, Ilomaki J, Zomer E, Curtis AJ, Zoungas S, Liew D. A 10-Year Trend in Statin Use Among Older Adults in Australia: an Analysis Using National Pharmacy Claims Data. Cardiovascular Drugs and Therapy. 2018;32(3):265–72. https://doi.org/10.1007/s10557-018-6794-x
126. Ortiz M, Calcino G, Dunagan F. Prescription usage patterns of two formulations of paracetamol in osteoarthritis: Australia-wide experience 2008–11. Australian Family Physician. 2016;45(5):321–5.
127. Parkinson B, Viney R, Haas M, Goodall S, Srasuebkul P, Pearson SA. Real-World Evidence: A Comparison of the Australian Herceptin Program and Clinical Trials of Trastuzumab for HER2-Positive Metastatic Breast Cancer. Pharmacoeconomics. 2016;34(10):1039–50. https://doi.org/10.1007/s40273-016-0411-2
128. Pearson SA, Abrahamowicz M, Srasuebkul P, Buckley NA. Antidepressant therapy in cancer patients: initiation and factors associated with treatment. Pharmacoepidemiology & Drug Safety. 2015;24(6):600–9. https://doi.org/10.1002/pds.3753
129. Pearson SA, Schaffer A. The use and impact of cancer medicines in routine clinical care: Methods and observations in a cohort of elderly Australians. BMJ Open. 2014;4(5). https://doi.org/10.1136/bmjopen-2013-004099
130. Perera M, Papa N, Christidis D, McGrath S, Manning T, Roberts M, et al. The impact of the global bacille Calmette-Guerin shortage on treatment patterns: population-based data. BJU International. 2018;121(2):169–72. https://doi.org/10.1111/bju.14065
131. Pratt N, Chan EW, Choi NK, Kimura M, Kimura T, Kubota K, et al. Prescription sequence symmetry analysis: assessing risk, temporality, and consistency for adverse drug reactions across datasets in five countries. Pharmacoepidemiology & Drug Safety. 2015;24(8):858–64. https://doi.org/10.1002/pds.3780
132. Pratt NL, Kalisch Ellett LM, Sluggett JK, Gadzhanova SV, Ramsay EN, Kerr M, et al. Use of proton pump inhibitors among older Australians: National quality improvement programmes have led to sustained practice change. International Journal for Quality in Health Care. 2017;29(1):75–82. https://doi.org/10.1093/intqhc/mzw138
133. Pratt NL, Kalisch Ellett LM, Sluggett JK, Ramsay EN, Kerr M, LeBlanc VT, et al. Commitment questions targeting patients promotes uptake of under-used health services: Findings from a national quality improvement program in Australia. Social Science & Medicine. 2015;145:1–6. https://doi.org/10.1016/j.socscimed.2015.09.019
134. Pratt NL, Kerr M, Barratt JD, Kemp-Casey A, Kalisch Ellett LM, Ramsay E, et al. The validity of the Rx-Risk Comorbidity Index using medicines mapped to the Anatomical Therapeutic Chemical (ATC) Classification System. BMJ Open. 2018;8(4):e021122. https://doi.org/10.1136/bmjopen-2017-021122
135. Pratt NL, Ramsay EN, Caughey GE, Shakib S, Roughead EE. Uptake of novel oral anticoagulants in Australia. Medical Journal of Australia. 2016;204(3):104–5.e1. https://doi.org/10.5694/mja15.01000
136. Pratt NL, Ramsay EN, Kalisch Ellett LM, Nguyen TA, Barratt JD, Roughead EE. Association between use of multiple psychoactive medicines and hospitalization for falls: Retrospective analysis of a large healthcare claim database. Drug Safety. 2014;37(7):529–35. https://doi.org/10.1007/s40264-014-0179-2
137. Pratt NL, Ramsay EN, Kalisch Ellett LM, Nguyen TA, Roughead EE. Association between Ophthalmic Timolol and Hospitalisation for Bradycardia. Journal of ophthalmology. 2015;2015:567387. https://doi.org/10.1155/2015/567387
138. Pratt NL, Ramsay EN, Kemp A, Kalisch-Ellett LM, Shakib S, Caughey GE, et al. Ranibizumab and Risk of Hospitalisation for Ischaemic Stroke and Myocardial Infarction in Patients with Age-Related Macular Degeneration: A Self-Controlled Case-Series Analysis. Drug Safety. 2014;37(12):1021–7. https://doi.org/10.1007/s40264-014-0231-2
139. Price SD, Holman CD, Sanfilippo FM, Emery JD. Are older Western Australians exposed to potentially inappropriate medications according to the Beers Criteria? A 13-year prevalence study. Australasian journal on ageing. 2014;33(3):E39–48. https://doi.org/10.1111/ajag.12136
140. Price SD, Holman CD, Sanfilippo FM, Emery JD. Association between potentially inappropriate medications from the Beers criteria and the risk of unplanned hospitalization in elderly patients. The Annals of pharmacotherapy. 2014;48(1):6–16. https://doi.org/10.1177/1060028013504904

141. Price SD, Holman CD, Sanfilippo FM, Emery JD. Does ongoing general practitioner care in elderly patients help reduce the risk of unplanned hospitalization related to Beers potentially inappropriate medications? Geriatrics & gerontology international. 2015;15(8):1031–9. https://doi.org/10.1111/ggi.12400
142. Qin X, Hung J, Knuiman M, Teng THK, Briffa T, Sanfilippo FM. Evidence-based pharmacotherapies used in the postdischarge phase are associated with improved one-year survival in senior patients hospitalized with heart failure. Cardiovascular Therapeutics. 2018;36(6):e12464. https://doi.org/10.1111/1755-5922.12464
143. Qin X, Teng THK, Hung J, Briffa T, Sanfilippo FM. Long-term use of secondary prevention medications for heart failure in Western Australia: A protocol for a population-based cohort study. BMJ Open. 2016;6 (11) (no pagination) (e006258). https://doi.org/10.1136/bmjopen-2016-014397
144. Raman SR, Man KKC, Bahmanyar S, Berard A, Bilder S, Boukhris T, et al. Trends in attention-deficit hyperactivity disorder medication use: a retrospective observational study using population-based databases. The Lancet Psychiatry. 2018;5(10):824–35. https://doi.org/10.1016/s2215-0366(18)30293-1
145. Ramsay EN, Pratt NL, Ryan P, Roughead EE. Proton pump inhibitors and the risk of pneumonia: a comparison of cohort and self-controlled case series designs. BMC medical research methodology. 2013;13:82. https://doi.org/10.1186/1471-2288-13-82
146. Reeve R, Srasuebkul P, Langton JM, Haas M, Viney R, Pearson SA. Health care use and costs at the end of life: a comparison of elderly Australian decedents with and without a cancer history. BMC palliative care. 2017;17(1):1. https://doi.org/10.1186/s12904-017-0213-0
147. Roper L, Tran DT, Einarsdóttir K, Preen DB, Havard A. Algorithm for resolving discrepancies between claims for smoking cessation pharmacotherapies during pregnancy and smoking status in delivery records: The impact on estimates of utilisation. PLOS ONE. 2018;13(8):e0202999. https://doi.org/10.1371/journal.pone.0202999
148. Roughead EE, Chan EW, Choi NK, Griffiths J, Jin XM, Lee J, et al. Proton pump inhibitors and risk of Clostridium difficile infection: a multi-country study using sequence symmetry analysis. Expert Opinion on Drug Safety. 2016;15(12):1589–95. https://doi.org/10.1080/14740338.2016.1238071
149. Roughead EE, Chan EW, Choi NK, Kimura M, Kimura T, Kubota K, et al. Variation in Association Between Thiazolidinediones and Heart Failure Across Ethnic Groups: Retrospective analysis of Large Healthcare Claims Databases in Six Countries. Drug Safety. 2015;38(9):823–31. https://doi.org/10.1007/s40264-015-0318-4
150. Roughead EE, Kalisch Ellett LM, Ramsay EN, Pratt NL, Barratt JD, LeBlanc VT, et al. Bridging evidence-practice gaps: improving use of medicines in elderly Australian veterans. BMC Health Services Research. 2013;13:514. https://doi.org/10.1186/1472-6963-13-514
151. Roughead EE, Kim DS, Ong B, Kemp-Casey A. Pricing policies for generic medicines in Australia, New Zealand, the Republic of Korea and Singapore: patent expiry and influence on atorvastatin price. WHO South-East Asia journal of public health. 2018;7(2):99–106. https://doi.org/10.4103/2224-3151.239421
152. Roughead EE, Pratt NL, Kalisch Ellett LM, Ramsay EN, Barratt JD, Morris P, et al. Posttraumatic Stress Disorder, Antipsychotic Use and Risk of Dementia in Veterans. Journal of the American Geriatrics Society. 2017;65(7):1521–6. https://doi.org/10.1111/jgs.14837
153. Rowell D, Nghiem S, Ramagopalan S, Meier UC. Seasonal temperature is associated with Parkinson's disease prescriptions: an ecological study. International journal of biometeorology. 2017;61(12):2205–11. https://doi.org/10.1007/s00484-017-1427-9
154. Roxburgh A, Hall WD, Dobbins T, Gisev N, Burns L, Pearson S, et al. Trends in heroin and pharmaceutical opioid overdose deaths in Australia. Drug and alcohol dependence. 2017;179:291–8. https://doi.org/10.1016/j.drugalcdep.2017.07.018
155. Schaffer AL, Buckley NA, Cairns R, Pearson SA. Interrupted time series analysis of the effect of rescheduling alprazolam in Australia: Taking control of prescription drug use. JAMA Internal Medicine. 2016;176(8):1223–5. https://doi.org/10.1001/jamainternmed.2016.2992
156. Schaffer AL, Buckley NA, Degenhardt L, Larance B, Cairns R, Dobbins TA, et al. Person-level changes in oxycodone use after the introduction of a tamper-resistant formulation in Australia. CMAJ. 2018;190(12):E355–E62. https://doi.org/10.1503/cmaj.170666
157. Schaffer AL, Buckley NA, Dobbins TA, Banks E, Pearson SA. The crux of the matter: Did the ABC's Catalyst program change statin use in Australia? Medical Journal of Australia. 2015;202(11):591–5. https://doi.org/10.5694/mja15.00103
158. Schaffer AL, Buckley NA, Pearson SA. Who benefits from fixed-dose combinations? Two-year statin adherence trajectories in initiators of combined amlodipine/atorvastatin therapy. Pharmacoepidemiology and Drug Safety. 2017;26(12):1465–73. https://doi.org/10.1002/pds.4342
159. Schaffer AL, Pearson SA, Buckley NA. How does prescribing for antihypertensive products stack up against guideline recommendations? An Australian population-based study (2006-2014). British Journal of Clinical Pharmacology. 2016;82(4):1134–45. https://doi.org/10.1111/bcp.13043
160. Schaffer AL, Pearson SA, Dobbins TA, Er CC, Ward RL, Vajdic CM. Patterns of care and survival after a cancer of unknown primary (CUP) diagnosis: A population-based nested cohort study in Australian Government Department of Veterans' Affairs clients. Cancer epidemiology. 2015;39(4):578–84. https://doi.org/10.1016/j.canep.2015.02.007
161. Seaman KL, Sanfilippo FM, Roughead EE, Bulsara MK, Kemp-Casey A, Bulsara C, et al. Impact of consumer copayments for subsidised medicines on health services use and outcomes: a protocol using linked administrative data from Western Australia. BMJ Open. 2017;7(6):e013691. https://doi.org/10.1136/bmjopen-2016-013691
162. Simons LA, Chung E. Are high coronary risk patients missing out on lipid-lowering drugs in Australia? Medical Journal of Australia. 2014;201(4):213–6. Are high coronary risk patients missing out on lipid-lowering drugs in Australia?
163. Simons LA, Chung E, Ortiz M. Long-term persistence with single-pill, fixed-dose combination therapy versus two pills of amlodipine and perindopril for hypertension:

Australian experience. Current Medical Research and Opinion. 2017;33(10):1783–7. https://doi.org/10.1080/03007995.2017.1367275
164. Simons LA, Ortiz M, Freedman B, Waterhouse BJ, Colquhoun D. Medium- to long-term persistence with non-vitamin-K oral anticoagulants in patients with atrial fibrillation: Australian experience. Current Medical Research and Opinion. 2017;33(7):1337–41. https://doi.org/10.1080/03007995.2017.1321535
165. Simons LA, Ortiz M, Freedman SB, Waterhouse BJ, Colquhoun D, Thomas G. Improved persistence with non-vitamin-K oral anticoagulants compared with warfarin in patients with atrial fibrillation: recent Australian experience. Current Medical Research & Opinion. 2016;32(11):1857–61. https://doi.org/10.1080/03007995.2016.1218325
166. Sluggett JK, Caughey GE, Ward MB, Gilbert AL. Antithrombotic use following transient ischaemic attack or ischaemic stroke among older Australians with atrial fibrillation. Internal medicine journal. 2014;44(11):1134–7. https://doi.org/10.1111/imj.12582
167. Sluggett JK, Caughey GE, Ward MB, Gilbert AL. Use of secondary stroke prevention medicines in Australia: National trends, 2003-2009. Medical Journal of Australia. 2014;201(1):54–7. https://doi.org/10.5694/mja13.00186
168. Sluggett JK, Caughey GE, Ward MB, Gilbert AL. Medicines taken by older Australians after transient ischaemic attack or ischaemic stroke: a retrospective database study. International Journal of Clinical Pharmacy. 2015;37(5):782-9. https://doi.org/10.1007/s11096-015-0115-2
169. Thai LP, Moss JR, Godman B, Vitry AI. Cost driver analysis of statin expenditure on Australia's Pharmaceutical Benefits Scheme. Expert Review of Pharmacoeconomics & Outcomes Research. 2016;16(3):419-33. https://doi.org/10.1586/14737167.2016.1136790
170. Thai LP, Vitry AI, Moss JR. Pricing and utilisation of proton pump inhibitors in South Australian public hospitals and the Pharmaceutical Benefits Scheme. Journal of Pharmacy Practice and Research. 2016;46(2):130–6. https://doi.org/10.1002/jppr.1114
171. Thai LP, Vitry AI, Moss JR. Price and utilisation differences for statins between four countries. Expert Review of Pharmacoeconomics and Outcomes Research. 2018;18(1):71–81. https://doi.org/10.1080/14737167.2017.1366856
172. Tran DT, Havard A, Jorm LR. Data cleaning and management protocols for linked perinatal research data: a good practice example from the Smoking MUMS (Maternal Use of Medications and Safety) Study. BMC medical research methodology. 2017;17(1):97. https://doi.org/10.1186/s12874-017-0385-6
173. Turkstra E, Bettington E, Donohue ML, Mervin MC. Pharmaceutical benefits advisory committee recommendations in Australia. International Journal of Technology Assessment in Health Care. 2017;33(4):521–8. https://doi.org/10.1017/S0266462317000617
174. Vajdic CM, Schaffer AL, Dobbins TA, Ward RL, Er CC, Pearson SA. Health service utilisation and investigations before diagnosis of cancer of unknown primary (CUP): A population-based nested case-control study in Australian Government Department of Veterans' Affairs clients. Cancer epidemiology. 2015;39(4):585–92. https://doi.org/10.1016/j.canep.2015.02.006
175. Vitry AI, Nguyen TA, Ramsay EN, Caughey GE, Gilbert AL, Shakib S, et al. General practitioner management plans delaying time to next potentially preventable hospitalisation for patients with heart failure. Internal Medicine Journal. 2014;44(11):1117–23. https://doi.org/10.1111/imj.12512
176. Wagemaakers FN, Hollingworth SA, Kreijkamp-Kaspers S, Tee EHL, Leendertse AJ, van Driel ML. Opioid analgesic use in Australia and The Netherlands: a cross-country comparison. International Journal of Clinical Pharmacy. 2017;39(4):874–80. https://doi.org/10.1007/s11096-017-0492-9
177. Wahab IA, Pratt NL, Ellett LK, Roughead EE. Sequence Symmetry Analysis as a Signal Detection Tool for Potential Heart Failure Adverse Events in an Administrative Claims Database. Drug Safety. 2016;39(4):347-54. https://doi.org/10.1007/s40264-015-0391-8 178
178. Whitely M, Lester L, Phillimore J, Robinson S. Influence of birth month on the probability of western australian children being treated for ADHD. Medical Journal of Australia. 2017;206(2):85. https://doi.org/10.5694/mja17.00165
179. Wu J, Taylor D, Ovchinikova L, Heaney A, Morgan T, Dartnell J, et al. Relationship between antimicrobial-resistance programs and antibiotic dispensing for upper respiratory tract infection: An analysis of Australian data between 2004 and 2015. Journal of International Medical Research. 2018;46(4):1326–38. https://doi.org/10.1177/0300060517740813
180. Zhan C, Roughead E, Liu L, Pratt N, Li J. A data-driven method to detect adverse drug events from prescription data. Journal of Biomedical Informatics. 2018;85:10–20. https://doi.org/10.1016/j.jbi.2018.07.013

Supplementary Appendix D: Details of included studies features by study focus and analytical approach

First author, year of publication	Study aim	Data source	Study period (duration)	Primary outcome measure
Drug Utilisation by drug, age and gender				
Claims-level (14 studies)				
Bingham, 2018 [12]	Levonorgestrel-releasing intra-uterine device prescribing	PBS ad hoc extracts (DHS) ABS	2008–2012 (4 years and 10 months)	Annual prescription rates per 1000 women by age and location
Gisev, 2018 [49]	Quantify the extent in which subsidised medicine data underestimate prescription-only and total opioid utilisation	DUSC IMS Health	2010–2014 (5 years)	Difference (%) in opioid utilisation in PBS/RPBS and IMS Health data, calculated using OME
Karanges, 2018 [92]	Opioid prescribing according to three volume-based metrics and a person-based metric	PBS 10% sample, DUSC	2006–2015 (10 years)	Annual opioid use (DDD/1000 pop/day OME/1000 pop/day No. opioid dispensings/1000 pop No. persons dispensed opioids/1000 pop
Khan, 2018 [97]	Trends in rhythm control for atrial fibrillation	PBS Online (ASM) MBS Online	1997–2016 (20 years)	No. (%) of prescriptions of antiarrhythmic drugs and atrial fibrillation ablations/pop/year
Lee, 2018 [110]	Determine current trends in quetiapine overdose, misuse and mortality.	PBS Online (ASM) VIC Poisonings Information Centre Mortality data	2000–2015 (16 years)	No. of calls for quetiapine poisonings and% of overdoses No. (%) of quetiapine mortality cases No. prescriptions (DDDs)
Perera, 2018 [130]	Intravesical bacille Calmette–Guérin prescribing in Australia during fluctuations in global availability	PBS Online (Medicare) MBS Online	2006–2016 (11 years)	No. prescriptions per month per clinical indication
Eyre, 2017 [37]	Triptan derivatives prescribing compared with available international data	PBS Online (Medicare, Section 85 DoS/DoP) Centrelink Income Assistance data	1997–2015 (19 years)	Annual DDD/1000 concessional beneficiaries/day
Ford, 2017 [39]	Antimicrobial medicines prescribing by dental practitioners	PBS Online (Medicare) (concession) ABS Centrelink Income Assistance data	2001–2012 (12 years)	DDD/1000 concessional beneficiaries/day by medicine and year
Hollingworth, 2017 [61]	Non-antimicrobial medicines prescribing by dental practitioners	PBS Online (Medicare) (concession) ABS Centrelink Income Assistance data	2001–2012 (12 years)	DDD/1000 concessional beneficiaries/day Yearly % change in utilisation rates
Turkstra, 2017 [173]	Examine submissions made to the Pharmaceutical Benefits Advisory Committee and assess whether the predicted financial impact and utilisation was associated with a recommendation	PBS Online (Medicare)	2012–2014 (3 years)	No. submissions accepted, rejected, or deferred No. predicted vs observed prescriptions $AUD and *e* EUR predicted vs observed expenditure
Hopkins, 2016 [65]	Trends in biological disease-modifying antirheumatic drug use and expenditure for rheumatoid arthritis	PBS Online (Medicare) ABS	2000–2014 (15 years)	Annual DDD/1000 pop/day by drug group Annual PBS expenditure
Thai, 2016 [169]	Influence of policies and drivers affecting PBS statin utilisation and expenditure	PBS Online (Medicare) ABS	1992–2013 (22 years)	Monthly expenditure/prescription Annual DDD/1000 pop/day
Barozzi, 2015 [6]	Change in COX-2 inhibitors dispensing after rofecoxib withdrawal and bisphosphonates dispensing	PBS Online (Medicare) ABS Centrelink Pharmaceutical Industry Marketing Expenditure	2000–2012 (13 years)	Annual, quarterly and/or monthly DDD/1000 pop/day of COX-2 inhibitors and bisphosphonates by drug
Hasan, 2015 [58]	Diabetes prevalence and anti-diabetic medication dispensing (Australia and Malaysia)	PBS Online (ASM) Other international dispensing data	2004–2008 (5 years)	Annual antidiabetic use (DDD/1000 pop/day), overall, by drug and country

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Supplementary Appendix D: Continued

First author, year of publication	Study aim	Data source	Study period (duration)	Primary outcome measure
Extended drug utilisation Claims (22 studies)				
De Graaff, 2018 [35]	Uptake and financial impact of direct-acting antiviral agents	PBS Online (Medicare) ABS NNDSS	2016–2017 (1 year and 6 months)	Total no. of prescriptions Prescriptions per 100000 pop by jurisdiction Expenditure costs ($AUD per medicine)
Islam, 2018 [77]	Relationship between opioid dispensings and neighbourhood-disadvantage-index, and standardised doses	PBS ad hoc extracts (VIC only) ABS VIC Cancer Registry	2013–2015 (3 years)	DDD/1000 pop/day
Islam, 2018 [79]	Trends in prescription opioid dispensing, identified high dispensing areas and factors associated with the doses dispensed	PBS ad hoc extracts (NSW, ACT only) ABS	2013–2015 (3 years)	% of persons dispensed opioids No. of prescriptions over time in DDD/1000 pop/day
Thai, 2018 [171]	Compare the prices and utilisation of statins with three international countries	PBS Online (Section 85 DoS) Other international dispensing data	2011–2013 (3 years)	Statin DDD/1000/day per year by country Weighted average strengths per year by country Price indices per year and country (using unit price and utilisation measures)
Islam, 2016 [80]	Trends and types of opioid prescribing and geographic variations	PBS Online (ASM, not specified) ABS	1992–2011 (20 years)	Annual DDD/1000 pop/day by state Trends in dispensing and seasonal variations Differences between states in dispensing trends
Berecki-Gisolf, 2017 [10]	Trends in opioid prescribing and poisoning resulting in hospitalisation or death in Victoria, Australia	PBS ad hoc extracts (VIC only) ABS, VIC Admitted Episodes Data Cause of Death Unit Record File	2006–2013 (8 years)	Annual opioid dispensings per residential pop by age group and gender No. events (deaths, admissions) per 1,000,000 person-years by age group, gender and year % change in rates per year
Hollingworth, 2017 [64]	Ezetimibe use and reported adverse events	PBS Online (Medicare) ABS DAEN	2004–2015 (12 years)	Annual DDD/1000 pop/day by state % average yearly increase in utilisation No. (%) adverse events by organ class system
Wagemaakers 2017 [176]	Compare the use of opioids in two countries	PBS Online (ASM) International dispensing data	2000–2014 (15 years)	Annual DDD/1000 pops/day Annual (%) change in prescribing
Berling, 2016 [11]	Compare trends in prescriptions and overdoses of antipsychotic medicines in Hunter, NSW region	PBS Online (ASM) (NSW only) Hunter Toxicology Admissions	1990–2011 (22 years)	Rates of antipsychotic overdose by class and subclass No. overdoses per 100,000/pop/year Annual DDD/1000/day
Bingham, 2016 [13]	Trends in etonogestrel-releasing subdermal implant prescribing and associated factors	PBS ad hoc extracts (DHS)	2008–2012 (4 years and 10 months)	Annual rate of prescription per 1000 women by age group, remoteness, no. of Aboriginal medical services and family planning clinic
Cairns, 2016 [24]	Trends in overdoses with medications used to treat attention deficit hyperactivity disorder	PBS Online (not specified) NSW Poisonings Information Centre	2004–2014 (11 years)	Average annual % change Calls due to ADHD by demographics, no. of exposures, coingestants, route and disposition Annual DDD/1000 pop/day by medicine
Degenhardt, 2016 [36]	Total opioid utilisation (PBS subsidized and over the counter) and sociodemographic correlates of use	PBS Online (Section 85 DoS) IMS Health ABS	2013 (12 months)	No. packs sold (%) and dispensing by medicine type and location No. packs sold per person by location and medicine Annual OME mg per person by location and medicine
Gardiner, 2016 [45]	Immunosuppressants in transplant recipients compared to European countries	PBS Online (Medicare) ABS HSD Expenditure Reports Other international drug and population datasets	2007–2013 (7 years)	Annual DDD/1000 pop/day

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Supplementary Appendix D: Continued

First author, year of publication	Study aim	Data source	Study period (duration)	Primary outcome measure
Hawke, 2016 [59]	Trends in consumer help-seeking about antibiotics in relation to age and antibiotic utilisation	PBS Online (ASM) Medicines call centre data BEACH-GP Survey ABS	2002–2010 (7 years and 10 months)	Calls per 100,000 people/population by medicine and other characteristics No of calls per 100,000 ASM prescriptions Ratio of the % of Medicines Line calls to the % of BEACH prescriptions for a specific antibiotic
Thai, 2016 [170]	Community and hospital differences in proton pump inhibitor utilisation and pricing	PBS Online (Medicare) Hospital Sales data	2011–2012 (2 years)	Average weighted price per DDD DDD/1000 persons/day
Forrester, 2015 [40]	Trends in community and hospital clozapine use	PBS Online (Medicare) (QLD only) QLD Hospital data, ABS	2004–2013 (10 years)	Number of clozapine dispensings, by year and data source Prevalence of initiators (people/100,000 pop/year) Median duration of treatment and % ceasing treatment
Hollingworth, 2015 [62]	Trends in opioids dispensings	DUSC	2002–2009 (8 years)	DDD/1000 pop/day and yearly % change in dispensings by overall, drug, prescription type (PBS-subsidised, under general co-payment and private), gender,10-year age groups, and medicine strength
Kelly, 2015 [95]	Trends in use of endocrine therapies for breast cancer in nine countries	PBS Online (Medicare) Other international dispensing and population databases	2001–2012 (12 years)	Total and age-adjusted DDD/1000 population/day DDD/1000 new breast cancer cases/day by year, country and medicine (overall and by individual drug)
Macintyre, 2015 [112]	Trends in herpes zoster and post-herpetic neuralgia incidence and associated healthcare utilisation pre- and post- varicella vaccination introduction	PBS ad hoc extracts (DHS) NHMD, NSW, VIC; Emergency Department Data BEACH GP survey ABS	1998–2013 (16 years and 6 months)	Incidence of herpes zoster/post-herpetic neuralgia (defined by the number of GP visits, antiviral dispensings, hospital separations, emergency department admissions) by age group, dataset and year
Meumann, 2015 [114]	Trends in E. Coli antimicrobial resistance and antibiotic use	PBS Online (Medicare) (TAS only) Laboratory data ABS	2010–2012 (3 years)	Antibiotic use (DDD/1000 pop/day) by drug and time period (month, season) % of *E.coli* samples with antimicrobial susceptibility by drug and overall Odds of antimicrobial resistance following increased antibiotic use by time lag (same month, 1m, 2m, 3m and season prior)
Karanges, 2014 [93]	Antidepressant, antipsychotic and ADHD medication prescribing	PBS ad hoc extracts	2009–2012 (4 years)	No. and % change in prescriptions by drug, age, gender, prescriber specialty and year
Islam, 2014 [78]	Benzodiazepine dispensing	DUSC	1992–2011 (20 years)	DDD/1000 pop/day by drug, script type, state/territory, and year No. prescriptions and Ashton diazepam equivalent dose/1000 pop/day by drug, script type and year DDD/script by script type and year

Note: ABS = Australian Bureau of Statistics, ACT = Australian Capital Territory, ADHD = attention deficit hyperactivity disorder, ASM = Australian Statistics on Medicines, ATC = Anatomical Therapeutic Class, BEACH-GP Survey = Bettering the Evaluation and Care of Health in General Practice Survey, DDD = Defined Daily Dose, DHS = Department of Human Services, DoH = Department of Health, DoP = Date of Processing, Dos = Date of Supply, DUSC = Drug Utilisation Sub-Committee, DVA = Department of Veterans' Affairs, HSD = Highly specialised drugs, MBS = Medicare Benefits Schedule, NNDSS= National Notifiable Diseases Surveillance System, NSW = New South Wales, OME = Oral Morphine Equivalent, PBS = Pharmaceutical Benefits Scheme, QLD = Queensland, RPBS = Repatriation Pharmaceutical Benefits Scheme, VIC = Victoria, TAS = Tasmania.

Supplementary Appendix D: Continued

First author, year of publication	Study aim	Data source	Study period (duration)	Primary outcome measure
Clinician Practices				
Individual-level (47 studies)				
Brett, 2018 [22]	Quantify the extent of low value psychotropic prescribing practices	PBS 10% sample ABS	2010 – 2016 (7 years)	Annual rate of low-value prescribing practice indicators (/100 persons)
Brett, 2018 [20]	Detail annual trends in benzodiazepine incidence and prevalence in older adults in three countries	Not specified (concession) Other international dispensing data	2010 – 2016 (7 years)	Annual incidence and prevalence of use (per 1000) by age and sex Change in annual incidence and prevalence
Daniels, 2018 [30]	Examine the treatment of women receiving trastuzumab for HER2-positive metastatic breast cancer and adherence to national prescribing restrictions	PBS ad hoc extracts Herceptin Program	2001–2016 (15 years and 6 months)	% of women prescribed trastuzumab receiving at least one non-adherent HER2-targeted treatment, according to different clusters
Hajarizadeh, 2018 [52]	Estimate levels and patterns of direct-acting antiviral agents treatment uptake	PBS 10% sample Not specified (PBS Online) Other data	1997–2016 (20 years)	Monthly no. of persons receiving direct-acting antiviral agents among people living with Hepatitis C
Hajati, 2018 [54]	Examine the extent to which the adult Australian population on lipid-lowering medications receives the level of high-density lipoprotein cholesterol (HDL-C) testing recommended by national guidelines	PBS 10% sample MBS	2008–2014 (7 years)	% of persons on lipid-lowering treatment who did not receive any HDL-C test in a given year % of the same population that received two or more HDL-C tests within the year
Kalisch Ellett, 2018 [85]	Prevalence of antipsychotic polypharmacy and the use of medicines to manage adverse events associated with antipsychotics	RPBS (full entitlement) DVA: Health services, Hospitalisations	2013–2014 (1 year and 4 months)	% of persons dispensed an antipsychotic medicine in the study period, co-dispensed anticholinergic, hyperlactatemia, oral diabetes medicine and those on dual antipsychotics
Keen, 2018 [94]	Estimate the HIV cascade in 2016 in NSW and describe enhanced data collection methods	PBS 10% sample (NSW only) ABS Other data	2016 (12 months)	No. of people living with HIV No. (%) of people diagnosed, receiving antiretrovirals, and with virological suppression in the previous stage of the cascade
Kemp-Casey, 2018 [96]	Describe how post-market utilisation analysis informs cost-effectiveness assessment and pricing decisions, through case studies	RPBS (full entitlement) PBS Online (Section 85 DoS) DVA: Hospitalisations	2010–2017 (6 years and 1 month)	Monthly no. of aflibercept and ranibizumab prescriptions dispensed to veterans and non-veterans by demographic and clinical characteristics.
Lim, 2018 [111]	Compare the use of medicines and health services for chronic obstructive pulmonary disease (COPD) against guideline recommendations	RPBS (full entitlement) MBS DVA: Health services, Hospitalisations	2014–2016 (2 years and 3 months)	No. (%) of persons on COPD medicines No. (%) with clinical visits for health services by COPD patients in the prior 1–2 years
Ofori-Asenso, 2018 [125]	Trends in statin use among older patients	PBS 10% sample (concession)	2006–2016 (11 years)	Annual prevalence (%) of use Annual incidence (per 1000) of use
Ofori-Asenso, 2018 [123]	Evaluate changes in the rate of medication dispensation for multiple chronic conditions among older Australians	PBS 10% sample	2013 – 2016 (4 years)	% of persons dispensed medications for 22 pre-specified chronic conditions % of persons dispensed medications for multiple chronic conditions within 180-days per year
Raman, 2018 [144]	Prevalence of attention-deficit hyperactivity disorder (ADHD) medication use in children and adults in multiple countries	PBS ad hoc extracts (DoH) International dispensing datasets	2009–2014 (6 years)	Annual prevalence of ADHD medication use by country and region, stratified by age and sex. Annual absolute and relative percentage changes over years (2001 - 2015)
Brett, 2017 [19]	Examine changes in annual patterns of psychotropic medication use	PBS 10% sample (concession)	2006–2015 (10 years)	Incidence and prevalence by subclass and class (/1000 persons/year) Annual duration of exposure Median DDD/person/year
Brett, 2017 [18]	Psychotropic polypharmacy prescribing	PBS 10% sample (concession)	2006–2015 (10 years)	Prevalence of >1 psychotropic use (%) by year and class % polypharmacy by number of unique prescribers
Caughey, 2017 [26]	Examine the appropriateness of medicine use and potentially high-risk prescribing before and after hospitalisation for diabetes	RPBS (entitlement not specified) DVA: Health services, Hospitalisations	2007–2013 (5 years and 3 months)	% of persons on non-recommended treatments 4 months after hospitalisations

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Supplementary Appendix D: Continued

First author, year of publication	Study aim	Data source	Study period (duration)	Primary outcome measure
Finger, 2017 [38]	Assess disparities in treatment provision and need for treatment for neovascular age-related macular degeneration across Australia	PBS ad hoc extracts ABS Other data	2010–2014 (4 years and 6 months)	No. (%) of incident cases not treated per year Factors associated with percentage of untreated incident cases
Hajarizadeh, 2017 [53]	Provide updated estimates of chronic hepatitis C infection care cascade and burden	PBS 10% sample and Not specified PBS data NNDSS Other data	1997–2014 (18 years)	No. of individuals living with hepatitis C, diagnosed, on treatment, cured and on various clinical stages Increase in the % of persons dispensed hepatitis C treatment
Hálfdánarson, 2017 [55]	International trends in antipsychotic use	PBS 10% sample International datasets	2006–2014 (9 years)	Overall prevalence of antipsychotic use by year and country
Hansen, 2017 [57]	Characterize the use of opioids in total knee arthroplasty patients before and after surgery and identify risk factors of chronic opioid use	RPBS (entitlement not specified) DVA: Health services, Hospitalisations	2000 – 2013 (14 years)	% of persons prescribed opioids before and after surgery by duration of use (none, some, chronic) % of change by duration of use (none, some, chronic) Factors associated with chronic opioid use after surgery
Handelsman, 2017 [56]	Estimate the impact of the first year of new eligibility criteria for testosterone prescribing	PBS Online (Medicare) PBS ad hoc extracts ABS	1992 – 2016 (25 years)	Total PBS expenditure $AUD per year No. Prescriptions per year by new, renewed and total, prescriber type, and age
Kjosavik, 2017 [99]	Analyse average treatment duration with antipsychotics, the incidence and prevalence of prescribing and trends over time	PBS 10% sample (concession)	2005–2013 (9 years)	Annual incidence of antipsychotics use Annual prevalence of antipsychotics use Average duration of antipsychotics use (prevalence/incidence) by age group and year
Morley, 2017 [118]	Explore the pattern of dispensing of pharmacotherapy for alcohol dependence across remote and disadvantaged Australia	PBS ad hoc extracts ABS	2009 –2013 (4 years)	Age-standardized mean dispensing ratio (observed vs expected) by remoteness and disadvantage
Reeve, 2017 [146]	Quantify health care use and costs in the last 6 months of life in a cohort of elderly decedents and to examine the factors associated with end-of-life resource use and costs	RPBS (full entitlement, NSW only) DVA: Health services, Hospitalisations, Aged care NSW: RBDM, CCR, APDC, EDDC	1994–2009 (16 years)	Mean (per person) health service use in 6month before death Mean total costs ($AUD per decadent) by health service by month
Whitely, 2017 [178]	Association of birth month and probability of children being treated for ADHD)	Not specified (WA only)	2013 (12 months)	Prevalence of children prescribed ADHD medicines
Baker, 2016 [5]	Compare direct oral anticoagulants and other antithrombotic therapy use in patients with Atrial Fibrillation/Flutter within one NSW hospital and national use of these medicines	Not specified (PBS Online) Manning Hospital data	2013 – 2014 (2 years)	Annual prevalence (%) by medicine No. (%) dispensings by medicine
Gadzhanova, 2016 [42]	Current use of medicines in children	PBS 10% sample ABS	2013 (12 months)	% of dispensings per ATC group Prevalence per 1000 children by medicine group, age group Prevalence of antibiotic per 1000 children by class, age, no. dispensings, sex, comorbidity
Gisev, 2016 [48]	Characterize individuals initiating strong opioids and factors associated with the type of opioid initiated	PBS 10% sample (concession) ABS	2009 – 2013 (4 years and 6 months)	No. (%) of persons initiating therapy according to demographics and previous non-opioid and weak opioid analgesics use
Gunnell, 2016 [50]	Evaluate dispensing patterns in people with acute coronary syndrome by gender and time since hospitalisation	PBS ad hoc extracts (WA only) EDDC HMDC MBS	1989 – 2008 (19 years and 7 months)	Prevalence of use by year of last admission
Inacio, 2016 [70]	Determine chronic opioid use pre-THA (total hip arthroplasty) and post-THA, and risk factors for persistent or new chronic opioid use post-THA	RPBS (entitlement not specified) DVA: Health services, Hospitalisations	2001–2013 (13 years)	Prevalence of opioid and chronic opioid use before and after surgery Factors associated with persistent chronic opioid use before and after surgery

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Supplementary Appendix D: Continued

First author, year of publication	Study aim	Data source	Study period (duration)	Primary outcome measure
Kjosavik, 2016 [98]	Analyse the average treatment duration with antidepressants	PBS 10% sample (concession)	2005 – 2013 (9 years)	No. of prevalent and incident users per year and age group Mean duration of treatment % prescriptions issued by prescriber type (GP, psychiatrist, other physicians)
Langton, 2016 [104]	Characterise health service use and associated costs from a health care payer perspective in the last six months of life in a cohort of elderly decedents with a cancer history	RPBS (full entitlement, NSW only) DVA: Health services, Hospitalisations, Aged care NSW: RBDM, CCR, APDC, EDDC ABS	1994–2009 (16 years)	Mean (95% CI) health service use and cost ($AUD) per decedent in the last 6 months of life stratified by health service type
Moon, 2016 [115]	Trends in the utilisation of metformin in Australia and the appropriateness of metformin doses in patients attending a teaching hospital	DUSC PBS Online (Medicare) ABS Hospital data	1990–2012 (23 years)	DDDs/1000 pop/day 5-year prevalence of diabetes mellitus type II Average daily dose and appropriate dose using glomerular filtration rate
Parkinson, 2016 [127]	Examine differences between clinical trial and real-world setting data characteristics and outcomes using a case study.	PBS ad hoc extracts MBS Mortality data Herceptin Program	2001–2010 (8 years and 4 months)	No. (%) of persons treated weekly vs. thrice weekly and on concomitant chemotherapies Treatment duration Overall survival and progression-free survival
Pratt, 2016 [135]	Evaluate the uptake of oral anticoagulants after PBS listing	RPBS (full entitlement)	2012–2014 (2 years and 8 months)	Monthly rates of use per 1000 veterans by medicine No. of persons initiating therapy by dose
Schaffer, 2016 [159]	Evaluate the use of first-line antihypertensive drug therapy and the uptake of fixed-dose combinations and its impact on treatment discontinuation	PBS 10% sample (concession)	2005–2014 (9 years)	No. (%) of persons initiating non-recommended antihypertensive therapy No. (%) discontinued therapy in 12 months
Allard, 2015 [3]	Access to guideline-based clinical care in chronic hepatitis B	PBS ad hoc extracts ABS NNDSS MBS HSD Expenditure Reports Pharmaceutical company drug supply data	2011–2012 (2 years)	No. and % of patients receiving Hepatitis B Virus DNA tests and anti-viral treatment by state and territory
Gadzhanova, 2015 [41]	Use of teratogens and other medicines in women of reproductive age	PBS 10% sample	2013 (12 months)	Prevalence and % total dispensings by pregnancy risk category and therapeutic class
Gadzhanova, 2015 [43]	Anti-dementia medicine initiation and anticholinergic and sedative use	Not specified (Full)	2008 – 2011 (4 years)	Prevalence of sedative and anticholinergic use among anti-dementia medicine initiators in 6 months pre and post-initiation
Pearson, 2015 [128]	Patterns of antidepressant initiation around cancer diagnosis and associated factors	RPBS (full entitlement, NSW only) DVA: Health services, Hospitalisations, Aged care NSW: RBDM, CCR, APDC, EDDC	1994–2009 (16 years)	Adjusted hazards ratio for antidepressant initiation in cancer vs non-cancer patients, overall and according to time from cancer diagnosis % cancer patients initiating or discontinuing antidepressant treatment by class Median time to initiation/discontinuation by class
Schaffer, 2015 [160]	Describe and compare the treatment, health service use and survival of patients with cancer of unknown primary diagnosis	RPBS (entitlement not specified, NSW only) DVA: Health services, Hospitalisations, Aged care NSW: RBDM, CCR, APDC, EDDC ABS	1999–2009 (10 years and 6 months)	Probability of receiving less treatment (medicines, therapy or surgery) one-year post diagnosis Incident rate ratio of health service use (primary care consults, emergency department visits, hospitalisation) Risk of death within 30 days of diagnosis
Sluggett, 2015 [168]	Medicine use after hospitalisation for transient ischaemic attack or ischaemic stroke	RPBS (full entitlement) DVA: Hospitalisations	2001–2010 (9 years and 6 months)	Prevalence of antihypertensive, antithrombotic and lipid lowering medicine use before and after incident hospitalisation by age and medicine class

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Supplementary Appendix D: Continued

First author, year of publication	Study aim	Data source	Study period (duration)	Primary outcome measure
Vajdic, 2015 [174]	Compare the pathways to diagnosis between people with cancer of unknown primary diagnosis and other cancers	RPBS (full & specific entitlement, NSW only) DVA: Health services, Hospitalisations, Aged care NSW: RBDM, CCR, APDC, EDDC	1999–2007 (10 years and 6 months)	% of consultations, visits, cancer-related procedures and pathology tests in the 3 months prior and month of diagnosis Predictors of cancer of unknown primary diagnosis
Kalisch Ellett, 2014 [84]	Incident oxybutynin dispensing after initiation of medicines associated with urinary incontinence	RPBS (full entitlement) DVA: Hospitalisations	2001–2011 (11 years)	No. oxybutynin users Risk of oxybutynin initiation by medicine class
Price, 2014 [139]	Examine time trends and factors associated with exposure to potentially inappropriate medications (PIMs) by the Beers Criteria	PBS ad hoc extracts (WA only) MBS Aged care Electoral roll	1993–2005 (13 years)	No. (%) of persons exposed to PIMs DDD/1000 person-years for overall and individual PIMs
Simons, 2014 [162]	Use of lipid-lowering drugs according to contemporary guidelines in patients with high coronary risk	PBS 10% sample (concession)	2006–2013 (7 years and 5 months)	% of persons using lipid-lowering drugs by age, gender and risk status
Sluggett, 2014 [167]	Use of secondary stroke prevention medicines in survivors of transient ischemic attack and ischemic stroke	RPBS (full entitlement) DVA: Hospitalisations	2000 – 2010 (10 years and 6 months)	Rate of medicine use/100 persons by month % annual change in medicine use
Slugget, 2014 [166]	Estimate the use of anticoagulants among acute ischaemic stroke patients with atrial fibrillation after discharge	RPBS (full entitlement) DVA: Health services, Hospitalisations	2001 – 2010 (9 years and 6 months)	% of persons using antithrombotic agents in the 4 months after hospitalisation
Patient practices				
Individual-level (16 studies)				
Acar, 2018 [1]	Describe subcutaneous tumour necrosis factor inhibitors treatment persistence in immune-mediated rheumatic disease	PBS 10% sample	2010 – 2016 (6 years and 6 months)	Median treatment persistence (time from initiation to switch or discontinuation) by treatment and line of therapy (1st, 2nd, 3rd)
Bartlett, 2018 [8]	Compare the persistence rates among people who initiate the combination of amlodipine and statin as a fixed-dose combination or separate pill combination and impact of prior medicine exposure on this outcome	PBS ad hoc extracts	2012 – 2015 (3 years)	Time to cessation of combination therapy (both an antihypertensive and lipid lowering therapy), i.e., persistence of combination therapy, with a minimum of 15 months' follow-up for each patient.
Bartlett, 2018 [9]	Demonstrate the effect of prior medicine experience on persistence in those initiating combinations of cardiovascular medicines	PBS ad hoc extracts	2012–2014 (2 years and 9 months)	% ceasing combination therapy over 12 months with a minimum of 15 months' follow-up for each patient.
Blanch, 2018 [15]	Examine associations between patient factors and increasing opioid access measured by three metrics	PBS 10% sample (concession)	2009–2013 (4 years and 6 months)	No. of unique opioid prescribers and dispensing pharmacies No. of opioid dispensings recorded within 1-year after initiating or reinitiating strong opioid treatment
Jones, 2018 [82]	Describe the persistence of biologic disease modifying anti-rheumatic drugs according to the use of other concomitant therapy	PBS 10% sample	2010–2014 (3 years and 11 months)	% persistence at 12 months post-treatment initiation Median time to stopping (months)
Lalic, 2018 [102]	Identify patterns of opioid analgesic use and determine predictors of persistent opioid use among people without cancer	PBS 10% sample	2012–2016 (4 years and 6 months)	% persistence over 12 months following opioid initiation defined by patterns using group-based trajectory modelling
Ofori-Asenso, 2018 [124]	Examine the prevalence of statin use and assess long term adherence and persistence among older diabetes patients	PBS 10% sample (concession)	2006–2016 (11 years)	1-year prevalence of statin use per year % adherent to therapy at 6 up to 9 years % discontinued therapy in 9 years

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Supplementary Appendix D: Continued

First author, year of publication	Study aim	Data source	Study period (duration)	Primary outcome measure
Bartlett, 2017 [7]	Compare adherence and persistence in patients who add ezetimibe to statin therapy as a separate pill combination or fixed dose combination	PBS ad hoc extracts	2004–2014 (10 years and 9 months)	Mean medication possession ratio per group after 6 months of initiation (separate or fixed dose) % adherent after 6 months of initiation (separate or fixed dose) Time to discontinuation (persistence) of initial medicines, any lipid-lowering therapy, within 12 months of follow-up
Blanch, 2017 [16]	Benchmark prescriber access patterns for opioids against statins in Australia and British Columbia, Canada	PBS 10% sample (concession) Other international dispensing data	2011 (12 months)	No. (%) of unique prescribers No. of prescribers visited
Schaffer, 2017 [158]	Compare statin adherence in individuals initiating fixed-dose or free combination	PBS 10% sample (concession)	2005 – 2015 (11 years)	Patterns of adherence in 24 months following initiation (near perfect, good, declining and early non-adherence)
Simons, 2017 [164]	Examine medium-term persistence in atrial fibrillation patients using a non-vitamin-K antagonist oral anticoagulant drugs (NOACs)	PBS 10% sample (concession)	2013 – 2016 (2 years and 10 months)	% filled their first repeat prescription % persistent with NOACs over 12 and 30 months % switching to another NOAC or warfarin
Simons, 2017 [163]	Evaluate treatment persistence and mortality using a single-pill, fixed-dose combination tablet compared with a two-pill combination for hypertension	PBS 10% sample (concession)	2011–2014 (4 years)	% discontinued within 12months by single- or two pill Median persistence time (months) by single- or two pill Survival (%) in 48 months of follow up by single- or two pill
Gadzhanova, 2016 [44]	Compare the persistence rates among people using fixed or separate antihypertensive therapy	PBS ad hoc extracts (concession)	2005–2012 (7 years)	Median time on index therapy (persistence) Persistence rate over 4 years
Morley, 2016 [117]	Characterise patterns of alcohol pharmacotherapy use and costs	PBS ad hoc extracts (DHS)	2009–2013 (4 years)	No. (%) of persons dispensed each medicine by age and gender Median days on medication % of patients with 2 and 3 dispenses
Ortiz, 2016 [126]	Compare extended-release paracetamol with standard paracetamol use in patients with osteoarthritis	PBS 10% sample (concession)	2008–2010 (3 years)	No. of patients and prescriptions dispensed by medicine Analgesic equivalent days ((strength*quantity*number scripts)/DDD) Median persistence in 2 years by medicine
Simons, 2016 [165]	Evaluate the persistence in atrial fibrillation patients using a non-vitamin-K oral anticoagulant	PBS 10% sample (concession)	2005–2015 (10 years and 3 months)	% failing to fill first repeat prescription % discontinued within 12 months

Note: ABS = Australian Bureau of Statistics, ADHD = attention-deficit hyperactivity disorder, APDC = Admitted Patients Data Collection, CCR = Central Cancer Registry, COPD = chronic obstructive pulmonary disease, DDD = Defined Daily Dose, DoH = Department of Health, DUSC = Drug Utilisation Sub-Committee, DVA = Department of Veterans' Affairs, EDDC = Emergency Department Data Collection, GP = General Practitioner, HDL-C = high-density lipoprotein cholesterol, HMDC = Hospital Morbidity Data Collection, HSD = Highly Specialised Drugs, MBS = Medicare Benefits Schedule, NNDSS= National Notifiable Diseases Surveillance System, NOAC = non-vitamin-K antagonist oral anticoagulant drugs, NSW = New South Wales, PBS = Pharmaceutical Benefits Scheme, PIM = potentially inappropriate medications, RBDM = Registry of Births, Deaths, and Marriages, RPBS = Repatriation Pharmaceutical Benefits Scheme, THA = total hip arthroplasty, WA = Western Australia.

Supplementary Appendix D: Continued

First author, year of publication	Study aim	Data source	Study period (duration)	Primary outcome measure
Intervention impacts, policy				
Claims-level (4 studies)				
Roughead, 2018 [151]	Impact of the policies for generic medicines on the total prices of atorvastatin therapy	PBS Online (ASM) 3 Asia Pacific pharmacy databases	2006–2015 (10 years)	Annual price per DDD supplied or sold by country % price reduction in 4 years following generic drug entry
Hopkins, 2017 [66]	Impact of subsidy restriction changes on the use and expenditure on leflunomide and bDMARDs	PBS Online (Medicare) ABS	2000–2013 (14 years)	DDD/1000 pop/day by year Total expenditure per year ($AUD)
Karanges, 2016 [91]	Trends in community use of prescribed opioids according to major changes to opioid registration and subsidy	DUSC ABS	1990–2014 (25 years)	Annual DDD/1000 population/day Absolute and percentage changes in use over time
Niyomnaitham, 2014 [122]	Impact of safety warnings on rosiglitazone and pioglitazone use	Not specified (DUSC or PBS online)	2004–2012 (8 years and 5 months)	DDD/1000 persons/day by year % change in medicine use after warnings
Individual-level (6 studies)				
Brett, 2018 [21]	Impact of two subsidy restriction changes on quetiapine dispensing: removal of prior authorisation and repeat prescriptions	PBS 10% sample (concession)	2005–2015 (10 years and 10 months)	Monthly quetiapine dispensing % of persons discontinuing within 90 days and switching quetiapine strength
Morgan, 2018 [116]	Impact of introduction of non-vitamin K antagonist anticoagulants in anticoagulant use and government expenditure	PBS 10% sample (concession) PBS Online (Medicare)	2005–2016 (11 years)	Monthly no. and % of persons dispensed each oral anticoagulant and change (%) following the introduction of a new class of oral anticoagulant
Schaffer, 2018 [156]	Impact of the reformulation tamper-resistant controlled-release oxycodone on dispensing, switching and poisonings	PBS 10% sample NSW Poisons Information Centre ABS	2012–2016 (4 years and 6 months)	% change in monthly dispensing rate/100,000 persons after the reformulation % of persons discontinuing and switching opioids before and after the reformulation No of poisoning calls before and after reformulations
Caughey, 2016 [29]	Impact of a general practitioner management plan (GPMP) on the risk of hospitalisation for diabetes	RPBS (entitlement not specified) DVA: Health services, Hospitalisations	2006–2014 (8 years)	Risk of diabetes-related hospitalisation in the 12 months following GPMP
Schaffer, 2016 [155]	Impact of rescheduling alprazolam on benzodiazepine prescribing, dispensing, and intentional poisonings	PBS 10% sample (concession) NSW Poisons Information Centre	2010–2015 (5 years and 6 months)	Monthly prescriptions/100,000 population Monthly no. calls about poisoning Monthly no. people switching
Vitry, 2014 [175]	Impact of chronic disease management programme in long-term health outcomes	RPBS (full entitlement) DVA: Health services, Hospitalisations	2004–2012 (8 years)	Time until next potentially preventable hospitalisation for heart failure
Intervention impacts, educational				
Claims-level (1 studies)				
Wu, 2018 [179]	Impact of educational interventions on antimicrobial dispensings	PBS ad hoc extracts (concession) MBS	2004–2015 (11 years and 6 months)	Monthly estimated change (%) in dispensing following interventions Monthly no. dispensed scripts by health practitioner type
Individual-level (6 studies)				
Kalisch Ellett, 2018 [89]	Impact of quality improvement interventions on the uptake of collaborative Home Medicines Reviews (HMR)	RPBS (entitlement not specified) DVA: Health services, Hospitalisations, Aged care	2001–2016 (15 years and 2 months)	% of HMR use 9-months after each intervention
Kalisch Ellett, 2018 [83]	Impact of interventions on hypnotic use among Australian veterans and associated health consequences	RPBS (entitlement not specified)	2007–2014 (7 years and 3 months)	Rate of BMD testing in 9-months after the intervention Rate of initiation of any treatment for osteoporosis in 9-months after the intervention
Kalisch Ellett, 2017 [90]	Impact of two national quality improvement initiatives on the uptake of bone mineral density (BMD) testing and osteoporosis medicines	RPBS (entitlement not specified) DVA: Health services, Hospitalisations	2006–2012 (6 years)	% of BMD testing in 9-months after the intervention % of initiation of any treatment for osteoporosis in 9-months after the intervention

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Supplementary Appendix D: Continued

First author, year of publication	Study aim	Data source	Study period (duration)	Primary outcome measure
Pratt, 2017 [132]	Impact of national initiatives on proton pump inhibitors (PPI) use among older Australians	RPBS (entitlement not specified)	2003–2013 (11 years)	% changes in: the monthly rate of PPI use the monthly rate of low strength PPIs
Pratt, 2015 [133]	Impact of commitment to discuss health issue with GP (via commitment questions) on uptake of targeted health services in Veterans	RPBS (entitlement not specified) DVA: Health services	2006–2013 (8 years)	Change in health service use (rate/ 1000 targeted patients/month) Commitment question response (yes, no/unsure, no response) Association (rate ratio) between positive response and health service use
Roughead, 2013 [150]	Impact of audit and feedback educational interventions on medicine use in the elderly	RPBS (entitlement not specified) DVA: Health services, Hospitalisations	2003–2009 (6 years and 7 months)	Rate of medicine use/1000 veterans by month % change in medicine use after each intervention Estimated no. of patients with a sustained change in medicine use 2 years following the intervention
Intervention impacts, other Individual-level (1 study)				
Schaffer, 2015 [157]	Impact of televised science journalism program on statin use	PBS 10% sample (concession)	2009–2014 (5 years)	Weekly change (%) in statin dispensings, persons discontinuing statins before and after the program by risk category

Note: ABS = Australian Bureau of Statistics, bDMARDs = biological Disease-modifying antirheumatic drug use, BMD = bone mineral density, DDD = Defined Daily Dose, DVA = Department of Veterans' Affairs, HMR = Home Medicines Reviews, MBS = Medicare Benefits Schedule, PBS = Pharmaceutical Benefits Scheme, PPI = proton pump inhibitors, RPBS = Repatriation Pharmaceutical Benefits Scheme.

Supplementary Appendix D: Continued

First author, year of publication	Study aim	Data source	Study period (duration)	Primary outcome measure
Exposure and Outcomes (Other exposure and outcomes)				
Claims-level (1 study)				
Rowell, 2017 [153]	Evaluate the effect of weather on medications prescribed to treat Parkinson's disease	Not specified Bureau of Meteorology ABS	1992–2014 (23 years)	Aggregate levodopa equivalent dose (LED) for 51 Parkinson's medications
Individual-level (4 studies)				
Gillam, 2018 [47]	Describe the type and frequency of re-hospitalisations for complications and mortality after discharge following pacemaker implantations	RPBS (full entitlement) DVA: Health services, Hospitalisations	2005–2015 (10 years and 6 months)	No. and % of re-hospitalisations for each type of complication Mortality assessed at 30, 90 days following discharge from hospital after pacemaker implantation
Inacio, 2018 [75]	Prevalence and change in analgesic medications use prior to joint replacement in older patients	RPBS (entitlement not specified) DVA: Health services, Hospitalisations	2001–2012 (12 years)	Prevalence of prescription analgesics, hypnotics and muscle relaxants 1-year period prior to joint replacement Yearly rate of change
Caughey, 2017 [28]	Identify factors associated with re-hospitalised within 30 days of discharge among older Australians admitted to hospital with diabetes	RPBS (full entitlement) DVA: Health services, Hospitalisations	2011–2013 (2 years and 1 month)	Causes of re-hospitalisation Prevalence of clinical factors associated with re-hospitalisation within 30 days of discharge
Gillam, 2017 [46]	Compare the risk of heart failure in patients with conventional metal-on-metal or metal-on-polyethylene total hip arthroplasty	RPBS (full entitlement) DVA: Health services, Hospitalisations	2003–2014 (11 years and 6 months)	Incidence of hospitalisation after the primary procedure Incidence of all-cause mortality
Exposure and Outcomes (Medicine use and outcomes)				
Claims-level (4 studies)				
Blanch, 2014 [17]	Trends in opioid use, costs and outcomes	PBS Online NHMD ABS Cause of Death	1992–2012 (21 years)	No. prescriptions and costs by drug by year No. hospitalisations due to opioid poisonings by year No. accidental deaths related to illicit drugs and pharmaceutical opioids by year
Hollingworth, 2015 [63]	Pattern of reported adverse events for dopamine agonists	Not specified DAEN	1992–2012 (21 years)	No. dopamine agonist adverse event reports by drug, type of adverse event, and year No. prescriptions by drug and year
Huang, 2015 [68]	Evaluate reports and incidence of lactic acidosis cases associated with metformin	PBS Online DAEN	1997–2011 (15 years)	Estimated incidence of metformin-associated lactic acidosis Annual no. of cases of lactic acidosis reported to the TGA Annual no. of community prescriptions of metformin
Jamolowicz, 2015 [81]	Association between statin use and memory-related adverse events	PBS Online DAEN	1992–2013 (21 Years and 4 months)	No. and incidence rate of memory-related adverse events by drug and type of adverse event No. of dispensings
Individual-level (29 studies)				
Linked (21 studies)				
Ahmed, 2018 [2]	Association between ?rst trimester exposure to renin-angiotensin system blockers and maternal and perinatal outcomes among women with chronic hypertension	PBS ad hoc extracts (concession, NSW only) ADPC PDC	2005–2012 (8 years)	% hypertensive pregnant women exposed to renin-angiotensin system blockers with a record of preterm delivery, caesarean section, baby low birth weight, small for gestational age and Apgar score <7
Daniels, 2018 [32]	Real-world treatment patterns and overall survival for women receiving trastuzumab for metastatic breast cancer compared with results of clinical trials	PBS ad hoc extracts Herceptin Program	2001–2016 (15 years and 6 months)	Time on trastuzumab and overall survival from initiation Rates of cardiac monitoring prior to and during treatment

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Supplementary Appendix D: Continued

First author, year of publication	Study aim	Data source	Study period (duration)	Primary outcome measure
Daniels, 2018 [33]	Real-world treatment patterns and overall survival for women surviving five or more years from initiation of trastuzumab for HER2-positive metastatic breast cancer	PBS ad hoc extracts Herceptin Program	2001–2016 (15 years and 6 months)	% of women initiating trastuzumab surviving $\geq$ 5 years and conditional probability of surviving an additional 5 years Time on trastuzumab and other HER2-targeted therapies Frequency and duration of breaks from trastuzumab and other HER2-targeted therapies
Daniels, 2018 [31]	Survival outcomes for patients using (neo)adjuvant trastuzumab who relapse (early breast cancer) and then receive trastuzumab for metastatic breast cancer	PBS ad hoc extracts Herceptin Program	2001–2014 (13 years and 3 months)	Overall survival from initiation of trastuzumab for metastatic breast cancer Duration of trastuzumab in the metastatic setting Time from cessation of trastuzumab for early breast cancer until initiation of trastuzumab for metastatic cancer
Lai, 2018 [101]	Risk of gastrointestinal hospitalisation with loxoprofen and mefenamic acid use compared with other nonsteroidal anti-inflammatory use in Asia-Pacific populations	RPBS (entitlement not specified) Other international hospital databases	2001–2012 (12 years)	No. and incidence of gastrointestinal hospitalization/1,000 person-years in Japan, Taiwan, Korea, Hong Kong and Australia
Qin, 2018 [142]	Association between renin-angiotensin system inhibitors and β-blockers dispensed to patients within 60 days post-heart failure hospital discharge and improved 1-year survival	PBS ad hoc extracts (concession, WA only) HMDC Mortality registry	1983–2011 (28 years and 6 months)	Time from hospital discharge and 60 days later to all-cause mortality censored at 1 year of follow-up Time to rehospitalisation Composite of all-cause mortality or re-hospitalisation, whichever occurred first
Roughead, 2017 [152]	Assess whether antipsychotic use is a contributing factor in the association between Post-traumatic stress disorder and dementia	RPBS (entitlement not specified) DVA: Health services, Hospitalisations	2001–2014 (13 years and 6 months)	Annual median DDD/person No. (%) people with dementia Risk of dementia in 12 year follow up among those with or without antipsychotic medicines or Post-traumatic stress disorder
Leach, 2017 [109]	Risk of hip fracture in older people following concurrent use of psychoactive medicines	RPBS (full entitlement) DVA: Health services, Hospitalisations	2008–2012 (5 years)	Risk of hip fracture associated with each of the individual medicine Risk of hip fracture as a result of concurrent use of two medicines
Leach, 2017 [108]	Risk of hip fracture due to mirtazapine, and the use of other antidepressant medicines in combination with mirtazapine	RPBS (entitlement not specified) DVA: Health services, Hospitalisations	2008–2012 (5 years)	Risk of hip fracture due to use of antidepressants alone Risk of hip fracture due to mirtazapine in combination with other antidepressants
Kalisch Ellett, 2016 [88]	Risk of hospitalisation in older people associated with concurrent use of psychotropics	RPBS (full entitlement) DVA: Health services, Hospitalisations	2011–2013 (2 years)	Hospitalisation rates by: cumulative number of DDDs no. of central nervous system medicines used
Kalisch Ellett, 2016 [86]	Risk of hospital admission for dehydration or other heat-related illness following initiation of medicines	RPBS (entitlement not specified) DVA: Health services, Hospitalisations	2000–2013 (13 years and 6 months)	No. persons hospitalised for heat-related illness in the 12 months pre and post initiation of medicine
Caughey, 2015 [27]	Prevalence of suboptimal medication related care before hospitalisation of older patients	RPBS (entitlement not specified) DVA: Client file, Health services, Hospitalisations	2007–2012 (5 years)	% and no. of hospitalisations preceded by suboptimal medication-related care by problem/disease state
Leach, 2015 [107]	Association between psychoactive medicine use and hip fracture in the elderly	RPBS (entitlement not specified) DVA: Health services, Hospitalisations	2008–2012 (5 years)	Odds of hip fracture after psychoactive drug exposure (in intermittent users vs intermittent non-users) by class and individual medicine
Pratt, 2015 [137]	Association between initiation of ophthalmic timolol and risk of hospitalisation for bradycardia	RPBS (full entitlement) DVA: Health services, Hospitalisations	2002–2009 (7 years)	Incidence of hospitalisation for bradycardia after 1-30, 31-180 and >180 days of timolol initiation

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Supplementary Appendix D: Continued

First author, year of publication	Study aim	Data source	Study period (duration)	Primary outcome measure
Price, 2015 [141]	Impact of level of GP care on unplanned hospitalisations due to potentially inappropriate prescribing in the elderly	PBS ad hoc extracts (WA only) MBS Aged care Electoral roll	1993–2005 (13 years)	Odds of unplanned hospitalisation following potentially inappropriate medicine exposure (Beers criteria) by level of GP coverage (<6m, 6-8m, 8-10m, >10m) and medicine (all and individual high-risk)
Kalisch Ellett, 2014 [87]	Association between multiple anticholinergic medication use and risk of hospitalisation for confusion with dementia	RPBS (full entitlement) DVA: Hospitalisations	2009–2012 (3 years)	Cumulative anticholinergic medicine use Risk of hospitalisation for confusion or dementia
Pratt, 2014 [138]	Association between ranibizumab use and risk of hospitalisation for ischaemic stroke and myocardial infarction	RPBS (full entitlement) DVA: Hospitalisations	2006–2013 (6 years and 7 months)	Risk of hospitalisation for ischaemic stroke and myocardial infarction
Pratt, 2014 [136]	Association between use of multiple psychoactive medicines and hospitalisation for falls	RPBS (full entitlement) DVA: Hospitalisations	2010–2012 (2 years)	No. and cumulative daily dose of psychoactive medicines used Risk of hospitalisation for fall
Price, 2014 [140]	Evaluate if potentially inappropriate medications are predictors of adverse events	PBS ad hoc extracts (WA only) MBS Aged care Electoral	1993–2005| (13 years)	Risk of index unplanned hospitalisation by drug class, 'dose' over 3 months
Leach, 2013 [106]	Medicine use associated with falls or hip fracture before hip fracture and whether medicine use changed after hip fracture	RPBS (full entitlement) DVA: Hospitalisations	2009 (12 months)	Use of medicines associated with greater risk of falls and hip fracture prior to hip fracture % change in medicine use after hospitalisation for hip fracture
Ramsay, 2013 [145]	Association between proton pump inhibitor use and hospitalisation	RPBS (full entitlement) DVA: Hospitalisations	2007–2011 (4 years and 6 months)	Risk of hospitalisation for pneumonia
Ecological (3 studies)				
Roxburgh, 2017 [154]	Trends in heroin and pharmaceutical opioid overdose deaths	DUSC National Coronial Information System ABS	2001–2012 (12 years)	Annual rate of (heroin) overdose deaths per million persons by age, gender and intent Annual rate of pharmaceutical overdose deaths per 100,000 OME by age, gender and intent
Buckley, 2015 [23]	Association between in hospital mortality and morbidity and self-poisoning with different drug classes over an extended period	Not specified (ASM) Hunter Area Toxicology Service	1991–2011 (21 years)	Hospital length of stay, types of drugs ingested, intensive care unit admission, requirement for ventilation, in hospital Deaths (per 1000) Rates of antidepressant drug use (DDD/1000 pop/day)
Roughead, 2015 [149]	Comparative risk of heart failure and oedema associated with thiazolidinediones across six countries	RPBS (entitlement not specified) DUSC Other international dispensing or hospital databases	2005–2010 (6 years)	Risk (adjusted sequence ratio) of oedema (i.e. incident furosemide dispensing) or incident heart failure hospitalisation after incident rosiglitazone, pioglitazone or metformin dispensing, by country and ethnic group
Only dispensing claims, using medicine as a proxy of outcome (5 studies)				
Castle, 2018 [25]	Risk of people on medication for schizophrenia developing different components of the metabolic syndrome and their life expectancy compared with people without schizophrenia	PBS 10% sample	2006–2015 (10 years)	Time taken from first prescription of schizophrenia treatment to the first prescription for the treatment of comorbidities Median life expectancy
Kumar, 2018 [100]	Factors that predict the need for add-on therapy in patients with type II diabetes in the community	PBS 10% sample (concession)	2006–2014 (7 years and 9 months)	Median time (years) to add-on therapy in adherent and non-adherent patients
Ng, 2018 [120]	Compare how frequently selected chronic diseases developed in women with breast cancer receiving endocrine therapy, and in women without cancer.	PBS 10% sample (concession)	2003–2014 (12 years)	Ten-year incidence rates for comorbidities, identified with the RxRisk-V model

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Supplementary Appendix D: Continued

First author, year of publication	Study aim	Data source	Study period (duration)	Primary outcome measure
Ng, 2018 [119]	Patterns of comorbidities among men with prostate cancer treated with androgen deprivation therapy	PBS 10% sample (concession)	2003–2014 (12 years)	Risk of comorbidities dispensings over time
Roughead, 2016 [148]	Association between proton pump inhibitor use and *Clostridium difficile* infections across multiple countries	PBS ad hoc extracts RPBS (entitlement not specified) Other international dispensing databases	2001–2013 (13 years)	No. (%) people dispensed oral vancomycin as a proxy for *Clostridium difficile* infection

Note: ABS = Australian Bureau of Statistics, ASM = Australian Statistics on Medicines, ADPC = Admitted Patients Data Collection, DAEN = Database of Adverse Event Notifications, DDD = Defined Daily Dose, DUSC = Drug Utilisation Sub-Committee, DVA = Department of Veterans' Affairs, GP = General Practitioner, MBS = Medicare Benefits Schedule, NHMD = National Hospital Morbidity Database, NSW = New South Wales, OME = Oral Morphine Equivalent, PBS = Pharmaceutical Benefits Scheme, PDC = Perinatal Data Collection, RPBS = Repatriation Pharmaceutical Benefits Scheme, WA = Western Australia.

Supplementary Appendix D: Continued

First author, year of publication	Study aim	Data source	Study period (duration)	Primary outcome measure
Methods				
Claims-level (1 study)				
Huang, 2018 [67]	Validate use of a large HIV-positive cohort compared to the PBS 10% sample Sample for surveillance and monitoring purposes	PBS 10% sample Australian HIV Observational Database	2013–2016 (2 years and 9 months)	Distribution of patient demographics, state/territory of residence, and HIV treatment (% use) data in both datasets per year
Individual-level (18 studies)				
Arnet, 2018 [4]	Operationalise and validate new method of adherence, the daily polypharmacy possession ratio compared with medication possession ratio	PBS ad hoc extracts (concession, WA only)	2002–2011 (9 years)	Mean adherence values using daily polypharmacy possession ratio and medication possession ratio
Hoang, 2018 [60]	Assess the use of supervised machine learning as a signal detection tool for adverse drug reactions	PBS 10% sample Other data	2012–2016 (4 years and 6 months)	Performance measures of model: sensitivity, specificity, positive and negative predictive values and area under the receiver operating characteristic curve
Langton, 2018 [103]	Demonstrate the value-add of cross-jurisdictional data and the factors associated with healthcare use towards the end of life	RPBS (full entitlement, National and NSW) DVA: Health services, Hospitalisations, Aged care NSW: RBDM, CCR, APDC, EDDC	2005–2007 (2 years and 6 months)	Associations between cohort characteristics and $\geq$3 hospitalisations/$\geq$3 emergency department presentations during the last six months of life in the population cohort and DVA cohort
Pratt, 2018 [134]	Map ATC Classification System codes to individual Rx-Risk comorbidities and validate the Rx-Risk Comorbidity Index.	RPBS (full entitlements), PBS 10% sample DVA: Health services, Hospitalisations	2013–2015 (2 years and 6 months)	Mortality after 1-year AIC model fit and c-statistics for external validation
Roper, 2018 [147]	Develop an algorithm and validate it to resolve disparity between the evidence of pharmacotherapy utilisation for smoking cessation and the recording of smoking in pregnancy	PBS ad hoc extracts (WA, NSW only)	2003–2012 (10 years)	No. of women dispensed smoking cessation therapy identified by the algorithm Distribution of characteristics between smokers and non-smokers (as validity measure) Prevalence of smoking cessation pharmacotherapy utilisation
Zhan, 2018 [180]	Develop and validate a data-driven method to automatically detect potential adverse drug events from prescription data	PBS ad hoc extracts Other data	2013 – 2014 (2 years)	Estimated frequency and proportion (%) of adverse drug events (validated, suspected and false) Sensitivity, specificity, positive and negative predictive value
Tran, 2017 [172]	Present the data cleaning and preparation process for a large-scale linkage study	PBS ad hoc extracts (WA, NSW only)	2002 – 2014 (13 years)	No. of records and persons in each dataset No. and type of corrections made No. of duplicates, excluded persons and likely false positives
Inacio, 2016 [74]	Evaluate if opioid use can be used as a proxy for patient-reported pain and as an indicator for early surgical failure	RPBS (entitlement not specified) DVA: Health services, Hospitalisations	2001–2013 (13 years)	Prevalence of medication use after total hip arthroplasty surgery % revisions within one and five years
Inacio, 2016 [76]	Evaluate the predictive ability of co-morbidity measures in total hip arthroplasty and total knee arthroplasty patients	RPBS (full entitlement) DVA: Health services, Hospitalisations	2000–2013 (14 years)	Mortality rates within 90 days and 1 year of the surgery Model discrimination ability (c statistic) and calibration (Hosmer and Lemeshow Goodness of Fit)
Wahab, 2016 [177]	Assess the utility of sequence symmetry analysis as a signal detection tool for detecting adverse event signals	RPBS (entitlement not specified) DVA: Health services, Hospitalisations	2002–2011 (10 years)	No. (%) with heart failure No. (%) using medicines used to treat adverse events
Blanch, 2015 [14]	Effect of look-back period length on new user misclassification	PBS 10% sample (concession)	2005–2014 (9 years)	% of persons misclassified as new users of therapy based on 10 different look-back periods (range 1 m- 7y)
Inacio, 2015 [73]	Compare the ability of three comorbidity indices to predict infection after total joint arthroplasty.	RPBS (full entitlement) DVA: Hospitalisations	2000 – 2012 (13 years)	Cumulative infection incidence by type of arthroplasty and no. of comorbidities Association between the number of comorbidities and infection within 90 days of surgery

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Supplementary Appendix D: Continued

First author, year of publication	Study aim	Data source	Study period (duration)	Primary outcome measure
Inacio, 2015 [71]	Compare ability of RxRisk-V, and two other comorbidity indices to predict post-operative revision in joint arthroplasty	RPBS (entitlement not specified) DVA: Hospitalisations	2000 – 2012 (13 years)	Association between number of comorbidities and post-operative revision 1 and 5 years following total hip or knee arthroplasty
Inacio, 2015 [72]	Compare the prevalence and identity of comorbidities identified using three comorbidity indices	RPBS (full entitlement) DVA: Hospitalisations	2000–2012 (13 years)	Prevalence of comorbidities, overall and by individual conditions, for each metric and type of arthroplasty Agreement between metrics by comorbidity and type of arthroplasty.
Nguyen, 2015 [121]	Assess whether linking pharmaceutical and hospital data can identify medicines associated with drug-induced hospitalisations	RPBS (full entitlement) DVA: Hospitalisations	2005 – 2012 (7 years and 6 months)	No. (%) of admissions for drug-induced liver toxicity with: causative medicines or medicine classes recorded causative medicines matched to outpatient dispensings other potentially contributory outpatient medicine dispensings
Mellish, 2015 [113]	Overview and guide for researchers using PBS data	PBS Online (Section 85 DoS & DoP, ASM), DUSC	1998 – 2014 (16 years)	No. of dispensings by month/year of select medicines by date of supply vs processing and script type No. of dispensings, DDD/1000 pop/day and cost to government for psychotropics
Pratt, 2015 [131]	Cross-country consistency of prescription sequence symmetry analysis in assessing the temporal association between medicine dispensings and adverse drug events	RPBS (entitlement not specified) Other international dispensing data	2001 – 2012 (12 years)	Temporal association (adjusted sequence ratio) between amiodarone or allopurinol initiation and subsequent thyroxine initiation, by country
Protocol				
Individual-level (6 studies)				
Daniels, 2017 [34]	Protocol of a programme of work that will provide evidence of prescribing patterns, safety monitoring and outcomes of patients with breast cancer treated with HER2-targeted therapies	PBS ad hoc extracts MBS Herceptin Program	2001–2014 (13 years and 4 months)	Reported: No. dispensings by medicine type and type of breast cancer No. persons receiving treatment Intended: Duration of therapy and survival outcomes Extent of resource use of each service type by patient demographics and treatment setting
Seaman, 2017 [161]	Protocol for a whole-of-population study that will evaluate health outcomes and health service utilisation after the consumer co-payment changes	PBS ad hoc extracts (WA Only) MBS HMDC Mortality data	2000–2010 (11 years)	Reported: No. of dispensings and persons dispensed statins Intended: Risk of hospitalisation, death for each statin group (continuing, reduced, ceased) Health service utilisation, additional medicines, clinical and demographic characteristics for each statin group (continuing, reduced, ceased)
Qin, 2016 [143]	Protocol of a study that will evaluate trends in dispensing of heart failure medicine use, and outcomes following hospitalisation for heart failure	PBS ad hoc extracts (concession, WA only) HMDC Death registry	2002 – 2014 (12 years and 6 months)	Reported: No. of persons included in the study cohort Intended: Adherence, persistence
Langton, 2015 [105]	Protocol of program that will examine resource use, costs and quality of end-of-life cancer care.	RPBS (full entitlement, NSW only) DVA: Health services, Hospitalisations, Aged care NSW: APDC, EDDC, RBDM, CCR ABS	1994 – 2009 (16 years)	Reported: Cohort characteristics (No., %) Intended: Resource use (%) and costs ($AUD per decadent) in 6 months end of life

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Supplementary Appendix D: Continued

First author, year of publication	Study aim	Data source	Study period (duration)	Primary outcome measure
Gunnell, 2014 [51]	Protocol of a study that will investigate trends dispensing of medicines for secondary prevention of cardiovascular events	PBS ad hoc extracts (NSW only) PBS Online (concession) NSW: APDC, EDDC, RBDM, MBS	1980–2013 (34 years)	Reported: No. of persons in the cohort after linkage and number of records in each data set Annual concessional dispensings counts by drug and state Intended: dispensed drug trends, drug adherence, all-cause/cardiovascular events, cost-effectiveness of these long- term therapies and the impact of adherence
Pearson, 2014 [129]	Protocol of study that will examine the use and impact of cancer medicines in elderly cancer patients	RPBS (any entitlement, NSW only) DVA: Health service, Hospitalisations, Aged care NSW: APDC, EDDC, RBDM, CCR ABS	2004 – 2012 (19 years)	Reported: Patient demographics, most common medicine, cancer treatments and No. of health service use over a 1-year period Intended: Patterns of use of cancer medicines, treatments, and health services prior to diagnosis by patient characteristics Predictors and risk of health outcomes by medicine

Note: ABS = Australian Bureau of Statistics, AIC = Akaike information criterion, ASM = Australian Statistics on Medicines, APDC = Admitted Patients Data Collection, CCR = Central Cancer Registry, DDD = Defined Daily Dose, DoP = Date of Processing, DoS = Date of Supply, DUSC = Drug Utilisation Sub-Committee, DVA = Department of Veterans' Affairs, EDDC = Emergency Department Data Collection, HMDC = Hospital Morbidity Data Collection, MBS = Medicare Benefits Schedule, NSW = New South Wales, PBS = Pharmaceutical Benefits Scheme, RBDM = Registry of Births, Deaths, and Marriages, RPBS = Repatriation Pharmaceutical Benefits Scheme, WA = Western Australia.