

1 **Impact of medication reviews on potentially inappropriate medications and associated**
2 **costs among older women in aged care**

3 Kaeshaelya Thiruchelvam ^{a,b}, Julie Byles ^{a,c}, Syed Shahzad Hasan ^{a,d}, Nicholas Egan ^{a,c}, Therese
4 Kairuz ^{a,b}

5

6 ^a University of Newcastle, University Drive, Callaghan, New South Wales 2308, Australia

7 ^b International Medical University, 126 Jalan Jalil Perkasa 19, Bukit Jalil, 57000 Kuala
8 Lumpur, Malaysia

9 ^c Priority Research Centre for Generational Health and Ageing, Hunter Medical Research
10 Institute, New Lambton Heights, New South Wales 2305, Australia

11 ^d Department of Pharmacy, University of Huddersfield, Queensgate, Huddersfield HD1 3DH,
12 United Kingdom

13

14

15 **Corresponding author**

16 Ms Kaeshaelya Thiruchelvam, MSc

17 International Medical University, 126 Jalan Jalil Perkasa 19, Bukit Jalil, 57000 Kuala Lumpur,
18 Malaysia

19 kaeshaelyathiruchelvam@uon.edu.au; kaeshaelya@gmail.com

20 +60126305852

21 ORCID ID: <https://orcid.org/0000-0002-3754-1690>

22

23 Professor Julie Byles

24 julie.byles@newcastle.edu.au

25 ORCID ID: <https://orcid.org/0000-0002-3984-6877>

26

27 Dr Syed Shahzad Hasan

28 S.Hasan@hud.ac.uk

29 ORCID ID: <https://orcid.org/0000-0002-4058-2215>

30

31 Mr Nicholas Egan

32 Nick.Egan@newcastle.edu.au

33 ORCID ID: <https://orcid.org/0000-0002-0854-7444>

34

35 Associate Professor Therese Kairuz

36 Therese.kairuz@newcastle.edu.au

37 ORCID ID: <https://orcid.org/0000-0002-3311-187X>

38

39 **Declarations of interest:** None

40

41

42

43

44

45 **Abstract**

46 **Background:** The Residential Medication Management Review (RMMR) service is a large
47 investment by the Australian government and involves considerable time commitment.

48 **Objectives:** This study determined the impact of RMMRs on the use of potentially
49 inappropriate medications (PIMs), benzodiazepines and antidepressants, described patterns of
50 PIM use, and examined costs.

51 **Methods:** The study included 5576 participants from the Australian Longitudinal Study on
52 Women's Health from 2005 to 2017. Three generalised estimating equation (GEE) models
53 were specified to separately analyse the impact of RMMRs on the use of PIMs,
54 benzodiazepines and antidepressants. Descriptive statistics were used to present, at each year,
55 the proportions of participants with PIMs, patterns of PIMs and costs of PIMs.

56 **Results:** There was no evidence for an association between the use of RMMRs and the use of
57 PIMs (OR=0.99; 95% CI=0.88, 1.11), benzodiazepines (OR=1.02; 95% CI=0.95, 1.08) or
58 antidepressants (OR=0.99; 95% CI=0.90, 1.10) in the following year. There were few
59 differences in the use of particular classes of PIMs, nor any differences in the median benefits
60 paid by government or out-of-pocket costs, between participants who did and did not receive
61 RMMRs. There was a slight increase in median OOP costs and a decrease in government
62 benefits over time.

63 **Conclusions:** There was a lack of long-term changes on use of PIMs, however, its appropriate
64 use must be considered during RMMRs. Healthcare professionals have an obligation to
65 optimise the service to reduce medication costs whilst improving health outcomes among
66 individuals residing in RACF.

67 **Keywords:** Aged care, costs, medication review, potentially inappropriate medications,
68 Residential Medication Management Review

69

70 **Introduction**

71

72 Improvements in global socioeconomic development (1) have led to greater longevity which
73 has negatively impacted healthcare systems due to increased multimorbidity. Multimorbidity
74 is more common among older women, who are more likely than men to be admitted to
75 residential aged care facilities (RACFs) (2,3). People residing in RACFs appear to be more
76 frail than those residing in the community (4), with a higher risk of multimorbidity and use of
77 multiple medications. Older people are more vulnerable to adverse effects, and are at higher
78 risk of polypharmacy (five or more concurrent medications) (5,6). Polypharmacy is associated
79 with unnecessary or potentially inappropriate medications (PIMs) (7).

80

81 Lists of PIMs (i.e. Beers Criteria) were first published in 1991 and are defined as “medications
82 or medication classes that should generally be avoided in persons 65 years and older because
83 they are either ineffective or they pose an unnecessarily high risk for older persons and a safer
84 alternative is available” (8). PIMs listed in the Beers Criteria are intended to facilitate improved
85 selection of medications, reduce adverse drug events, educate physicians and patients, and
86 function as a tool to evaluate quality of care, cost and patterns of medication use (9). The list
87 is regularly updated and was last updated in 2019 (9). PIMs increase the risk of falls, fractures,
88 hallucination, delirium and mortality (10,11). Benzodiazepines and antidepressants are
89 examples (12–14); benzodiazepines may impair cognition and mobility (15) while
90 antidepressants may result in or worsen orthostatic hypotension (16). Both medications
91 increase the risk of falls (15,16), hospitalisations and related healthcare costs.

92

93 Often overlooked are costs resulting from the use of PIMs, particularly out-of-pocket (OOP)
94 costs. The cost of PIMs has only been reported in a few studies and focussed on costs borne by

95 the government (benefits paid or subsidised costs) (17,18). OOP costs account for about 18%
96 of healthcare spending within Australia and half of the total medication expenditure are OOP
97 costs (19). Avoiding PIMs is an effective and simple measure to reduce costs, medication-
98 related problems and adverse drug events in older adults (20). Clinical interventions, such as
99 pharmacist-led medication reviews, may improve patient care by reducing PIMs (21).

100

101 In Australia, Residential Medication Management Reviews (RMMRs) are patient-centred
102 medication reviews initiated by general practitioners (GPs) or medical practitioners, and
103 conducted by Accredited Pharmacists; the process involves systematically evaluating the
104 individual's medication regimen and management (22). The RMMR aims to optimise the
105 benefits of medications, improve therapeutic outcomes, and ensure appropriate use of
106 medications (22). The RMMR is a federally-funded service by Medicare, Australia's universal
107 health insurance scheme, and GPs and Accredited Pharmacists are remunerated by the
108 Australian Department of Health and the Pharmacy Programs Administrator (23,24). The
109 Australian Government has allocated AUD\$1.20 billion for professional pharmacy programs,
110 including RMMRs, from 2020 until 2025 (25).

111

112 The RMMR guidelines (22,26) promote the use of various prescribing indicator tools,
113 including the Beers Criteria, to identify medication-related problems including PIMs. Given
114 that the RMMR service is a large investment by the Australian government and the service
115 requires significant time commitment, it is important to determine its impact on the use of PIMs
116 among older people. In this analysis, the focus was narrowed to older women living in aged
117 care, who appear to be more vulnerable to the negative effects of PIMs. The effect of RMMRs
118 on the costs of using PIMs should also be examined. Additionally, identifying patterns and

119 characteristics associated with the use of PIMs may assist in optimising prescribing for older
120 people.

121

122 Therefore, this study determined the impact of RMMRs on PIMs, benzodiazepines, and
123 antidepressants, while adjusting for characteristics associated with their use among older
124 Australian women residing in RACFs. We also described the different patterns of PIM use, and
125 the differences in costs (both OOP and benefits paid by the government) for women who
126 received and did not receive RMMRs.

127

128 **Methods**

129

130 **Study population and data sources**

131

132 The study included participants from the oldest cohort of the Australian Longitudinal Study on
133 Women's Health (ALSWH) who were born between 1921 and 1926. The ALSWH is an
134 ongoing longitudinal population-based survey that investigates the health and wellbeing of
135 Australian women (27). The participants completed a baseline survey in 1996 and every three
136 years thereafter until 2011, followed by an abbreviated survey every six months. When
137 compared to the 1996 Australian National Census data, participants were largely representative
138 of older Australian women of the same age group (28). Further details on the ALSWH are
139 reported elsewhere (29).

140

141 Participants' survey data were linked to data from the Medicare Benefits Schedule (MBS)
142 (23), a list of medical services for which the Australian government provides a rebate, and the
143 Pharmaceutical Benefits Schedule (PBS) (30), a government program which provides access

144 to subsidised medications. The PBS data includes medications covered by the Repatriation
145 Pharmaceutical Benefits Scheme (RPBS), which subsidises medications for Australian
146 veterans and governed by the Department of Veterans' Affairs (DVA). Participants were
147 determined to be residing in RACF if they had at least one MBS RACF service in a year
148 ([Online Resource 1](#)).

149

150 **Eligible participants**

151

152 The study period was from 2005 (aged 79 to 84 years) to 2017 (aged 91 to 96 years), with
153 identification of RMMRs, PIM use and costs at each year. Eligible participants had to fulfil
154 the following criteria:

155

- 156 i) Alive at 1 January 2005, and
- 157 ii) Eligible for and did not withdraw consent to data linkage to the MBS and PBS
158 prior to 2017, and
- 159 iii) Had at least one PBS record in 2005, and
- 160 iv) Had at least one MBS record any time from 2005 to 2017, and
- 161 v) Had at least one MBS service provided in a RACF any time from 2005 to 2017.

162

163 [Online Resource 2](#) shows the stepwise approach used to obtain the final study sample.

164

165 **Residential Medication Management Reviews**

166

167 The use of RMMRs was identified from the MBS via the item numbers for referrals of
168 RMMRs (00903 for GPs and 00249 for medical practitioners) (23). The RMMR was

169 introduced in Australia in 1997, however, this service was only available as an MBS item
170 from November 2004. Therefore, participants were classified as having had an RMMR or not
171 at each year from 2005 to 2017.

172

173 **Potentially inappropriate medications and costs**

174

175 The use of PIMs was identified using the Beers Criteria 2019 based on the table ‘2019
176 American Geriatrics Society Beers Criteria® for Potentially Inappropriate Medication Use in
177 Older Adults’, which included PIMs to avoid regardless of underlying diseases (9). We
178 counted and presented PIMs listed in the table as unique medications (although some PIMs
179 were classified as medication classes) based on information from the PBS and using the
180 Anatomic Therapeutic Chemical (ATC) classification (31). We included all PIMs from the
181 table regardless of avoidance criteria, if any. Participants were categorised as PIM users if
182 they used one or more PIMs at each calendar year. Benzodiazepines (alprazolam, oxazepam,
183 temazepam, clonazepam, and diazepam) and antidepressants (amitriptyline, clomipramine,
184 doxepin, imipramine, nortriptyline and paroxetine) were identified based on their ATC codes.

185

186 The analysis considered benefits paid by the government and OOP costs, both included in the
187 PBS dataset. The total annual costs of each participant’s PIMs were calculated for each year
188 from 2005 to 2017. Median costs at each year, based on having had RMMRs (or not), are
189 presented in Australian dollars (AUD) as both raw and inflation-adjusted values. Inflation-
190 adjusted costs were calculated for the 2019 calendar year, rather than 2020 as inflation may
191 have been impacted by COVID-19; inflation-adjusted costs were calculated using the
192 Inflation Calculator provided by the Reserve Bank of Australia (32).

193

194 **Explanatory variables**

195

196 Survey 4 (2005) was treated as the baseline survey for this study, and age at baseline was
197 determined from this survey. Time (in years) was included as a continuous variable to
198 account for time trends in the study. Categorical variables included DVA coverage (yes or
199 no), number of GP visits (≤ 4 or > 4), hospital admissions (yes or no) and falls in the last 12
200 months (yes or no), number of chronic diseases (< 4 or ≥ 4), presence of continuous
201 polypharmacy (yes or no) and whether participants lived alone (yes or no). Education level
202 ($< \text{Year 12}$ or $\geq \text{Year 12}$) was determined from Survey 1 (1996). Chronic diseases were
203 considered enduring if reported at any survey point: heart disease (myocardial infarction,
204 angina or any other heart problem), hypertension, diabetes mellitus, respiratory disease
205 (bronchitis, asthma or emphysema), stroke, cancer, mental illness (depression,
206 anxiety/nervous disorder, or Alzheimer's disease/dementia), osteoporosis and arthritis
207 (rheumatoid arthritis and osteoarthritis). Continuous polypharmacy was indicated if the same
208 unique medication appeared in two different time windows of the same year (1 April to 30
209 June, and 1 October to 31 December). This definition prevented underestimating exposure to
210 medications which can occur as some patients tend to stockpile medications (33). Data were
211 carried forward from the previous survey when missing in non-survey years. The same
212 explanatory variables were used in each model to determine the impact of RMMRs on PIMs,
213 benzodiazepines and antidepressants.

214

215 **Statistical analysis**

216

217 Descriptive statistics were used to present, at each year, the proportions of participants with
218 PIMs, patterns of PIMs and costs of PIMs (OOP and benefits paid by the government) based

219 on having had RMMRs or not. Costs of PIMs were presented as median values with their
220 associated interquartile range as a measure of variability in the data. Generalised Estimating
221 Equation (GEE) models were used to analyse longitudinal data to account for the correlation
222 of repeated measures on the same individual, hence providing a strong advantage over cross-
223 sectional regressions at a single time point (34).

224

225 GEEs were used to determine the association between explanatory variables and the outcome
226 in the following calendar year to ensure that the RMMR preceded the outcome. Three models
227 were specified to separately analyse the impact of RMMRs on the use of PIMs,
228 benzodiazepines and antidepressants. GEEs were specified with a logit link and binomial
229 family to estimate odds ratios (OR) with 95% confidence intervals; the GEEs for PIMs and
230 benzodiazepines employed an unstructured correlation matrix, whereas the GEE for
231 antidepressants used an exchangeable correlation structure due to convergence issues with the
232 more flexible unstructured correlation matrix. The first step involved identifying
233 multicollinearity among variables; variables with Pearson's correlation coefficients >0.8 or
234 variance inflation factor values >10 (35) were considered collinear and removed from the
235 model. The first multivariable model was determined by performing univariate regressions
236 and selecting variables with p-values <0.25 (36). Backward stepwise elimination was then
237 performed on the first multivariable model until the final parsimonious model was obtained.
238 All analyses were conducted in Stata 16 (37).

239

240 **Ethics approval**

241

242 The Australian Longitudinal Study on Women's Health (ALSWH) program obtained ongoing
243 ethical approval from the Human Research Ethics Committees (HRECs) of the Universities

244 of Queensland and Newcastle (approval numbers 2004000224 and H-076-0795,
245 respectively). Institutional HREC approvals for record linkage (approval numbers
246 2012000132 and H-2011-0371, respectively) are also maintained by the ALSWH. Access to
247 national data collections is approved by the Australian Institute of Health and Welfare HREC,
248 and the Departments of Defence and Veterans' Affairs HREC.

249

250 **Results**

251

252 A total of 5576 participants was included in the study, but the sample size varied over time
253 due to missing items and attrition. The study included 768 participants in 2005, reached a
254 maximum of 1738 participants in 2012 and decreased to 1485 participants in 2017.

255 Approximately a quarter (23.08%) of the sample had died by the end of 2010, and 76.40% of
256 the sample had died by the conclusion of the study at the end of 2017. Baseline
257 characteristics of study participants in 2005 are summarised in [Online Resource 3](#). Only
258 54/768 participants had RMMRs in 2005 (7.00%).

259

260 [Figure 1](#) shows the proportion of participants with PIMs at each calendar year based on
261 having received an RMMR, or not (summarised in [Online Resource 4](#)). For most of the
262 study period, there was little difference in the prevalence of participants with at least one PIM
263 between participants who had and had not received an RMMR. The prevalence of PIMs
264 among participants who had an RMMR decreased from 2005 to 2009, while during the same
265 time, the prevalence of PIMs increased among participants who had not had a review. The
266 prevalence of PIMs among both groups decreased from 2014 to 2017. Only 22% of
267 participants received multiple RMMRs during the study. Across all time points, there was no
268 evidence for a difference in the number of PIMs between participants who received one

269 RMMR and participants who received multiple RMMRs. When the impact of RMMRs on the
270 use of PIMs in the following calendar year was investigated using GEE regression models,
271 there was no evidence for an association between the use of RMMRs and the use of PIMs
272 (OR 0.99; 95% CI 0.88, 1.11), benzodiazepines (OR 1.02; 95% CI 0.95, 1.08) or
273 antidepressants (OR 0.99; 95% CI 0.90, 1.10) (see [Table 1](#)).

274

275 The findings also depict different variables associated with the use of different PIM groups.
276 Participants had higher odds of using at least one PIM in the following year if they had DVA
277 coverage (OR 1.40; 95% CI 1.02, 1.91), >4 GP visits (OR 1.55; 95% CI 1.28, 1.87), ≥ 4
278 chronic diseases (OR 1.38; 95% CI 1.13, 1.68), hospital admissions in the last 12 months (OR
279 1.28; 95% CI 1.04, 1.56) and continuous polypharmacy (OR 1.86; 95% CI 1.61, 2.14).

280 Additionally, for every 1-year increase in time, they had 3% lower odds of using PIMs in the
281 following year (OR 0.97; 95% CI 0.94, 0.99). In comparison, participants had higher odds of
282 using benzodiazepines in the following year if they had >4 GP visits (OR 1.35; 95% CI 1.18,
283 1.54) and continuous polypharmacy (OR 1.12; 95% CI 1.04, 1.21). Participants had higher
284 odds of using antidepressants in the following year if they also had >4 GP visits (OR 1.29;
285 95% CI 1.06, 1.56) and continuous polypharmacy (OR 1.32; 95% CI 1.18, 1.47).

286 Additionally, for every 1-year increase in time, they had 4% lower odds of using
287 antidepressants in the following year (OR 0.96; 95% CI 0.94, 0.98).

288

289 We also examined the use of PIMs of interest among participants who did and did not have
290 RMMRs (see [Figure 2](#)). Overall, there were few differences in usage of PIMs between the
291 two groups. Use of antidepressants, antipsychotics, long-acting sulfonylureas, and
292 nonsteroidal anti-inflammatory drugs (NSAIDs) decreased over time in both groups, while

293 use of proton pump inhibitors (PPIs) increased over time. However, antispasmodics and
294 anticholinergics did not depict any consistent trends ([Online Resource 5](#)).

295

296 Median OOP costs of PIMs and benefits paid by the government were also examined. [Figure](#)
297 [3](#) depicts raw unadjusted costs, whereas [Figure 4](#) depicts inflation-adjusted costs; inflation-
298 adjusted costs will be the focus of this paper. [Figure 4](#) shows a decrease in the median
299 benefits paid by the government over time and a slight increase in the median OOP costs over
300 time. The median benefits paid by the government for PIMs decreased from 2005 to 2017 in
301 both the RMMR (from approximately AUD\$1050 to AUD\$225) and non-RMMR (from
302 approximately AUD\$810 to AUD\$220) groups (see [Online Resource 6](#)). Over time, there
303 was an increase in OOP costs for both the RMMR (from approximately AUD\$96 to
304 AUD\$104) and non-RMMR (from approximately AUD\$84 to AUD\$98) groups. Overall,
305 participants who received RMMRs had higher median government and OOP costs than
306 participants who did not receive RMMRs, but we cannot conclude that the higher costs were
307 attributable to the use of RMMRs.

308

309 **Discussion**

310

311 This study found no evidence that RMMRs had any impact on the use of PIMs,
312 benzodiazepines and antidepressants in the following calendar year. There were no
313 substantial differences in the prevalence of particular classes of PIMs between women who
314 did and did not receive RMMRs. There was a decrease in the median benefits paid by
315 government over time, and a slight increase in the median OOP costs, while women who
316 received RMMRs had higher median costs than women who did not receive
317 RMMRs.

318

319 The lack of differences in PIM use between women who received RMMRs and women who
320 did not was investigated further. An evaluation of the impact of RMMRs on use of PIMs
321 (including benzodiazepines and antidepressants) in our study suggested no evidence of an
322 association, a finding that is at odds with previous Australian studies (38–41). The lack of
323 evidence can be attributed to several reasons. Firstly, there may have been the need to
324 continue some PIMs, which could have been justified in certain circumstances and
325 prescribing practices. PIMs, especially those listed in the Beers Criteria, should *generally* be
326 avoided because they are *potentially* inappropriate (9). Lack of evidence of an association
327 between RMMRs and benzodiazepines and antidepressants may be partially attributable to
328 the prescribing of these medications in situations where their use was warranted. Between
329 2008 and 2012, Australian individuals admitted to RACFs with symptoms of depression had
330 higher care needs (42). Although antidepressants are deemed PIMs, antidepressants are a
331 cornerstone of treatment for depression and there appears to be robust evidence to support the
332 efficacy of modern antidepressants in treating depression among older adults (43,44).
333 Benzodiazepines have been associated with more risks compared to antidepressants and must
334 be used with caution. They are the most commonly reported PIM category used globally, and
335 15.3% of older Australians were prescribed at least one benzodiazepine in 2016 (45). A
336 review by Gerlach et al. (2018) reported at least 21 of 25 trials showed improvements in sleep
337 outcomes for older people treated with benzodiazepines (46).

338

339 Other reasons for not detecting evidence of an association between RMMRs and PIMs could
340 be that we determined the long-term impact of RMMRs on use of PIMs by considering the
341 use of PIMs in the year after the RMMR was conducted. This ensured that we captured all
342 PIMs prescribed to women in the period after an RMMR, rather than at a single time point

343 shortly after the RMMR, unlike earlier studies (40,41,47). Although RMMRs may have led to
344 an immediate reduction in dispensed PIMs after the RMMR report was generated, this effect
345 may not have been sustained over the next year. Furthermore, it has been reported that there
346 is a lack of process integration at RACFs where GPs do not have access to previous
347 medication review reports for individuals newly enrolled in a RACF, and this may not allow
348 for long-term changes from previous RMMRs (48). In such instances, GPs may be reluctant
349 to discontinue long-term medications due to fear of unidentified negative outcomes (49).
350 Additionally, although the identification and reduction of PIMs has been advocated in
351 RMMR guidelines (22,26), this is not mandatory, and it is at the discretion of the Accredited
352 Pharmacist.

353

354 The methods used to determine the impact of RMMRs on the use of PIMs in this study were
355 more robust than other studies. Longitudinal data permitted the use of longitudinal analysis
356 methods (i.e. GEE models), which allowed for more precise estimation of model estimates
357 than the cross-sectional approaches used in some earlier studies (38,47). Furthermore, this
358 study controlled for confounding variables, which is an improvement over presenting simple
359 summary statistics such as the proportion of individuals with at least one PIM as reported in
360 the study by Lenander et al. (2018) (47), the proportion of individuals with benzodiazepines
361 in the study by Westbury et al. (2010) (50), and median cumulative scores of prescribing
362 appropriateness as reported by Koria et al. (2018) (38). These studies found evidence of
363 significant reductions in the proportion of individuals with PIMs ($p < 0.001$), the proportion of
364 individuals with benzodiazepines ($p < 0.005$), and an improvement in the median cumulative
365 scores of prescribing appropriateness ($p < 0.001$), respectively.

366

367 Our study found evidence of other characteristics associated with use of all PIMs,
368 benzodiazepines and antidepressants: having DVA coverage, increased chronic diseases, GP
369 visits and hospital admission in the past year, and continuous polypharmacy, similar to
370 literature (51). Furthermore, women had increased odds of using benzodiazepines and
371 antidepressants in the following year if they had >4 GP visits or continuous polypharmacy.
372 Women had 4% decreased odds of using antidepressants in the following year with every
373 one-year increase in time; this is consistent with the decreasing use of antidepressants
374 identified in our study. These characteristics may identify individuals at high risk of being
375 prescribed PIMs, benzodiazepines or antidepressants. Additional caution should be made
376 when prescribing medications for women with increased GP visits or continuous
377 polypharmacy, as these factors appear to increase the risk of being prescribed PIMs.

378

379 When the use of particular PIM categories was examined, we found the highest distribution
380 and use were PPIs, consistent with a cross-sectional study by Hendrix et al. (2019) (52).
381 Deprescribing PPIs is challenging because abrupt cessation could result in rebound symptoms
382 caused by acid hypersecretion (53). The highest users of PPIs in Australia appear to be those
383 aged 80 years and over, with at least half of RACF residents taking PPIs regularly (52,54).
384 The impact of RMMRs on PPIs is inconclusive, although it has been reported that the
385 prevalence of PPIs increased between 2000 and 2017 (55). Decreased prescribing of
386 antidepressants, antipsychotics, long-acting sulfonylureas and NSAIDs is likely attributable
387 to improved prescribing guidelines.

388

389 An important finding of our study was the increasing trend in the median OOP cost of PIMs
390 over time. Harrison et al. (2018) reported similar high costs of PIMs (with PPIs as a major
391 contributor) (17). Increased OOP costs may be partially attributable to changes over time in

392 reimbursement rules of PBS Australia (56), and polypharmacy. A previous study reported
393 that older women with polypharmacy were 17% more likely to receive RMMRs, compared to
394 those without polypharmacy (57). There was a higher number of women with polypharmacy
395 among those who received RMMRs. The study also reported that OOP costs increased over
396 time, in accordance with the current study (57). Evidence demonstrates that much of the
397 economic household burden in Australia can be attributed to chronic illnesses, with each
398 additional chronic disease increasing the likelihood of financial difficulties by 46% (58).
399 OOP costs are a component of this economic burden. Studies indicate that medication costs
400 associated with chronic illnesses may be prohibitive, thus utilising a major portion of the
401 resources made available to a household, exacerbating economic disadvantages (59). There is
402 a direct impact of OOP on access to healthcare, because 14% of older Australians (and 24%
403 of those with chronic illnesses) had failed to obtain appropriate healthcare treatment or attend
404 GP visits in 2013 due to cost (60); this may explain the decrease in the median benefits paid
405 by the government over time in our study. While women who received RMMRs had higher
406 median PIM costs, this could be partially attributable to PIMs that were warranted.

407

408 **Study limitations**

409

410 There were some limitations to our study. The PBS dataset excluded medications dispensed
411 on non-subsidised private prescriptions and there are limitations to the way anticholinergic
412 and antipsychotic medications are classified in the Beers Criteria. For example, antipsychotic
413 use was higher than that of anticholinergics even though some antipsychotics may have
414 anticholinergic properties (e.g. chlorpromazine, clozapine, quetiapine) and this was because
415 each medication was only present in one classification, i.e. antipsychotics or anticholinergics.
416 We were unable to consider the avoidance criteria included in the Beers Criteria table for

417 identification of PIMs, due to a lack of available data on specific conditions for each
418 participant. We referred to the most updated version of the Beers Criteria (2019) for our
419 study, and as a result some PIMs may have been misclassified due to varying Beers Criteria
420 over time. The analysis was limited by the lack of access to the details of the medication
421 reviews, which limited our ability to specifically determine if the review had an immediate
422 effect on the number of PIMs. However, our analysis showed that even if there might have
423 been an immediate reduction in the number of PIMs following a review, this reduction was
424 not sustained in the following year. Lastly, as data was filled-in for non-survey years (using
425 the last-observation-carried-forward method), this may have failed to adequately capture
426 year-to-year variation in the confounding variables resulting in some measurement error.

427

428 **Conclusions**

429

430 Our study provides key information that may aid future policies and guidelines pertaining to
431 the RMMR service. There was a lack of long-term changes, if any, on the use of PIMs among
432 older women aged 79 years and over residing in RACF. Although PIMs should generally be
433 avoided, appropriate use of PIMs among older people should be an important consideration
434 during RMMRs. The characteristics associated with use of PIMs, benzodiazepines and
435 antidepressants highlight the importance of the role of GPs in identifying and optimising
436 prescribing in the context of PIMs, particularly among individuals who have continuous
437 polypharmacy. The overall impact on use of PIM classes based on having RMMRs could not
438 be identified in our study, and provides an area to explore for future studies. The most
439 important finding of our study is that we provided evidence of increased OOP PIM costs over
440 time, which could translate to increased medication costs. Women receiving RMMRs
441 incurred higher OOP costs compared to those who did not, thus medication costs should be

442 considered during RMMRs. Policy makers, general practitioners and pharmacists have an
443 obligation to optimise the provision of the RMMR service to reduce costs whilst improving
444 health outcomes among individuals residing in RACF.

445

446 **Declarations of interest**

447

448 None

449

450 **Acknowledgements**

451

452 This study was conducted as part of the Australian Longitudinal Study on Women's Health
453 by the University of Newcastle and the University of Queensland. We are grateful to the
454 Australian Government Department of Health for funding, as well as to the women who
455 provided the survey data. The authors also acknowledge the Australian Institute of Health and
456 Welfare (AIHW) as the integrating authority, and the Departments of Health and Veterans'
457 Affairs, and Medicare Australia, for providing PBS data.

458

459 **Funding**

460

461 The Australian Government Department of Health funds the Australian Longitudinal Study
462 on Women's Health and permit use of Study data for research purposes. The Department has
463 no other role with respect to this research paper.

464

465 **Availability of data and material**

466

467 Use of the ALSWH dataset is subject to strict ethical conditions due to the personal nature of
468 the data collected. The ethics committees that oversee the ALSWH are the Australian
469 Government Department of Health Human Research Ethics Committee and the Human
470 Research Ethics Committees at the University of Queensland and the University of
471 Newcastle. Ethical approval of the ALSWH specifies that de-identified data are only
472 available to collaborating researchers where there is a formal request to make use of the
473 material, and that each request has to be approved by the ALSWH Data Access Committee.
474 Further details can be found at <http://alswh.org.au/for-researchers>.

475

476 **Code availability**

477

478 Codes can be made available upon request.

479

480 **References**

481

- 482 1. World Health Organization, National Institutes of Health, National Institute on Aging. Global
483 health and ageing [Internet]. 2011. Report No.: 11–7737. Available from:
484 https://www.who.int/ageing/publications/global_health.pdf
- 485 2. Australian Institute of Health and Welfare. Aged care [Internet]. Australian Institute of Health
486 and Welfare. 2019 [cited 2020 Sep 7]. Available from:
487 <https://www.aihw.gov.au/reports/australias-welfare/aged-care>
- 488 3. American Association of Retired Persons. Public Policy Institute analysis of data from the 2004
489 National Nursing Home Survey [Internet]. American Association of Retired Persons Public Policy
490 Institute; 2004. Available from: https://assets.aarp.org/rgcenter/il/fs10r_homes.pdf
- 491 4. Kojima G. Prevalence of Frailty in Nursing Homes: A Systematic Review and Meta-Analysis. *J Am*
492 *Med Dir Assoc*. 2015 Nov 1;16(11):940–5.
- 493 5. Fried TR, O’Leary J, Towle V, Goldstein MK, Trentalange M, Martin DK. Health outcomes
494 associated with polypharmacy in community-dwelling older adults: a systematic review. *J Am*
495 *Geriatr Soc*. 2014 Dec;62(12):2261–72.

- 496 6. Thiruchelvam K, Byles J, Hasan SS, Egan N, Kairuz T. Prevalence and association of continuous
497 polypharmacy and frailty among older women: A longitudinal analysis over 15 years. *Maturitas*.
498 2021 Apr 1;146:18–25.
- 499 7. Jetha S. Polypharmacy, the Elderly, and Deprescribing. *Consult Pharm J Am Soc Consult Pharm*.
500 2015 Sep;30(9):527–32.
- 501 8. Beers MH, Ouslander JG, Rollinger I, Reuben DB, Brooks J, Beck JC. Explicit criteria for
502 determining inappropriate medication use in nursing home residents. *UCLA Division of Geriatric*
503 *Medicine. Arch Intern Med*. 1991 Sep;151(9):1825–32.
- 504 9. By the 2019 American Geriatrics Society Beers Criteria® Update Expert Panel. American
505 Geriatrics Society 2019 Updated AGS Beers Criteria® for Potentially Inappropriate Medication
506 Use in Older Adults. *J Am Geriatr Soc*. 2019 Apr;67(4):674–94.
- 507 10. Stockl KM, Le L, Zhang S, Harada AS. Clinical and economic outcomes associated with potentially
508 inappropriate prescribing in the elderly. *Am J Manag Care*. 2010 Jan;16(1):e1-10.
- 509 11. Perri M, Menon AM, Deshpande AD, Shinde SB, Jiang R, Cooper JW, et al. Adverse outcomes
510 associated with inappropriate drug use in nursing homes. *Ann Pharmacother*. 2005
511 Mar;39(3):405–11.
- 512 12. Zhang X, Zhou S, Pan K, Li X, Zhao X, Zhou Y, et al. Potentially inappropriate medications in
513 hospitalized older patients: a cross-sectional study using the Beers 2015 criteria versus the 2012
514 criteria. *Clin Interv Aging*. 2017 Oct 12;12:1697–703.
- 515 13. Li G, Andrews HF, Chihuri S, Lang BH, Leu CS, Merle DP, et al. Prevalence of Potentially
516 Inappropriate Medication use in older drivers. *BMC Geriatr*. 2019 Oct 10;19(1):260.
- 517 14. Fulone I, Lopes LC. Potentially inappropriate prescriptions for elderly people taking
518 antidepressant: comparative tools. *BMC Geriatr*. 2017 Dec 2;17:278.
- 519 15. National Institutes of Health. Benzodiazepine Often Used in Older People Despite Risks
520 [Internet]. National Institutes of Health (NIH). 2015 [cited 2021 Jul 27]. Available from:
521 [https://www.nih.gov/news-events/nih-research-matters/benzodiazepine-often-used-older-](https://www.nih.gov/news-events/nih-research-matters/benzodiazepine-often-used-older-people-despite-risks)
522 [people-despite-risks](https://www.nih.gov/news-events/nih-research-matters/benzodiazepine-often-used-older-people-despite-risks)
- 523 16. Giovannini S, Onder G, van der Roest HG, Topinkova E, Gindin J, Cipriani MC, et al. Use of
524 antidepressant medications among older adults in European long-term care facilities: a cross-
525 sectional analysis from the SHELTER study. *BMC Geriatr*. 2020 Aug 27;20(1):310.
- 526 17. Harrison SL, Kouladjian O'Donnell L, Milte R, Dyer SM, Gnanamanickam ES, Bradley C, et al. Costs
527 of potentially inappropriate medication use in residential aged care facilities. *BMC Geriatr*
528 [Internet]. 2018 Jan 11 [cited 2019 Sep 3];18. Available from:
529 <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5765623/>
- 530 18. Unutmaz GD, Soysal P, Tuven B, Isik AT. Costs of medication in older patients: before and after
531 comprehensive geriatric assessment. *Clin Interv Aging*. 2018;13:607–13.
- 532 19. Essue B, Usherwood T, Laba T, Leeder S, Yusuf F, Gillespie J, Perkovic V, Wilson A, Jan S. Out-of-
533 pocket costs of health care in Australia: submission to the Senate Standing Committee on
534 Community Affairs [Internet]. The George Institute for Global Health Australia, Menzies Centre
535 for Health Policy, Australian National University, The University of Sydney; 2014 Mar [cited 2020

- 536 Sep 12]. Available from:
537 file:///C:/Users/c3316376/Downloads/sub28_Menzies_George%20(1).pdf
- 538 20. American Geriatrics Society 2012 Beers Criteria Update Expert Panel. American Geriatrics
539 Society updated Beers Criteria for potentially inappropriate medication use in older adults. *J Am*
540 *Geriatr Soc.* 2012 Apr;60(4):616–31.
- 541 21. Michalets E, Creger J, Shillinglaw WR. Outcomes of expanded use of clinical pharmacist
542 practitioners in addition to team-based care in a community health system intensive care unit.
543 *Am J Health-Syst Pharm AJHP Off J Am Soc Health-Syst Pharm.* 2015 Jan 1;72(1):47–53.
- 544 22. Pharmaceutical Society of Australia. Guidelines for pharmacists providing Residential Medication
545 Management Review (RMMR) and Quality Use of Medicines (QUM) services [Internet].
546 Pharmaceutical Society of Australia; 2017. Available from:
547 https://my.psa.org.au/servlet/fileField?entityId=ka17F000000cmjcQAA&field=PDF_File_Member_Content__Body__s
548
- 549 23. Australian Government Department of Health. Medicare Benefits Schedule [Internet]. 2019
550 [cited 2019 May 17]. Available from:
551 <http://www9.health.gov.au/mbs/search.cfm?q=900&sopt=S>
- 552 24. Pharmacy Programs Administrator. Residential Medication Management Review and Quality
553 Use of Medicines [Internet]. 2020 [cited 2020 Sep 10]. Available from:
554 [https://www.ppaonline.com.au/programs/medication-management-programs/residential-](https://www.ppaonline.com.au/programs/medication-management-programs/residential-medication-management-review-and-quality-use-of-medicines)
555 [medication-management-review-and-quality-use-of-medicines](https://www.ppaonline.com.au/programs/medication-management-programs/residential-medication-management-review-and-quality-use-of-medicines)
- 556 25. Australian Government Department of Health and Ageing. New (7th) Community Pharmacy
557 Agreement [Internet]. Australian Government Department of Health and Ageing; 2020 [cited
558 2020 Sep 7]. Available from:
559 [https://www1.health.gov.au/internet/main/publishing.nsf/Content/New-7th-Community-](https://www1.health.gov.au/internet/main/publishing.nsf/Content/New-7th-Community-Pharmacy-Agreement)
560 [Pharmacy-Agreement](https://www1.health.gov.au/internet/main/publishing.nsf/Content/New-7th-Community-Pharmacy-Agreement)
- 561 26. Pharmaceutical Society of Australia. Guidelines for comprehensive medication management
562 reviews [Internet]. Australia: Pharmaceutical Society of Australia; 2020 Mar [cited 2020 Sep 14].
563 Available from: [https://www.ppaonline.com.au/wp-content/uploads/2020/04/PSA-Guidelines-](https://www.ppaonline.com.au/wp-content/uploads/2020/04/PSA-Guidelines-for-Comprehensive-Medication-Management-Reviews.pdf)
564 [for-Comprehensive-Medication-Management-Reviews.pdf](https://www.ppaonline.com.au/wp-content/uploads/2020/04/PSA-Guidelines-for-Comprehensive-Medication-Management-Reviews.pdf)
- 565 27. Australian Longitudinal Study on Women’s Health. ALSWH Surveys [Internet]. 2019 [cited 2019
566 Sep 11]. Available from: <http://www.alswh.org.au/for-researchers/surveys>
- 567 28. Brown WJ, Dobson AJ, Bryson L, Byles JE. Women’s Health Australia: on the progress of the main
568 cohort studies. *J Womens Health Gend Based Med.* 1999 Jun;8(5):681–8.
- 569 29. Dobson AJ, Hockey R, Brown WJ, Byles JE, Loxton DJ, McLaughlin D, et al. Cohort Profile Update:
570 Australian Longitudinal Study on Women’s Health. *Int J Epidemiol.* 2015 Oct;44(5):1547a-
571 1547f.
- 572 30. Australian Government Department of Health. About the PBS [Internet]. 2019. Available from:
573 <http://www.pbs.gov.au/info/about-the-pbs>
- 574 31. World Health Organization. Anatomical Therapeutic Chemical (ATC) Classification [Internet].
575 WHO. 2019. Available from: [http://www.who.int/medicines/regulation/medicines-](http://www.who.int/medicines/regulation/medicines-safety/toolkit_atc/en/)
576 [safety/toolkit_atc/en/](http://www.who.int/medicines/regulation/medicines-safety/toolkit_atc/en/)

- 577 32. Reserve Bank of Australia ID. Inflation Calculator [Internet]. Reserve Bank of Australia. 2015
578 [cited 2021 Jul 29]. Available from: <https://www.rba.gov.au/calculator/annualDecimal.html>
- 579 33. Page AT, Falster MO, Litchfield M, Pearson S-A, Etherton-Beer C. Polypharmacy among older
580 Australians, 2006–2017: a population-based study. *Med J Aust*. 2019 Jul 15;211(2):71–5.
- 581 34. Sibbritt DW, Byles JE, Tavener MA. Older Australian women’s use of dentists: a longitudinal
582 analysis over 6 years. *Australas J Ageing*. 2010 Mar;29(1):14–20.
- 583 35. Midi H, Sarkar SK, Rana S. Collinearity diagnostics of binary logistic regression model. *J*
584 *Interdiscip Math*. 2010 Jun 1;13(3):253–67.
- 585 36. Lim LM, McStea M, Chung WW, Nor Azmi N, Abdul Aziz SA, Alwi S, et al. Prevalence, risk factors
586 and health outcomes associated with polypharmacy among urban community-dwelling older
587 adults in multi-ethnic Malaysia. *PloS One*. 2017;12(3):e0173466.
- 588 37. StataCorp. Stata statistical software: Release 16. College Station: TX: StataCorp LLC; 2019.
- 589 38. Koria LG, Zaidi TS, Peterson G, Nishtala P, Hannah PJ, Castelino R. Impact of medication reviews
590 on inappropriate prescribing in aged care. *Curr Med Res Opin*. 2018 May;34(5):833–8.
- 591 39. McLarin PE, Peterson GM, Curtain CM, Nishtala PS, Hannan PJ, Castelino RL. Impact of
592 residential medication management reviews on anticholinergic burden in aged care residents.
593 *Curr Med Res Opin*. 2016;32(1):123–31.
- 594 40. Nishtala PS, Hilmer SN, McLachlan AJ, Hannan PJ, Chen TF. Impact of residential medication
595 management reviews on drug burden index in aged-care homes: a retrospective analysis. *Drugs*
596 *Aging*. 2009;26(8):677–86.
- 597 41. Nishtala PS, McLachlan AJ, Bell JS, Chen TF. A retrospective study of drug-related problems in
598 Australian aged care homes: medication reviews involving pharmacists and general
599 practitioners. *J Eval Clin Pract*. 2011 Feb;17(1):97–103.
- 600 42. Australian Institute of Health and Welfare. Depression in residential aged care 2008-2012, Table
601 of contents [Internet]. Australian Institute of Health and Welfare. 2013 [cited 2021 Aug 13].
602 Available from: [https://www.aihw.gov.au/reports/aged-care/depression-in-residential-aged-](https://www.aihw.gov.au/reports/aged-care/depression-in-residential-aged-care-2008-2012/contents/table-of-contents)
603 [care-2008-2012/contents/table-of-contents](https://www.aihw.gov.au/reports/aged-care/depression-in-residential-aged-care-2008-2012/contents/table-of-contents)
- 604 43. Taylor WD. Clinical practice. Depression in the elderly. *N Engl J Med*. 2014 Sep 25;371(13):1228–
605 36.
- 606 44. Taylor WD. Should Antidepressant Medications Be Used in the Elderly? *Expert Rev Neurother*.
607 2015 Sep;15(9):961–3.
- 608 45. Brett J, Zoega H, Buckley NA, Daniels BJ, Elshaug AG, Pearson S-A. Choosing wisely? Quantifying
609 the extent of three low value psychotropic prescribing practices in Australia. *BMC Health Serv*
610 *Res*. 2018 Dec 29;18(1):1009.
- 611 46. Gerlach LB, Wiechers IR, Maust DT. Prescription benzodiazepine use among older adults: A
612 critical review. *Harv Rev Psychiatry*. 2018;26(5):264–73.

- 613 47. Lenander C, Bondesson Å, Viberg N, Beckman A, Midlöv P. Effects of medication reviews on use
614 of potentially inappropriate medications in elderly patients; a cross-sectional study in Swedish
615 primary care. *BMC Health Serv Res*. 2018 Aug 7;18(1):616.
- 616 48. Campbell Research and Consulting. Evaluation of the residential medication management
617 review program: main findings report [Internet]. Australia: Department of Health and Ageing;
618 2010 May [cited 2019 May 15]. Available from:
619 [https://www.health.gov.au/internet/main/publishing.nsf/Content/F520A0D5EDEA0172CA257B](https://www.health.gov.au/internet/main/publishing.nsf/Content/F520A0D5EDEA0172CA257BF0001D7B4D/$File/RMMR%20Report.pdf)
620 [F0001D7B4D/\\$File/RMMR%20Report.pdf](https://www.health.gov.au/internet/main/publishing.nsf/Content/F520A0D5EDEA0172CA257BF0001D7B4D/$File/RMMR%20Report.pdf)
- 621 49. Anderson K, Stowasser D, Freeman C, Scott I. Prescriber barriers and enablers to minimising
622 potentially inappropriate medications in adults: a systematic review and thematic synthesis.
623 *BMJ Open*. 2014;4(12):e006544.
- 624 50. Westbury J, Jackson S, Gee P, Peterson G. An effective approach to decrease antipsychotic and
625 benzodiazepine use in nursing homes: the RedUse project. *Int Psychogeriatr*. 2010
626 Feb;22(1):26–36.
- 627 51. Thiruchelvam K, Byles J, Hasan SS, Egan N, Kairuz T. Frailty and potentially inappropriate
628 medications using the 2019 Beers Criteria: findings from the Australian Longitudinal Study on
629 Women’s Health (ALSWH). *Aging Clin Exp Res*. 2021 Jan 15;
- 630 52. Hendrix I, Page AT, Korhonen MJ, Bell JS, Tan ECK, Visvanathan R, et al. Patterns of High-Dose
631 and Long-Term Proton Pump Inhibitor Use: A Cross-Sectional Study in Six South Australian
632 Residential Aged Care Services. *Drugs - Real World Outcomes*. 2019 Sep;6(3):105–13.
- 633 53. Reeve E, Andrews JM, Wiese MD, Hendrix I, Roberts MS, Shakib S. Feasibility of a patient-
634 centered deprescribing process to reduce inappropriate use of proton pump inhibitors. *Ann*
635 *Pharmacother*. 2015 Jan;49(1):29–38.
- 636 54. Hollingworth S, Duncan EL, Martin JH. Marked increase in proton pump inhibitors use in
637 Australia. *Pharmacoepidemiol Drug Saf*. 2010 Oct;19(10):1019–24.
- 638 55. Fick DM, Mion LC, Beers MH, L Waller J. Health outcomes associated with potentially
639 inappropriate medication use in older adults. *Res Nurs Health*. 2008 Feb;31(1):42–51.
- 640 56. Better Access Australia. PBS pricing framework means higher out-of-pocket costs for many
641 medicines [Internet]. Australia: BioPharmaDispatch; 2021 Nov [cited 2022 Feb 23]. Available
642 from:
643 [https://static1.squarespace.com/static/5f6a85425ec24b7aa4b07963/t/619d7cbba043a5212538](https://static1.squarespace.com/static/5f6a85425ec24b7aa4b07963/t/619d7cbba043a5212538b57d/1637711036130/PBS+pricing+framework+means+higher+out-of-pocket+costs+for+many+medicines.pdf)
644 [b57d/1637711036130/PBS+pricing+framework+means+higher+out-of-](https://static1.squarespace.com/static/5f6a85425ec24b7aa4b07963/t/619d7cbba043a5212538b57d/1637711036130/PBS+pricing+framework+means+higher+out-of-pocket+costs+for+many+medicines.pdf)
645 [pocket+costs+for+many+medicines.pdf](https://static1.squarespace.com/static/5f6a85425ec24b7aa4b07963/t/619d7cbba043a5212538b57d/1637711036130/PBS+pricing+framework+means+higher+out-of-pocket+costs+for+many+medicines.pdf)
- 646 57. Thiruchelvam K, Byles J, Hasan SS, Egan N, Kairuz T. Residential Medication Management
647 Reviews and continuous polypharmacy among older Australian women. *Int J Clin Pharm*. 2021
648 Jun 6;
- 649 58. McRae I, Yen L, Jeon Y-H, Herath PM, Essue B. Multimorbidity is associated with higher out-of-
650 pocket spending: a study of older Australians with multiple chronic conditions. *Aust J Prim*
651 *Health*. 2013;19(2):144–9.
- 652 59. Jan S, Essue BM, Leeder SR. Falling through the cracks: the hidden economic burden of chronic
653 illness and disability on Australian households. *Med J Aust*. 2012 Jan 16;196(1):29–31.

654 60. Schoen C, Osborn R, Squires D, Doty MM. Access, affordability, and insurance complexity are
655 often worse in the United States compared to ten other countries. *Health Aff Proj Hope*. 2013
656 Dec;32(12):2205–15.

657

658 **Table 1** Results from adjusted generalised estimating equations (GEEs) for lagged logistic regressions for the associations between Residential Medication
 659 Management Reviews (RMMRs) and use of potentially inappropriate medications (PIMs) from 2005 to 2017
 660

	All potentially inappropriate medications		Benzodiazepines		Antidepressants	
	Odds ratio (95% CI)	<i>p</i> -value	Odds ratio (95% CI)	<i>p</i> -value	Odds ratio (95% CI)	<i>p</i> -value
Use of RMMR^a (reference: no)						
Yes	0.99 (0.88, 1.11)	0.863	1.02 (0.95, 1.08)	0.617	0.99 (0.90, 1.10)	0.878
Time (in years)	0.97 (0.94, 0.99)	0.013	0.99 (0.97, 1.00)	0.107	0.96 (0.94, 0.98)	<0.001
Age at baseline	0.98 (0.92, 1.05)	0.606	-	-	0.94 (0.88, 1.00)	0.060
Living alone (reference: no)						
Yes	-	-	0.93 (0.82, 1.05)	0.223	0.85 (0.71, 1.02)	0.074
Education level (reference: below Year 12)						
Year 12 and above	0.90 (0.73, 1.10)	0.300	-	-	0.91 (0.73, 1.13)	0.378
DVA^b coverage (reference: no)						
Yes	1.40 (1.02, 1.91)	0.036	1.20 (0.99, 1.44)	0.056	-	-
Number of GP^c visits in the last 12 months (reference: ≤4 visits)						
>4 visits	1.55 (1.28, 1.87)	<0.001	1.35 (1.18, 1.54)	<0.001	1.29 (1.06, 1.56)	0.010
Hospital admissions in the last 12 months (reference: no)						
Yes	1.28 (1.04, 1.56)	0.017	-	-	-	-
Number of chronic diseases (reference: <4)						
≥4	1.38 (1.13, 1.68)	0.002	1.10 (0.96, 1.25)	0.167	-	-
Presence of continuous polypharmacy (reference: no)						
Yes	1.86 (1.61, 2.14)	<0.001	1.12 (1.04, 1.21)	0.002	1.32 (1.18, 1.47)	<0.001

661
 662 ^aResidential Medication Management Review
 663 ^bDepartment of Veterans Affairs
 664 ^cGeneral practitioner
 665

666
 667
 668
 669
 670

671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709

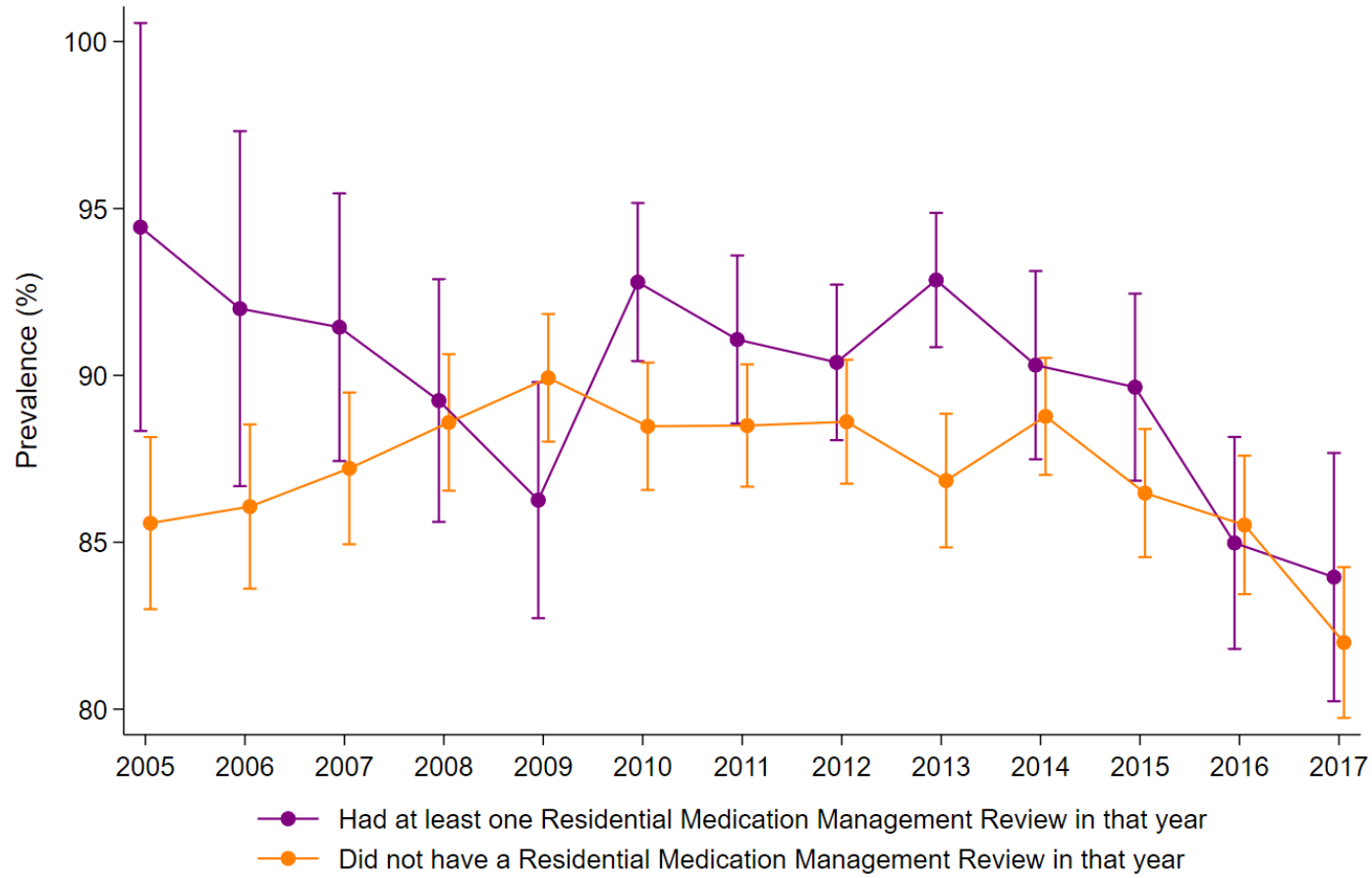


Fig. 1 Participants with potentially inappropriate medications based on having had a Residential Medication Management Review (RMMR) or not, from 2005 to 2017

710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757



Fig. 2 Patterns of potentially inappropriate medication (PIM) use among participants who did and did not have Residential Medication Management Reviews (RMMRs) from 2005 to 2017
 PPI: Proton-pump inhibitors; NSAIDs: Non-cyclooxygenase selective nonsteroidal anti-inflammatory drugs
 Note: PIMs with zero frequencies were omitted from visual display

758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795

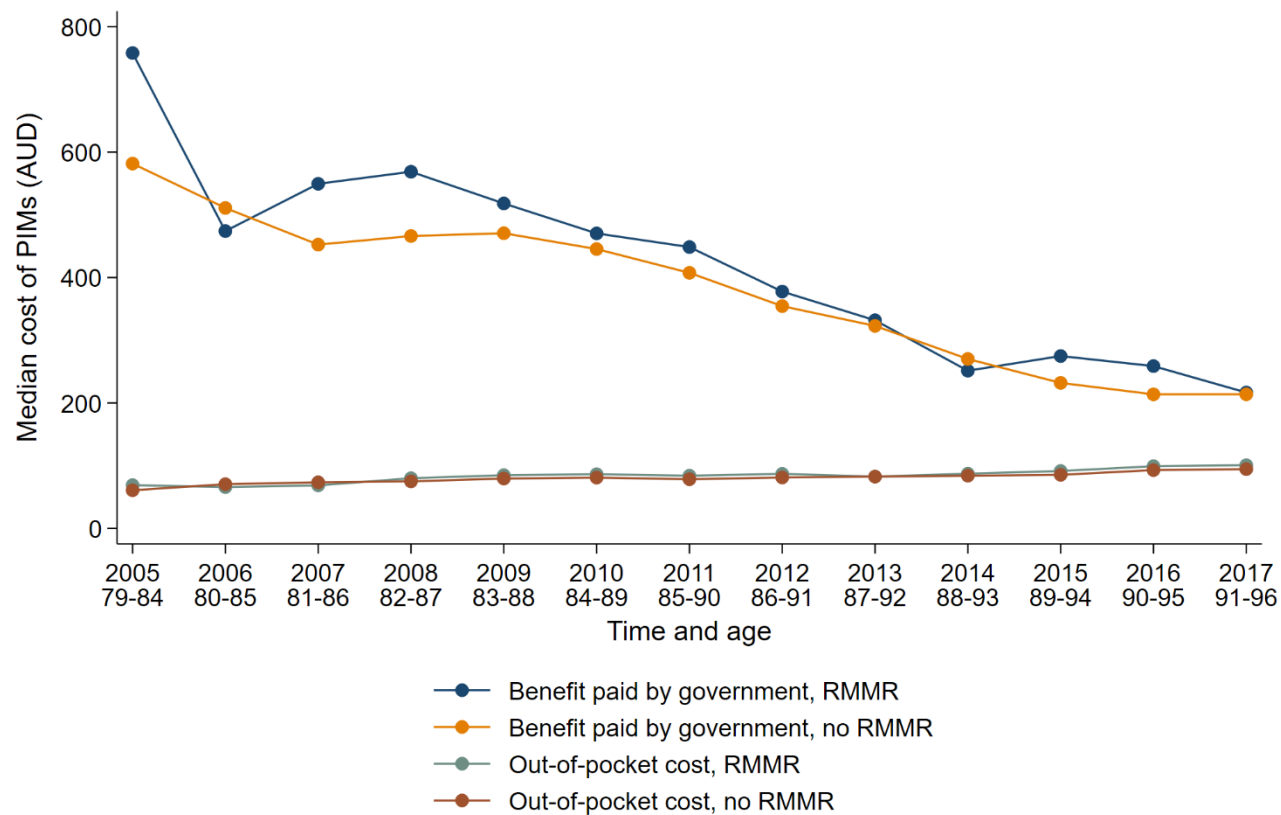


Fig. 3 Median costs of potentially inappropriate medications (government and out-of-pocket) based on having had a Residential Medication Management Review or not, from 2005 to 2017

PIMs: Potentially inappropriate medications; RMMR: Residential Medication Management Review

796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834

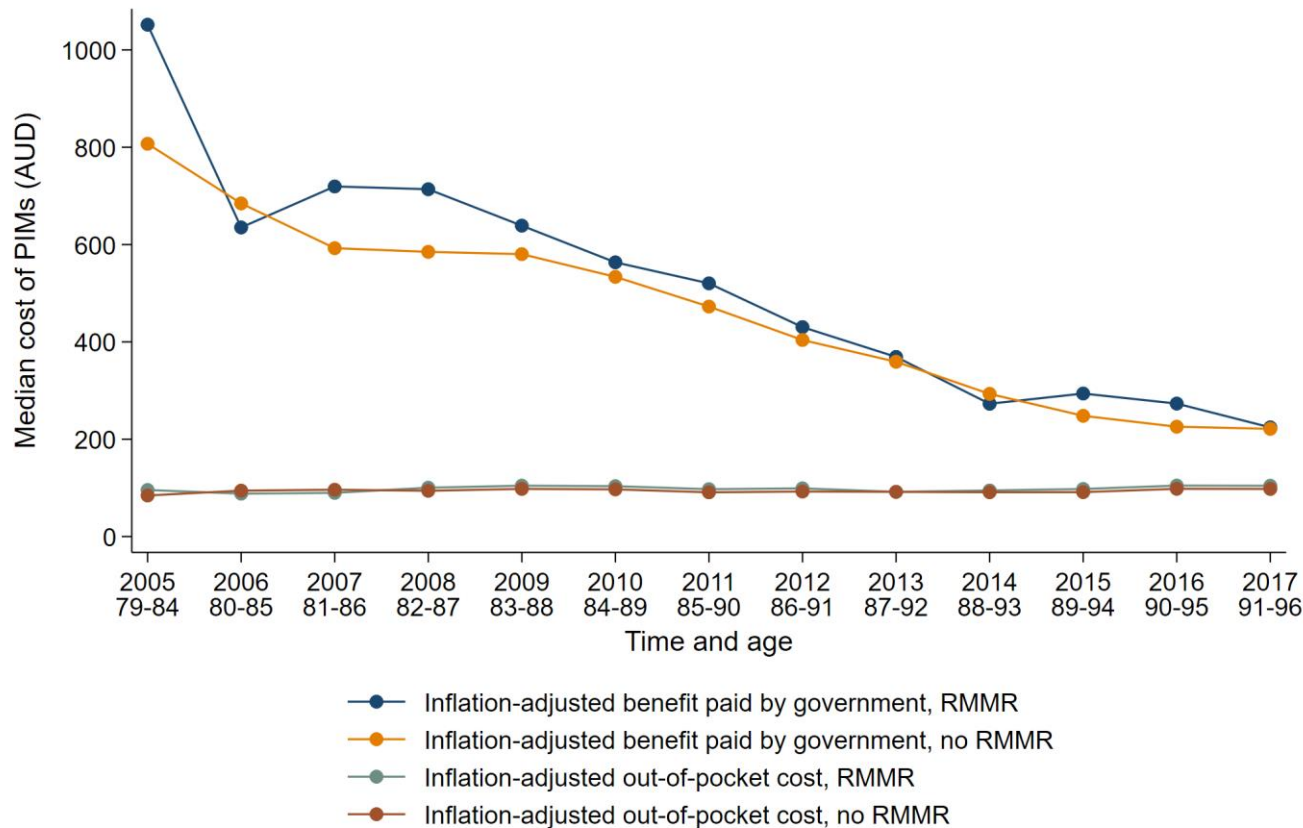


Fig. 4 Median costs of potentially inappropriate medications (inflation-adjusted government and out-of-pocket) costs based on having had a Residential Medication Management Review or not, from 2005 to 2017

PIMs: Potentially inappropriate medications; RMMR: Residential Medication Management Review

