Residential Medication Management Reviews and continuous polypharmacy among older Australian women

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Abstract

Background: Polypharmacy is an important consideration for the provision of Residential Medication Management Reviews (RMMRs) among older women given their enhanced risk of medication-related problems and admission to residential aged care (RAC).

Objectives: To determine the prevalence of the use of RMMRs among older women in RAC, and the association between RMMRs and polypharmacy, medications, and costs.

Setting: Older Australian women aged 79 to 84 years in 2005 who had at least one Medicare Benefits Schedule and Pharmaceutical Benefits Scheme record, received a service in aged care, and consented to data linkage.

Method: Generalised estimating equations were used to determine the association between polypharmacy and RMMRs, while adjusting for confounding variables.

Main outcome measures: Prevalence of the use of RMMRs among older women in RAC, association between RMMRs and polypharmacy, medications, and costs.

Results: Most participants did not have continuous polypharmacy and did not receive RMMRs from 2005 [451 (67.4%)] until 2017 [666 (66.6%)]. Participants with continuous polypharmacy were 17% more likely to receive a RMMR (risk ratio 1.17; 95% confidence interval: 1.11, 1.25). Participants in their final year of life and residing in outer regional/remote/very remote Australia were less likely to receive RMMRs. Out-of-pocket medication costs increased over time, and alendronate and aspirin were common contributors to polypharmacy among participants who received RMMRs.

Conclusion: Polypharmacy was associated with receiving RMMRs and around two-thirds of women who are entitled to a RMMR never received one. There is potential to improve the use of medicines by increasing awareness of the service among eligible individuals, their carers and health care professionals.

Impact of findings on practice statements

• Our findings suggest that there is a need for medication reviews among older women with polypharmacy.

• Even if medication reviews are supported and funded, low uptake may preclude benefits being experienced by patients.

• Given the underutilisation of the Residential Medication Management Review service, there is potential to improve the use of medicines by increasing awareness of the service among eligible individuals and their carers through aged care management, nursing staff, and health care professionals.

Introduction

There is a growing proportion of 'middle-old' (75 to 84 years) and 'oldest old' (85+) people admitted to residential aged care (RACs) [1, 2]. Around 1.2 million older adults recently received aged care services in Australia and 59% were >85 years [3]; it is estimated that 40% of older people will be admitted to aged care [4, 5]. Older women are 60% more likely than men to require assistance with activities of daily living, and their higher multimorbidity and disability, increases their need for long-term care [3, 6]; two-thirds of Australian aged care recipients appear to be women [7]. Individuals residing in RACs are more frail than their community-dwelling counterparts [8], are likely to have multimorbidity and polypharmacy (five or more medications) [9, 10, 11], and are at higher risk of medication-related problems [12]. Polypharmacy increases risk of falls, drug interactions, adverse drug reactions, cognitive impairment and poor nutritional status among individuals in RACs [13, 14]. Given the range of factors and possible cognitive impairment, these individuals require regular medication reviews and treatment adjustments to optimise medication use [15].

Medication reviews form the foundation of the safe and rational use of medications [16, 17]. In Australia, the Residential Medication Management Review (RMMR) is a national government-funded "comprehensive medication management review" provided to individuals of RACs since 1997 [18, 19]. Comprehensive medication management reviews "aim to identify, resolve and prevent medication-related problems, and optimize medicines use in partnership with medical practitioners and patients" [19]. The RMMR in Australia is a type of comprehensive medication management review and is similar to the Medication Therapy Management program in the United States [20], Medicines Use Review in the United Kingdom [21] and MedsCheck in Canada [22]. The RMMR service is resident-focused (patient-centred) and involves a systematic evaluation of a resident's medication regimen as well as its management. The RMMR is aimed at optimising [18] medication benefits, improving therapeutic outcomes for the individual and ensuring the appropriate and safe use of medications [18]. The RMMR process is usually initiated by a general practitioner (GP) and performed by an Accredited Pharmacist, and sometimes at the request of the individual. Both GPs and Accredited Pharmacists are remunerated by the Australian Department of Health via Medicare Australia [23] and the Pharmacy Programs Administrator [24], respectively. An individual in an Australian RAC is eligible for a RMMR if they have a current Australian Medicare or Department of Veterans Affairs (DVA) card and reside permanently in

the RAC. In the current program, individuals are eligible for a review upon admission and every 24 months, or sooner if clinically indicated [18, 19].

Although RMMR is a well-established program, there is limited information regarding the use of this service by individuals living in RACs [25, 26]. Polypharmacy is an important consideration for the provision of RMMRs among older women given their enhanced risk of medication-related problems due to a higher likelihood of multimorbidity, obtaining health care services and receiving diagnoses [27]. Women also account for a higher proportion of older adults due to longer life expectancy and they have an increased risk of admission to RACs [28]. However, data on polypharmacy and RMMRs are lacking in this population. It is also important to identify characteristics associated with current use of RMMRs to support future advancements.

Aim of the study

A recent publication revealed a high prevalence of polypharmacy among older women [10]. The current study complements the previous study and uses data from the same population of older women to investigate the uptake of medication reviews. This study determined the prevalence of the use of RMMRs among older women in RAC, and estimated the association between RMMRs and polypharmacy, medications, and costs (government contributions and out-of-pocket costs).

Ethics approval

The Australian Longitudinal Study on Women's Health (ALSWH) program has obtained ongoing ethical approval from the Human Research Ethics Committees (HRECs) of the Universities of Newcastle and Queensland (approval numbers H-076-0795 and 2004000224, respectively). Institutional HREC approvals for record linkage (approval numbers H-2011-0371 and 2012000132, respectively) are also maintained by the ALSWH. Access to national data collections is approved by the Australian Institute of Health and Welfare HREC and the Departments of Defence and Veterans' Affairs HREC.

Method

Study population and data sources

This study identifies participants' use of RMMRs over time and the longitudinal association with polypharmacy. Participants were from the 1921-1926 cohort of the ALSWH [29]. Participants were first surveyed in 1996 on a 3-yearly basis until 2011 and thereafter on a 6-monthly basis. Participants' survey data are linked to the Medicare Benefits Schedule (MBS) [23], a publicly-funded health care insurance scheme, and the Pharmaceutical Benefits Scheme (PBS) [30], a government program providing access to subsidised prescription medications. Participants whose services were subsidised by the Department of Veterans' Affairs (DVA) were also included. MBS RAC services (see Supplementary Table 1) were used to identify participants who resided in RACs. The study period was 2005 (age: 79 to 84 years) to 2017 (age: 91 to 96 years), identifying use of RMMRs and polypharmacy for each year. Participants must have met the following criteria:

i) Alive on 1 January 2005, and
ii) Did not withdraw consent to data linkage to the MBS and PBS prior to 2017, and
iii) Had at least one MBS record any time from 2005 to 2017, and
iv) Had a MBS service provided in a residential aged care (RAC) any time from 2005 to 2017, and
v) Had at least one complete PBS record in 2005 that contributed to continuous polypharmacy in months of interest.

These criteria and relevant sample sizes are presented in **Supplementary Fig. 1**.

Residential Medication Management Reviews

RMMRs were identified from MBS item numbers based on referrals by GPs (item 903) and medical practitioners (item 249) [23] on service dates for RMMRs. Although RMMRs were implemented from 1997, this service was added to the MBS from November 2004 and informed our study period which commenced in 2005. Participants were categorised as having had a RMMR or not, at each year from 2005 to 2017.

Continuous polypharmacy

The PBS dataset classified medications based on the Anatomic Therapeutic Chemical (ATC) classification [31]. Two definitions of continuous polypharmacy were used. The first definition had three categories: no polypharmacy (0-4 unique medications), continuous polypharmacy (5-9 unique medications), and continuous hyperpolypharmacy (≥10 unique medications) [32]. The second definition had two categories: no polypharmacy (0-4 unique medications) and continuous polypharmacy (≥5 unique medications). Under both definitions, polypharmacy required that the same unique medication appeared in two time windows, 1 April to 30 June, and 1 October to 31 December, to ensure that medications were prescribed regularly [9, 33]. These months were selected to avoid underestimating exposure to medications because some individuals who reach the PBS "safety net" stockpile medications towards the end of each year [34]; the selected time windows will offset the under and over-estimation of polypharmacy.

Explanatory variables

Education level (<Year 12 or ≥Year 12) was determined at Survey 1 (1996). Age at baseline was determined from ALSWH Survey 4 (2005). Variables included residential area (major cities, inner regional, and outer regional/remote/very remote), DVA coverage, number of GP visits (≤4 or >4) and whether they had hospital admissions or falls in the previous 12 months, number of chronic diseases (<4 or ≥4), and whether they were in their final year of life. Once reported, chronic diseases were deemed enduring, and included diabetes mellitus, hypertension, heart disease including myocardial infarction, angina or other heart problems, cancer, stroke, mental illness including depression, anxiety or nervous disorders and dementia or Alzheimer's disease, osteoporosis, arthritis and respiratory disease including bronchitis or emphysema and asthma. Time (in years) was included to account for time trends. Missing data were imputed using the last observation carried forward method.

Statistical analysis

Descriptive statistics present the proportion of participants who had a RMMR, the proportion with continuous polypharmacy and hyperpolypharmacy, and medication costs based on having had a RMMR or not, at each year. Generalised estimating equations (GEEs) with a log link, binomial family, unstructured correlation matrix and robust standard errors were used to determine the association between use of RMMRs and continuous

polypharmacy, and the association between use of RMMRs and benefits paid by government and out-of-pocket costs. Variables of interest identified *a priori* were checked for multicollinearity based on Pearson's correlation coefficients of >0.8 and confirmed through variance inflation factors >10 [35]. Variables that were not collinear were included in univariate models and variables that showed an effect with $p<0.25$ were included in the first multivariable model [36]. Backward stepwise elimination was implemented in multivariable models starting from the variable that had the greatest p-value. Effect estimates for all models were presented as risk ratios (RR) with 95% confidence intervals. Stata 16 [37] was used for all analyses.

Results

Table 1 presents baseline characteristics of participants in 2005. More participants became eligible over time as they were more likely to live in RAC at older ages: 723 participants were eligible in 2005 and 1356 participants were eligible by 2017. By the end of 2005, 139 (3.2%) participants had died. The greatest number of deaths (461) occurred in 2016, with 1463 participants aged 90 to 95 years who were alive and residing in RACs. Over time, the proportion of participants in RAC who had a RMMR increased from 7.5% in 2005 to 26.3% in 2017. Of participants who did receive RMMRs, majority received only one. Most participants did not have continuous polypharmacy and did not receive RMMRs (Fig. 1, summarised in Supplementary Table 2). However, participants with polypharmacy (33.1% in 2005; 34.7% in 2017), were more likely to have RMMRs than participants with no polypharmacy.

[Insert Table 1 here]

[Insert Fig. 1 here]

There was no evidence of multicollinearity in the univariate models. There was no evidence of an association between receiving RMMRs and the following variables in the univariate models: age at baseline (p=0.90), education level (p=0.64), number of GP visits (p=0.45), and falls in the last 12 months (p=0.45). Table 2 describes the variables that were included in the final model, with four variables showing evidence of associations with RMMRs: for every one-year increase in time, participants were 5% more likely to receive a RMMR (RR 1.05; 95% CI: 1.04, 1.06). Participants with continuous polypharmacy were 17% more likely to receive a RMMR (RR 1.17; 95% CI: 1.11, 1.25). Participants who lived in outer regional/remote/very remote

Australia were 11% less likely to receive RMMRs (RR 0.89; 95% CI: 0.81, 0.97) compared to those who lived in major cities, and participants in their final year of life were 33% less likely to receive RMMRs (RR 0.67; 95% CI: 0.61, 0.73).

[Insert Table 2 here]

Fig. 2 shows boxplots of out-of-pocket costs and benefits paid by the government associated with medications based on having had a RMMR or not. Averaging across the study period (2005 to 2017), participants who had RMMRs incurred higher median out-of-pocket costs ($AUD56.70 [37.80, 69.30]) and benefits paid by the government ($AUD168.84 [87.67, 320.05]), compared to those who did not receive RMMRs (out-of-pocket costs: $AUD50.40 [31.50, 63.00] and government benefits: $AUD149.08 [73.16-273.18]). Fig. 3 shows trends over time for benefits paid by the government (which decreased), and trends for out-of-pocket costs (which increased), among those who did and did not have RMMRs (summarised in Supplementary Table 3). Additionally, a GEE model compared the difference in benefits paid by government and out-of-pocket costs for participants who received and did not receive RMMRs. These results show that participants who received RMMRs had significantly higher annual benefits paid by government ($AUD15.61; 95% CI: 7.45, 23.76) and significantly higher annual out-of-pocket costs ($AUD2.72; 95% CI: 1.80, 3.65). Participants with polypharmacy also incurred higher out-of-pocket costs compared to no polypharmacy, in the RMMR ($AUD50.40 vs. $AUD35.00) and the non-RMMR ($AUD50.00 vs. $AUD32.20) groups. The same trend was observed for benefits paid by the government among participants with polypharmacy compared to those without polypharmacy in the RMMR ($AUD287.46 vs. $AUD97.48) and non-RMMR ($AUD296.36 vs. $AUD96.72) groups.

[Insert Fig. 2 here]

[Insert Fig. 3 here]

Medications that commonly contributed to continuous polypharmacy for both groups include paracetamol, furosemide, proton-pump inhibitors (esomeprazole, omeprazole and pantoprazole), and Macrogol 3350. However, considering the top three medication in any year, alendronate and aspirin were additional contributors to the RMMR group (alendronate (33.3% in 2005 to 1.5% in 2017), and aspirin (9.5% in 2005 to 4.4% in

2017)), whereas atorvastatin was an additional contributor to the non-RMMR group (17.0% in 2005 to 13.2% in 2017).

Discussion

This study found that women were 5% more likely to receive RMMRs for every one-year increase in time relative to the baseline year. There was a higher proportion of women with continuous hyper/polypharmacy among those who received RMMRs compared to those who did not, and women with polypharmacy were 17% more likely to receive RMMRs, relative to women without polypharmacy. Alendronate and aspirin were the most common contributors to polypharmacy. However, women were less likely to receive a RMMR if they were in their final year of life or if they resided in outer regional/remote/very remote Australia. Women who had RMMRs or had polypharmacy incurred higher medication costs (government benefits and out-of-pocket costs).

Although the prevalence of the use of RMMRs increased over time, in 2017, less than one-third of women in RAC received a RMMR. This is at odds with policy that all RAC residents should have medication reviews on admission, and then at least every 24 months [18, 19]. Similar results were recently reported by the Registry of Senior Australians (ROSA) where only one in five individuals in RAC received a medication review within 90 days of admission [38]. Most women in our study did not receive RMMRs and this is similar to a report which found that one-quarter of individuals did not receive a RMMR even though they had unmet clinical needs [25], despite positive feedback about the value of medication reviews [39, 40].

Time had a small effect on the likelihood of receiving RMMRs, and this may reflect changes in policy and practice over time. The increase in prevalence of the use of RMMRs from 2005 until 2010 among those with hyper/polypharmacy, and the rate in 2017, was similar to a study by Sluggett et al. (2017) that reported that, in 2015, 38% of RAC individuals received RMMRs over 12 months [41]. This increase is in line with Rogers' Diffusion of Innovations Theory which explains that newly introduced services will not have a uniform and immediate uptake [42], and this was reflected in the use of RMMRs in our study. The low use of RMMRs could also be attributed to time constraints and low remuneration for Accredited Pharmacists [25], changes in individual eligibility for RMMRs (such as restrictions introduced in 2013 that permit only one RMMR per individual every 24 months), and low awareness of RMMRs among older people and their carers.

Women with continuous polypharmacy were 17% more likely to receive a RMMR, suggesting that the RMMR is being appropriately targeted, albeit to a limited extent. Our results were stronger than those observed in a study of Australian veterans with polypharmacy who were found to be 8% more likely to have a Home Medicines Review compared to those without polypharmacy [43]. Women who received RMMRs were commonly using alendronate and aspirin. This supports appropriate targeting of RMMRs due to complications associated with bisphosphonates and aspirin [44, 45]. The use of bisphosphonate therapy for five years or more has been associated with long-term risks of atypical femur fractures and osteonecrosis of the jaw [44]. On the other hand, use of aspirin increases the morbidity and mortality of lower gastrointestinal bleeding from haemorrhage due to the effect of aspirin on blood clotting factors [45]. In optimising medication use, a national meeting convened by the National Health and Medical Research Council (NHMRC) Cognitive Decline Partnership Centre aimed to reduce the use of unnecessary and harmful medications by 50% within five years through policy and guideline changes addressing polypharmacy and deprescribing [46]. This represents an important initiative in curbing the use of unnecessary medications and polypharmacy, where the intended benefit of the medication is not achieved [47]. Another common drug was atorvastatin, particularly among women who did not receive RMMRs. An evaluation of time to benefit of statins in the primary prevention of cardiovascular events among individuals aged 50 to 75 years showed no mortality benefit where statin use prevented a major adverse cardiovascular event only if they had a life expectancy of at least 2.5 years [48]. Women in our study were aged 77 years and above, and have been identified as commonly using atorvastatin, which is concerning. This highlights the importance of RMMRs since women who received RMMRs did not commonly use atorvastatin, which may have been a consequence of the review.

RMMRs remain underutilised among women in their final year of life and for women living in outer regional, remote, and very remote areas, where they were 33% and 11% less likely to receive the service, respectively. Perhaps medications were deprescribed prior to their final year of life, or women simply did not have their medications reviewed. It is important to consider life expectancy and the benefits of deprescribing, given the greater risks of medication harm [49]. In prescribing for individuals with reduced life expectancy, a ‘shift’ occurs for medications that are appropriate; however, predicting the timing of this ‘shift’ and discontinuing medications that are no longer appropriate is challenging [49]. A study by Jokanovic et al. (2015) reported that individuals in rural and remote areas were deemed underserved because they had a low use of clinical

medication reviews [50]. There is a lower prevalence of RACs, and distribution of pharmacists in remote areas, thus reducing access to pharmacy services [51]. Given a higher prevalence of chronic diseases and poorer health in remote areas [51], RMMRs have been reported to be effective in these people [52]. As proposed by the National Rural Health Conference, there should be a concerted effort to increase access to health care, especially pharmacy services, where pharmacists can be based in rural hospitals but still be part of larger state teams [52].

Women who received RMMRs had higher medication costs, for benefits paid by the government and out-of-pocket costs. This is likely due to a higher prevalence of polypharmacy among women who received RMMRs, supported by our findings that suggest polypharmacy is associated with higher medication costs. However, the RMMR may have resulted in additional medications leading to higher medication costs [53], and a 'prescribing cascade' [54]. This may include PPIs to manage side effects of non-steroidal medications [54], and this was reflected in the high frequency of PPIs in our study. Women who had RMMRs incurred higher out-of-pocket costs. Whilst the issue of cost may be dynamic, medication costs may pose a substantial financial burden for the individual which could decrease treatment adherence [55]. In 2013, approximately 14% of Australians did not attend their doctors' appointments and failed to receive recommended care due to cost [56]. Studies have indicated the household economic burden of chronic illnesses in Australia, with out-of-pocket costs reported as a major component [56].

Study limitations

Although the data were only available until 2017, there have not been any major changes to RMMRs since then that would affect our findings. RMMRs were introduced in 1997, however the addition of the RMMR as a MBS benefit in late 2004 only allowed for analysis from 2005 onwards. RAC-specific MBS services were used to determine whether women were living in RAC, and may have led to an underestimation of the number of women in RAC and an overestimation of the proportion of women who had RMMRs. The self-report data from ALSWH surveys would have introduced some measurement error and recall bias. Although polypharmacy may be beneficial in certain instances depending on the medications used, appropriateness of polypharmacy could not be ascertained due to a lack of available data on women's specific medical conditions that would determine the appropriateness of specific medications.

Conclusion

Guidelines recommend that medication reviews remain crucial in optimising medication management and improving quality use of medicines for older individuals. This longitudinal study on the use of RMMRs found that women with polypharmacy were 17% more likely to receive a RMMR, compared to women without polypharmacy. However, more than two-thirds of women who are entitled to a RMMR never received one; and of those who did receive RMMRs, the majority received only one. Out-of-pocket medication costs increased over time, and as such costs should be considered during the review process to ensure maximum treatment adherence. RMMRs have cost-saving potential and may reduce the use of health care resources and lower the medication burden for older women. Increasing the uptake of medication reviews in this population is crucial to improving pharmacy-related outcomes for older women.

Declarations

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Conflicts of interests

The authors declare no conflicts of interest.

Availability of data and material

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

Code availability

Codes can be made available upon request.

Authors' Contributions

Kaeshaelya Thiruchelvam contributed to the design and conceptualization of the study, performed formal analysis, and wrote the first draft and made final corrections. Julie Byles contributed to the conceptualization of the study, reviewed and made final corrections to the manuscript. Syed Shahzad Hasan contributed to the conceptualization of the study, and reviewed and made final corrections to the manuscript. Nicholas Egan contributed to formal analysis, reviewed and edited the manuscript. Therese Kairuz contributed to the

conceptualization of the study, and reviewed and edited the manuscript. All authors approved the final manuscript.

Consent to participate

For the ALSWH survey data, all participants consented to joining the study and are free to withdraw or suspend their participation at any time with no need to provide a reason. For the linked data (PBS), ALSWH participants who decline health record linkage are excluded from linked data requests. Over 80 percent of all ALSWH participants have explicitly consented to record linkage. Since 2005, the responsible Human Research Ethics Committees have approved opt-out consent; in addition, a waiver applies to unconsented participants who were deceased or lost to follow up before 2005.

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Table 1 Baseline characteristics of study participants by Residential Medication Management Reviews (RMMRs) using their most recent data up to 2005

Participant characteristics	RMMR* (n=54)		No RMMR (n=669)	
	No continuous polypharmacy n (%)	Continuous polypharmacy n (%)	No continuous polypharmacy n (%)	Continuous polypharmacy n (%)
n	33	21	451	218
Age at baseline, mean ± SD	82.30 ± 1.41	81.79 ± 1.53	82.03 ± 1.45	81.88 ± 1.59
Education level				
Below Year 12	23 (69.7)	17 (81.0)	318 (70.5)	150 (68.8)
Year 12 and above	7 (21.2)	3 (14.3)	108 (23.9)	55 (25.2)
Missing	*3 (9.1)*	*1 (4.8)*	*25 (5.5)*	*13 (6.0)*
Residential area				
Major cities in Australia	15 (45.5)	12 (57.1)	190 (42.1)	103 (47.2)
Inner regional Australia	10 (30.3)	6 (28.6)	182 (40.4)	81 (37.2)
Outer regional/Remote/Very remote Australia	8 (24.2)	3 (14.3)	79 (17.5)	34 (15.6)
Missing	*0 (0)*	*0 (0)*	*0 (0)*	*0 (0)*
DVA† coverage				
No	22 (66.7)	13 (61.9)	307 (68.1)	151 (69.3)
Yes	2 (6.1)	2 (9.5)	24 (5.3)	15 (6.9)
Missing	*9 (27.3)*	*6 (28.6)*	*120 (26.6)*	*52 (23.9)*
Number of GP‡ visits in the last 12 months				
≤4 visits	12 (36.4)	6 (28.6)	163 (36.1)	35 (16.1)
>4 visits	20 (60.6)	15 (71.4)	283 (62.7)	180 (82.6)
Missing	*1 (3.0)*	*0 (0.0)*	*5 (1.1)*	*3 (1.4)*
Hospital admissions in the last 12 months				
No	20 (60.6)	10 (47.6)	294 (65.2)	119 (54.6)
Yes	12 (36.4)	11 (52.4)	152 (33.7)	97 (44.5)
Missing	*1 (3.0)*	*0 (0.0)*	*5 (1.1)*	*2 (0.9)*
Number of chronic diseases				
<4	23 (69.7)	7 (33.3)	308 (68.3)	95 (43.6)
≥4	10 (30.3)	14 (66.7)	137 (30.4)	122 (56.0)
Missing	*0 (0.0)*	*0 (0.0)*	*6 (1.3)*	*1 (0.5)*
Falls in the last 12 months				
No	19 (57.6)	13 (61.9)	340 (75.4)	154 (70.6)
Yes	12 (36.4)	7 (33.3)	109 (24.2)	64 (29.4)
Missing	*2 (6.1)*	*1 (4.8)*	*2 (0.4)*	*0 (0.0)*
Final year of life				
No	32 (97.0)	21 (100.0)	360 (79.8)	211 (96.8)
Yes	1 (3.0)	0 (0.0)	91 (20.2)	7 (3.2)
Missing	*0 (0)*	*0 (0)*	*0 (0)*	*0 (0)*

**Residential Medication Management Reviews; †Department of Veterans Affairs; ‡General practitioner*

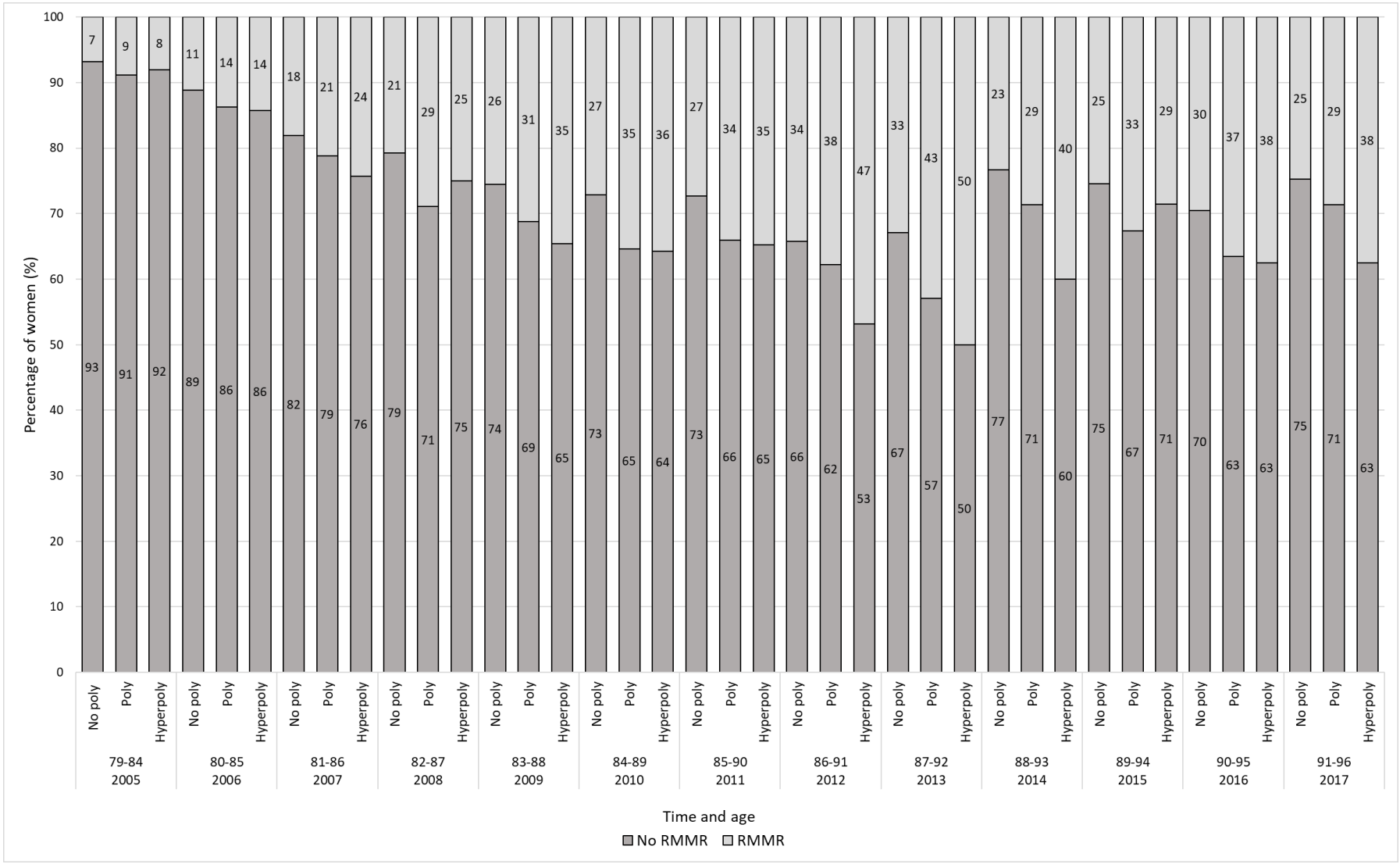


Fig. 1 Frequency of women who had continuous polypharmacy and hyperpolypharmacy among those who did and did not have Residential Medication Management Reviews (RMMRs) from 2005 to 2017

Table 2 Results from unadjusted and adjusted generalised estimating equations (GEEs) for the associations between polypharmacy and the risk of having a RMMR from 2005 to 2017

	Unadjusted models for women with RMMR*		**Adjusted model for women with RMMR**	
	Risk ratio (95% CI)	***p-value***	**Risk ratio (95% CI)**	***p-value***
Presence of polypharmacy				
No	Reference		Reference	
Yes	1.30 (1.23, 1.37)	<0.001	1.17 (1.11, 1.25)	<0.001
Time (in years)	1.05 (1.04, 1.06)	<0.001	1.05 (1.04, 1.06)	<0.001
Residential area				
Major cities in Australia	Reference		Reference	
Inner regional Australia	0.97 (0.92, 1.04)	0.405	0.99 (0.93, 1.05)	0.698
Outer regional/Remote/Very remote Australia	0.88 (0.81, 0.96)	0.004	0.89 (0.81, 0.97)	0.009
DVA† Coverage				
No	Reference		Reference	
Yes	1.12 (1.03, 1.21)	0.005	1.06 (0.98, 1.15)	0.130
Hospital admissions in the last 12 months				
No	Reference		Reference	
Yes	1.06 (0.99, 1.12)	0.056	1.03 (0.96, 1.09)	0.422
Number of chronic diseases				
<4	Reference		Reference	
≥4	1.05 (0.99, 1.11)	0.101	0.99 (0.93, 1.05)	0.782
Final year of life				
No	Reference		Reference	
Yes	0.65 (0.59, 0.70)	<0.001	0.67 (0.61, 0.73)	<0.001

**Residential Medication Management Reviews; †Department of Veterans Affairs*

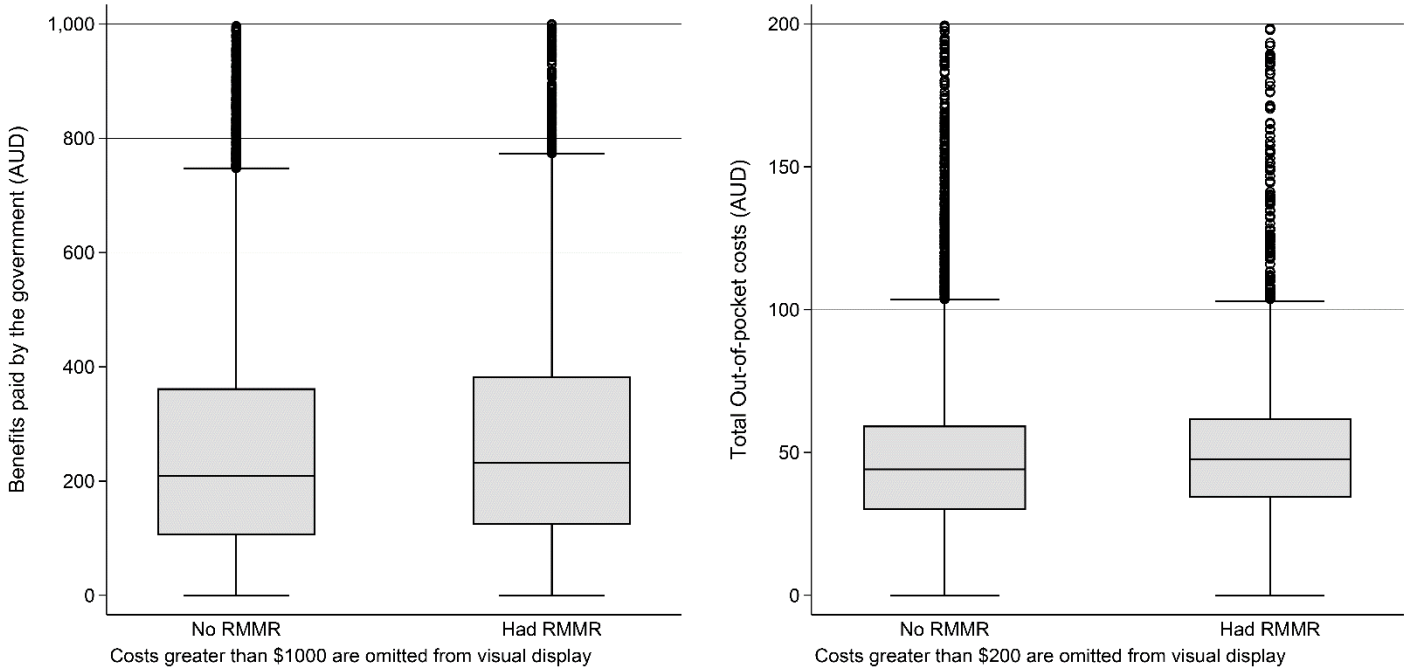


Fig. 2 Boxplots representing median medication costs (benefits paid by the government and out-of-pocket costs) based on having had a Residential Medication Management Review (RMMR) or not between 2005 and 2017

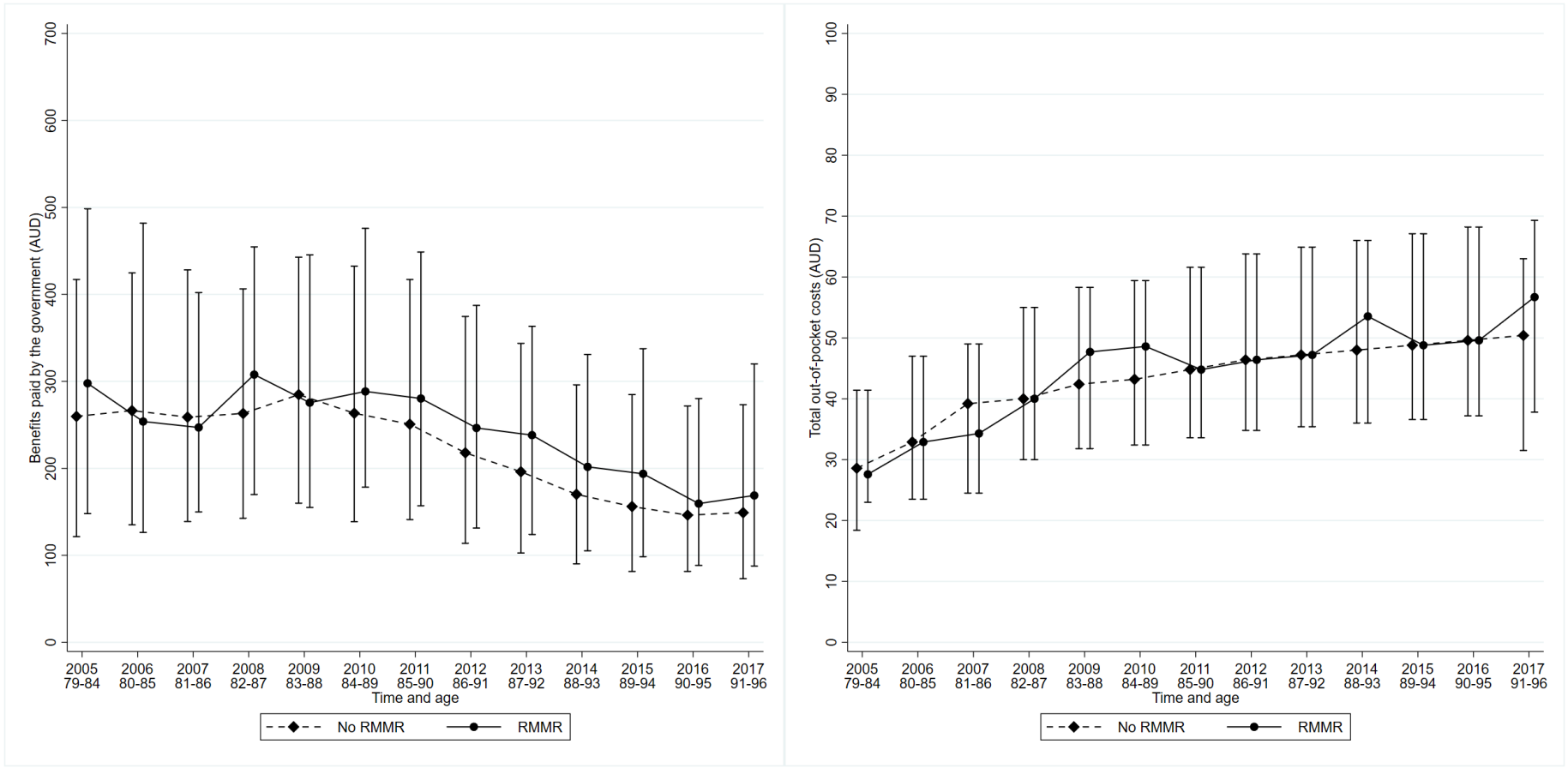
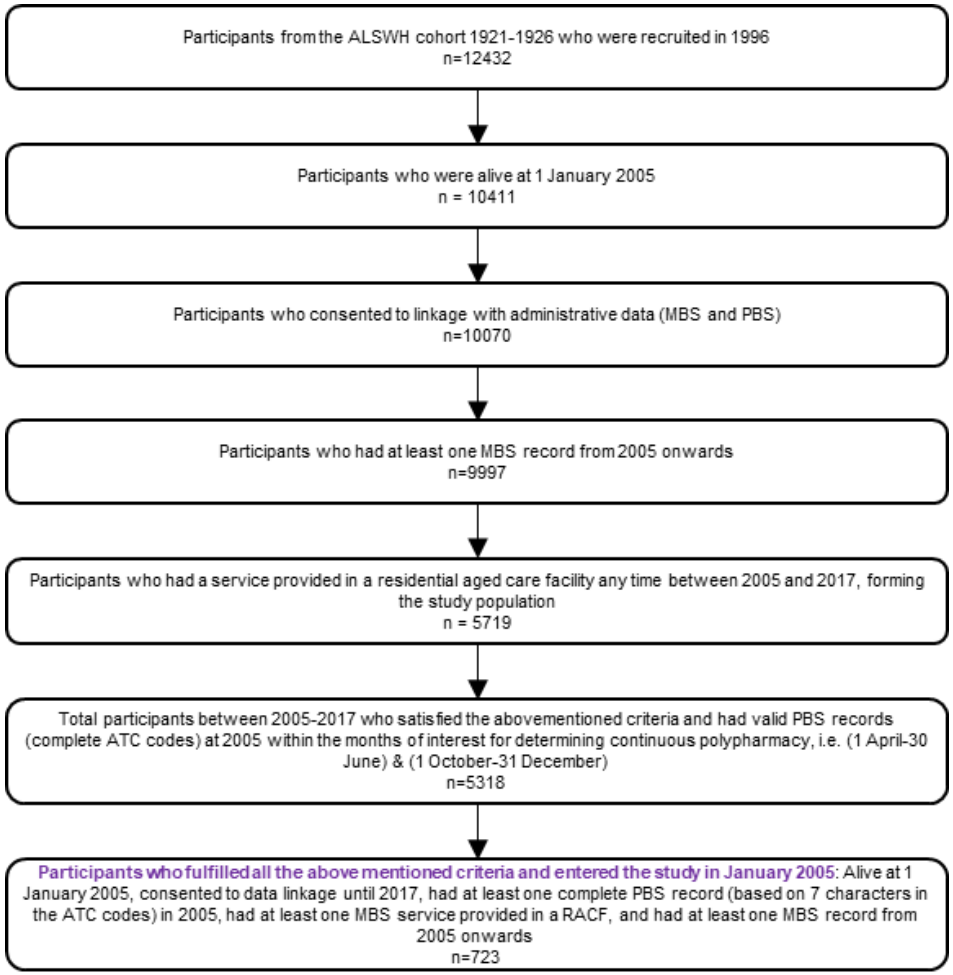


Fig. 3 Trends in medication costs (benefits paid by the government and out-of-pocket) based on having had a Residential Medication Management Review (RMMR) or not, between 2005 and 2017

Supplementary Table 1 Medicare Benefits Schedule (MBS) item numbers used to identify services in residential aged care (RAC)

Description	MBS item numbers
General practitioner and medical practitioner consultations in RAC	05010 05028 05049 05067 05260 05263 05265 05267 90001 90002 90020 90035 90043 90051 90092 90093 90095 90096 90183 90188 90202 90212
Telehealth services in RAC	02125 02138 02179 02220 10984 82223 82224 82225
Multidisciplinary care plan in RAC	00731



Supplementary Fig. 1 Flowchart representing participants included in the study

ALSWH: Australian Longitudinal Study on Women's Health
MBS: Medicare Benefits Schedule
PBS: Pharmaceutical Benefits Scheme

Supplementary Table 2 Proportion of women who had continuous polypharmacy and hyperpolypharmacy among those who did and did not have Residential Medication Management Reviews (RMMRs) from 2005 to 2017

- *This table presents results for RMMR and poly **in the same year**. E.g. RMMR in 2005 and polypharmacy in 2005*
- *Continuous hyperpolypharmacy is ≥10 medications; continuous polypharmacy is 5-9 medications; no continuous polypharmacy is ≤4 medications*
- *In determining continuous polypharmacy, a medication is counted, only if it appears at two pre-specified time windows in each year (1 April-30 June) & (1 October-31 December), ensuring that medications are taken on a long-term basis*
- *Denominator for proportions is based on total number who had and did not have RMMRs, at each year*

Age (years)	Year	Number of eligible participants	RMMR			No RMMR		
			Continuous hyper polypharmacy, n (%)	Continuous polypharmacy, n (%)	No continuous polypharmacy, n (%)	Continuous hyper polypharmacy, n (%)	Continuous polypharmacy, n (%)	No continuous polypharmacy n (%)
79-84	2005	723	2 (3.70)	19 (35.19)	33 (61.11)	23 (3.44)	195 (29.15)	451 (67.41)
80-85	2006	808	4 (4.08)	38 (38.78)	56 (57.14)	24 (3.38)	239 (33.66)	447 (62.96)
81-86	2007	953	8 (4.32)	73 (39.46)	104 (56.22)	25 (3.26)	271 (35.29)	472 (61.46)
82-87	2008	1141	9 (3.28)	128 (46.72)	137 (50.00)	27 (3.11)	315 (36.33)	525 (60.55)
83-88	2009	1245	19 (5.41)	154 (43.87)	178 (50.71)	36 (4.03)	339 (37.92)	519 (58.05)
84-89	2010	1447	25 (5.58)	213 (47.54)	210 (46.88)	45 (4.50)	389 (38.94)	565 (56.56)
85-90	2011	1563	24 (5.05)	216 (45.47)	235 (49.47)	45 (4.14)	418 (38.42)	625 (57.44)
86-91	2012	1622	37 (6.29)	247 (42.01)	304 (51.70)	42 (4.06)	407 (39.36)	585 (56.58)
87-92	2013	1617	41 (6.68)	293 (47.72)	280 (45.60)	41 (4.09)	390 (38.88)	572 (57.03)
88-93	2014	1543	28 (6.93)	174 (43.07)	202 (50.00)	42 (3.69)	434 (38.10)	663 (58.21)
89-94	2015	1553	18 (4.09)	193 (43.86)	229 (52.05)	45 (4.04)	398 (35.76)	670 (60.20)
90-95	2016	1463	12 (2.56)	179 (38.17)	278 (59.28)	20 (2.01)	311 (31.29)	663 (66.70)
91-96	2017	1356	9 (2.53)	128 (35.96)	219 (61.52)	15 (1.50)	319 (31.90)	666 (66.60)

Supplementary Table 3 Median medication costs (benefits paid by the government and out-of-pocket) based on having had a Residential Medication Management Review (RMMR) or not, between 2005 and 2017

Year	Median medication costs, $AUD (interquartile range)			
	RMMR		No RMMR	
	Benefits paid by the government	Out-of-pocket	Benefits paid by the government	Out-of-pocket
2005	297.80 (147.96-498.35)	27.60 (23.00-41.40)	259.80 (121.50-417.14)	28.60 (18.40-41.40)
2006	253.89 (126.36-481.91)	32.90 (23.50-47.00)	266.43 (135.13-424.78)	32.90 (23.50-47.00)
2007	247.03 (149.88-402.08)	34.30 (24.50-49.00)	258.90 (138.91-428.21)	39.20 (24.50-49.00)
2008	307.84 (169.85-454.63)	40.00 (30.00-55.00)	263.15 (142.50-406.33)	40.00 (30.00-55.00)
2009	275.58 (155.07-445.41)	47.70 (31.80-58.30)	284.78 (159.91-442.78)	42.40 (31.80-58.30)
2010	288.48 (178.43-475.99)	48.60 (32.40-59.40)	263.42 (138.74-432.47)	43.20 (32.40-59.40)
2011	280.35 (156.98-448.71)	44.80 (33.60-61.60)	250.81 (141.07-417.13)	44.80 (33.60-61.60)
2012	246.49 (131.39-387.40)	46.40 (34.80-63.80)	217.89 (113.77-374.62)	46.40 (34.80-63.80)
2013	238.19 (123.87-363.37)	47.20 (35.40-64.90)	196.12 (102.70-343.61)	47.20 (35.40-64.90)
2014	201.79 (105.16-330.94)	53.55 (36.00-66.00)	170.16 (90.21-295.95)	48.00 (36.0-66.00)
2015	193.77 (98.38-337.51)	48.80 (36.60-67.10)	156.14 (81.42-284.79)	48.80 (36.60-67.10)
2016	159.49 (88.44-280.22)	49.60 (37.20-68.20)	146.26 (81.42-271.70)	49.60 (37.20-68.20)
2017	168.84 (87.67-320.05)	56.70 (37.80-69.30)	149.08 (73.16-273.18)	50.40 (31.50-63.00)