Factors related to under-treatment of secondary cardiovascular risk, including primary healthcare: Australian National Health Survey linked data analysis

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Abstract

Objective: To inform national evidence gaps on cardiovascular disease (CVD) preventive medication use and factors relating to under-treatment - including primary healthcare engagement - among CVD survivors in Australia.

Methods: Data from 884 participants with self-reported CVD from the 2014–15 National Health Survey were linked to primary care and pharmaceutical dispensing data for 2016 through the Multi-Agency Data Integration Project. Logistic regression quantified the relation of combined blood pressure- and lipid-lowering medication use to participant characteristics.

Results: Overall, 94.8% had visited a general practitioner (GP) and 40.0% were on both blood pressure- and lipid-lowering medications. Medication use was least likely in: women versus men (OR=0.49[95%CI:0.37-0.65]), younger participants (e.g. 45–64y versus 65–85y: OR=0.58[0.42–0.79])and current versus never-smokers (OR=0.73[0.44–1.20]). Treatment was more likely in those with ≥9 versus ≤4 conditions (OR=2.15[1.39–3.31]), with ≥11 versus 0–2 GP visits/year (OR=2.62[1.53–4.48]) and with individual CVD risk factors (e.g. high blood pressure OR=3.13 [2.34–4.19]) versus without); the latter even accounting for GP service-use frequency.

Conclusions: Younger people, smokers, those with infrequent GP visits or without CVD risk factors were the least likely to be on medication.

Implications for public health: Substantial under-treatment, even among those using GP services, indicates opportunities to prevent further CVD events in primary care.

Key words: data linkage, health service use, cardiovascular disease, primary healthcare, prevention

Cardiovascular disease (CVD) is a leading contributor to disease burden in Australia,[1] with around 1.2 million people currently living with the disease[2] People with CVD are at high risk of future CVD events, such as myocardial infarction (MI), stroke and death, but this risk can be reduced by half with the use of lipid- and blood pressure-lowering therapy.[3] Current guidelines[4-6] recommend treatment of atherosclerotic CVD with combination therapy alongside lifestyle changes. At a minimum this includes anti-platelet agents and lipid- and blood pressure (BP)-lowering medication (and both ACE inhibitors and beta-blockers for selected patients following MI), including for those with normal BP or blood cholesterol levels. Despite this, there are large gaps in use of preventive treatments; of the one in ten Australian residents aged 45–74 years in 2011–12 who reported prior CVD, over half were not receiving guideline-recommended BP- and lipid-lowering therapy.[7]

Current national estimates of secondary preventive treatment levels are limited to self-report at a single point in time,[7,8] rather than objective measures of use over time. Addressing shortfalls in CVD preventive therapy is fundamental to reducing CVD burden and requires robust measures of use and an understanding of the factors likely to be contributing to under-treatment. Causes for suboptimal therapy are likely multiple, reflecting healthcare system, medication and patient factors.[9] Use of preventive medications in Australia has been shown to vary in relation to patient characteristics, with medication use lower among younger people,[7] women,[10-12] people living outside urban areas[13,14] and those of higher socioeconomic position[13,15] than their counterparts. Comorbidities or health risk factors may also influence prescribing and use of CVD medications,[9,16,17] although this has not been examined specifically for secondary prevention. There is also a lack of information on the extent to which undertreatment reflects lack of engagement with primary healthcare, which is essential to CVD preventative care.

This study aimed to quantify use of guideline-recommended medications in people with CVD in Australia in relation to heath status, individual CVD risk factors and use of primary healthcare to inform strategies for implementing best practice. Specifically, we examined use of both BP- and lipid-lowering medication as the minimum therapy recommended by current guidelines; we

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were unable to accurately ascertain use of anti-platelet agents. This study used National Health Survey (NHS) data linked for the first time to Medicare Benefits Schedule (MBS) and Pharmaceutical Benefits Scheme (PBS) data.

Methods

Data sources and sample

The Multi-Agency Data Integration Project (MADIP) is a secure data asset combining information on health, education, government payments, personal income tax, and population demographics (including Census data) to create a comprehensive picture of Australia over time. Underpinning MADIP data is a Person Linkage Spine, used to create a person-level identification key by linking data from three administrative databases, together resulting in virtually complete coverage of the resident population:[18] Medicare Enrolments Database (records of those covered by Medicare, Australia's universal health insurer); Social Security and Related Information database (records of those receiving government benefits); and Personal Income Tax database (records of those who lodge a tax return). The high coverage of the Spine enables high quality linkages of other datasets to the Spine. Linkage was performed by the Australian Bureau of Statistics (ABS), the Accredited Integrating Authority for this asset.

For this study we used 2014-2015 NHS data linked to MBS/PBS (1 January 2013–31 December 2016) and Death Registrations (to 2016) data via the Spine. The NHS is a nationally representative survey of private dwellings (~17,958) in urban and rural Australia covering approximately 97% of people living in Australia; very remote areas of Australia and discrete Aboriginal and Torres Strait Islander communities were excluded.[19] The overall response rate was 82%, with a total sample size of 19,259 persons. The NHS includes detailed measured and self-reported information, collected during face-to-face interviews, on sociodemographic factors, health conditions, health risk factors and health actions. MBS data contain information relating to claims for medical services that are reimbursable under Medicare, including visits to general practitioners (GPs) and other doctors outside a hospital (identified by specific MBS item numbers). PBS data provide information on government-subsided medications dispensed to patients in the community including details on prescription and dispensing dates, and medicine type (identified by Anatomical Therapeutic Chemical (ATC)[20] and PBS item codes). Death registrations data contained information on month and year of death occurrence, for all deaths registered in Australia for the 2014 to 2016 calendar years.[21] Linkages were performed using deterministic and probabilistic linking methods, using name, full date of birth, address and sex, with linkage rates of 95% for the NHS[22] and 97% for deaths.[18] A direct link exists between MBS/PBS data and the Spine.

We used data from adults aged 25 years or older who participated in the 2014–2015 NHS classified as having prior atherosclerotic CVD (forthwith referred to as prior CVD), as it is atherosclerotic conditions which are amenable to recommended medications. Participants were considered to have prior CVD if having responded 'yes' to the question "Including any conditions which can be controlled with medication, have you ever been told by a doctor or nurse that you have any heart or circulatory conditions?", in response to the subsequent question "what are the names of these conditions?" they indicated one or more of: angina, heart attack and other ischaemic heart disease, stroke, other cerebrovascular diseases, and diseases of the arteries, arterioles and capillaries; finer subtyping was not possible with the available data. Of note, our classification is distinct from the broader classifications of CVD typically reported using NHS data.[19]

Variables

The outcome was use of guideline-recommended CVD medications,[4-6] defined for this study as at least two dispensings of both a lipid- and blood pressure-lowering medication in each three-month period in the year following completion of the NHS (coded as yes/no). For our study we included ATC codes: C02, C03, C07, C08, C09 for blood pressure-lowering medications, and C10 for lipid-lowering and combination medications. While antiplatelet medications are also recommended for those with prior CVD, the majority of these are dispensed privately without requiring a prescription and hence are not captured in PBS data. As such, use of antiplatelet medication was not included. Data supplied were pre-aggregated by quarterly counts of dispensings and total quantity supplied by ATC codes; hence, we were unable to account for stockpiling or different pack sizes as per standard methods.[23]

Participant characteristics (Table 1) were derived from NHS data and included: i) sociodemographic variables: age, sex, marital status, educational attainment, equivalised weekly household income, region of residence, country of birth, private health insurance and concession card holder; ii) CVD risk factors: self-reported smoking status, alcohol consumption, physical activity; self-reported doctor- or nurse-ever diagnosed (if condition also reported long-term and continuing) high blood pressure, diabetes, high blood cholesterol and renal disease; and the only available measured CVD risk factors, blood pressure and body mass index (BMI); iii) self-reported CVD subtype: doctor- or nurse diagnosed ischaemic heart disease (IHD) including angina/heart attack/other IHD, and stroke/other cerebrovascular disease and; iv) health status: self-rated health status, and number of continuing long-term conditions.

Primary healthcare engagement was derived from linked MBS data and included: i) frequency of GP use, measured as the number of out-of-hospital GP MBS services and extended primary care services (broad type of services [BTOS] categories 101, 102 and 103); ii) continuity of primary care, measured by the usual provider concentration (UPC),[24] calculated as the proportion of GP MBS services with the most frequent provider of total GP MBS services.[25] As per standard definitions, the UPC was calculated over a two-year period and calculated only for those participants who used at least four services in the two-year period.

Analysis

Participants were followed-up for 12 months following completion of the NHS survey. Those who were unable to be linked to the Spine due to linkage error, with invalid death dates or who died during follow up were excluded. To describe treatment levels, we calculated the proportion on recommended treatment for the total sample and according to participant characteristics.

We used logistic regression to estimate odds ratios (ORs) and 95% confidence intervals (95% CI) to measure the strength of association between use of recommended treatment and participant characteristics and primary healthcare engagement. Where appropriate, we adjusted for age and sex, then additionally for self-rated health

Table 1: Characteristics of participants with self-reported CVD, total and by CVD subtype.

	Prior CVD	Heart attack/ angina	Stroke/ Cerebrovascular disease
	%(n)	%(n)	%(n)
Total (n, %)	100(884/884)	66.3(586)	29.8(263)
Sociodemographic			
Age group (years)			
25-44	4.6(41)	4.1(24)	<10%
45-64	30.0(265)	30.0(176)	25.9(68)
65-84	56.2(497)	56.3(330)	61.2(161)
≥85	9.2(81)	9.6(56)	<10%
Sex			
Male	56.8(502)	62.3(365)	46.8(123)
Female	43.2(382)	37.7(221)	53.2(140)
Education			
University degree	15.2(134)	13.0(76)	17.0(n.p.)
Other qual or yr12	40.2(355)	41.0(240)	39.0(n.p.)
No qual no yr12	43.1(381)	44.4(260)	44.0(n.p.)
Income			
1 (Richest)	9.2(81)	8.2(48)	6.5(17)
2	15.3(135)	14.5(85)	14.5(38)
3	30.2(267)	32.1(188)	32.3(85)
4 (Poorest)	26.8(237)	25.9(152)	30.0(79)
Region			
Major cities	60.1(531)	59.2(347)	62.4(164)
Inner regional	23.2(205)	23.2(136)	26.2(69)
Other	16.7(148)	17.6(103)	11.4(30)
Country of birth			
Australia/NZ	72.2(638)	70.7(414)	73.0(192)
Overseas born	27.8(246)	29.4(172)	27.0(71)
Marital status			
Married/defacto	51.7(457)	52.4(307)	49.4(130)
Not married	48.3(427)	47.6(279)	50.6(133)
Private health insurance			
PHI	47.0(n.p)	43.6(n.p.)	44.9(118)
No PHI	53.0(n.p.)	56.4(n.p.)	55.1(145)
Concession card status			
No	25.0(n.p.)	23.4(n.p.)	20.6(n.p.)
Yes	75(n.p.)	76.6(n.p.)	79.4(n.p.)
CVD Risk Factors			
Smoking status			
Never smoked	37.0(327)	34.3(201)	39.5(104)
Former smoker	49.3(436)	52.9(310)	46.8(123)
Current smoker	13.7(121)	12.8(75)	13.7(36)
Measured blood pressure			
<140/90	62.3(551)	62.5(366)	61.2(161)
140/90-<160/100)	25.9(229)	24.9(146)	28.1(74)
160/100 and above	11.8(104)	12.6(74)	10.7(28)
Measured BMI			
Normal/Underweight (<=24.99)	23.0(203)	21.5(126)	23.2(61)
Overweight (25.00-29.99)	37.4(331)	36.7(215)	36.9(97)
Obese (>=30.00)	39.6(350)	41.8(245)	39.9(105)
Sufficient physical activity			
Insufficient activity	87.9(777)	88.4(518)	90.1(237)
Sufficient activity	12.1(107)	11.6(68)	9.9(26)

Table 1 cont.: Characteristics of participants with self-reported CVD, total and by CVD subtype.

	Prior CVD	Heart attack/ angina	Stroke/ Cerebrovascular disease
	%(n)	%(n)	%(n)
Met dietary guidelines			
Not met	42.9(379)	45.1(264)	39.9(105)
Partially met	51.6(456)	49.3(289)	54.0(142)
Guidelines met	5.5(49)	5.6(33)	6.1(16)
Alcohol consumption			
Non drinker	10.6(94)	10.6(62)	13.3(35)
<=2 standard drinks/day	35.0(309)	34.8(204)	35.7(94)
>2 standard drinks/day	15.6(138)	15.4(90)	11.4(30)
Did not consume in last week	38.8(343)	39.3(230)	39.4(104)
Self-reported high blood pressure			
No	51.1(452)	51.0(299)	44.5(117)
Yes	48.9(432)	49.0(287)	55.5(146)
Self-reported diabetes			
No	75.8(670)	71.7(420)	78.3(206)
Yes	24.2(214)	28.3(166)	21.7(57)
Self-reported high blood cholesterol			
No	63.4(560)	61.8(362)	61.6(162)
Yes	36.7(324)	38.2(224)	38.4(101)
Self-reported renal disease			
No	95.4(843)	94.5(554)	95.4(251)
Yes	4.6(41)	5.5(32)	4.6(12)
General health status			
Self-Rated Health			
Excellent/Very Good/Good	53.9(476)	53.2(312)	49.4(130)
Fair/Poor	46.2(408)	46.8(274)	50.6(133)
Number of continuing long term conditions			
4 or less	17.7(156)	17.4(102)	12.9(34)
5-8	43.1(381)	41.8(245)	42.2(111)
9 or more	39.3(347)	40.8(239)	44.9(118)
PHC enagagement			
GP use			
Mean(SD)	13.0(10.2)	13.2(10.3)	14.5(11.8)
0-2 visits py	10.1(89)	10.1(59)	10.3(27)
3-10 visits py	36.5(323)	35.3(207)	30.8(81)
≥11 visits py	53.4(472)	54.6(320)	58.9(155)
Continuity of care			
Usual provider concentration<70%	39.1(346)	36.5(214)	42.6(112)
Usual provider concentration≥70%	53.1(469)	55.6(326)	51.0(134)

Notes

Income, quartiles of equivalised weekly household income.

Height and weight (used to estimate body mass index [BMI]) were measured directly during interviews. Physical activity was determined in line with the Active Australia Survey [26] and classified as sufficient/insufficient according to Australia's Physical Activity and Sedentary Behaviour Guidelines for specified age groups.[27]

Continuity of care was defined as at least 70% of a person's services were with the most frequent provider (categorised as yes/no).[24]

n.p. indicates that the count in that cell was <10 and has been suppressed, as have associated cells in that group. Proportions have been perturbed in these instances to preserve confidentiality e.g. <10%.

Missing data: education 1.6%(total), 1.7%(heart attack/angina); income 18.6(total), 19.3(heart attack/angina), 16.7(stoke/cerebrovascular disease); continuity of care 7.8%(total), 7.9%(heart attack/angina), 4.5%(stoke/cerebrovascular disease). The following also had missing data but are not reported as counts were <10: education (stoke/cerebrovascular disease), PHI (total and heart attack/angina), concession care (all groups).

Abbrev. BMI, body mass index; CVD, cardiovascular disease; GP, general practitioner; NZ, New Zealand; PHC, primary healthcare; PHI, private health insurance.

and number of conditions, to determine if associations remained after accounting for underlying health status. In addition to adjustment for age and sex, we additionally adjusted models separately for measures of primary healthcare engagement (frequency of use and continuity of care) and concession card ownership to determine if this explained the relationship between individual characteristics and use of recommended treatment. For the association with chronic high blood pressure, we chose self-report rather than measured blood pressure as the latter excludes people with a diagnosis of chronic high blood pressure which is currently controlled by medication.

In supplementary analyses, we also examined use of recommended treatment in the three months following participation in the NHS survey and medication possession over 12 months derived from the quantity per quarter supplied (defined as at least one tablet per day dispensed of both medications for 80% of the follow up period). In addition, to determine if associations differed, we examined non-users of recommended treatment, defined as those who did not have either a blood pressure- or lipid-lowering medication dispensed in the follow-up period.

In sensitivity analyses we repeated analyses to: i) include those who had died as these participants may differ in their sociodemographic and health risk profile to surviving members of the cohort; and ii) re-define the outcome to at least one dispensing of both a blood pressure and lipid-lowering medication per quarter over 12 months, to allow for infrequent medication use and differing pack sizes.

Stata version 15.1 was used for all analyses, completed in DataLab, a secure remote access computer facility for analysis of data compiled and managed by the ABS.

We obtained ethics approval for this study from The Australian National University Human Research Ethics Committee (HREC number 2019/138).

Results

Sample characteristics

After excluding participants whose data did not link to the Spine (n=31, 2.8%), or who died in the first year or had invalid death dates (n=32), the final study population included 884 people with self-reported CVD.

Our sample included more males (56.8%) than females, most (66.4%) participants were aged over 65 years and the majority (82.4%) reported five or more long-term health conditions (Table 1). The mean number of GP MBS services claimed in the year following participation in the NHS was 13 (SD 10.2) with a median of 11 (IQR 11); 94.8% had at least one GP MBS service. Just over half the cohort (52.6%) had continuity of care.

Use of recommended CVD preventative medications

Overall, 40.0% of participants had at least two dispensings per quarter over a 12-month period of both blood pressure- and lipid-lowering medications (Figure 1). Participants who were older (25–44 years OR 0.14 95% CI[0.05, 0.41], 45–64y 0.61[0.45, 0.84] versus 65-84y), male (women 0.49[0.37, 0.65] vs men), and held a concession card (2.00[1.36, 2.95] versus none) were more likely to be on recommended medications (Figure 1). Participants with CVD risk factors were more likely to be on recommended medications compared to those without these risk factors, including: obesity (2.32 [1.58, 3.41]), self-reported high blood pressure (3.13 [2.34, 4.19]), high blood cholesterol (2.77 [2.06, 3.71]) and renal disease (2.61 [1.32, 5.14]) (Figure 1). Smoking was also associated with being on therapy (p=0.016); former smokers (1.35 [0.99, 1.85]) were more likely and current smokers (0.73 [0.44, 1.20]) less likely to be on recommended medications compared to never smokers. Those with IHD were more likely to be on recommended medications compared to those with the other forms of CVD (1.67 [1.23, 2.27]). Further, participants with poorer health status as measured by the number of long-term conditions (five–eight conditions 1.62 [1.06, 2.48], nine or more conditions 2.15 [1.39, 3.31], compared to four or less) and increased frequency of GP use (medium 2.02 [1.16, 3.52], high 2.62 [1.53, 4.48], compared to low) were also more likely to be on recommended medications. Continuity of GP care was not associated with use of preventive medications. After additional adjustment for underlying health status, patterns of association between CVD risk factors, CVD subtype and medication use were unchanged, although odds ratios were marginally attenuated for some characteristics (Supplementary Table 2).

To determine if the relationship between health risk factors and CVD subtype with medication use was at least partly explained by a person's engagement with primary healthcare services, we additionally adjusted models for frequency of GP use and, separately, for continuity of care. Odds ratios were only marginally attenuated after this adjustment (supplementary files). This was also the case for models additionally adjusted separately for concession card ownership (supplementary files).

Supplementary and sensitivity analyses

Patterns of association for those who never had a blood pressure- or lipid- lowering medication dispensed in the follow up period were similar to those defined as non-medication users in main analyses. That is, those who were younger, current smokers, those without CVD risk factors, and those who had infrequent GP services were more likely to have not been dispensed a blood pressure- or lipid-lowering medication. In addition, those with cerebrovascular disease (1.63 [1.08, 2.48]) and with poor continuity of GP care (0.6 [0.4, 0.92]) were also more likely to be non-users. Results of supplementary analyses with three-month medication use or 12-month medication coverage did not differ materially from the main analysis (supplementary files), nor did results from sensitivity analyses (supplementary files).

Discussion

Our study found that 60% of people with CVD were not receiving the most basic recommended preventive medications. This is despite the fact that nearly all saw their GP in the study period. While use was low across the board, those who were younger, women, and those without a concession card were particularly at risk of not being on therapy. Current smokers were at particularly high-risk of being non-users of recommended therapy or being under-treated, irrespective of health status, use of GP services or concessional status.

After accounting for age and sex, those who had high use of GP services were nearly three times as likely to be using CVD preventive medications than those who had low use. This was the case even after accounting for other health conditions. Continuity of GP care, however, was not associated with medication use. People with individual CVD risk factors or with chronic conditions were also more likely to be using preventive medications than those in better health, even after

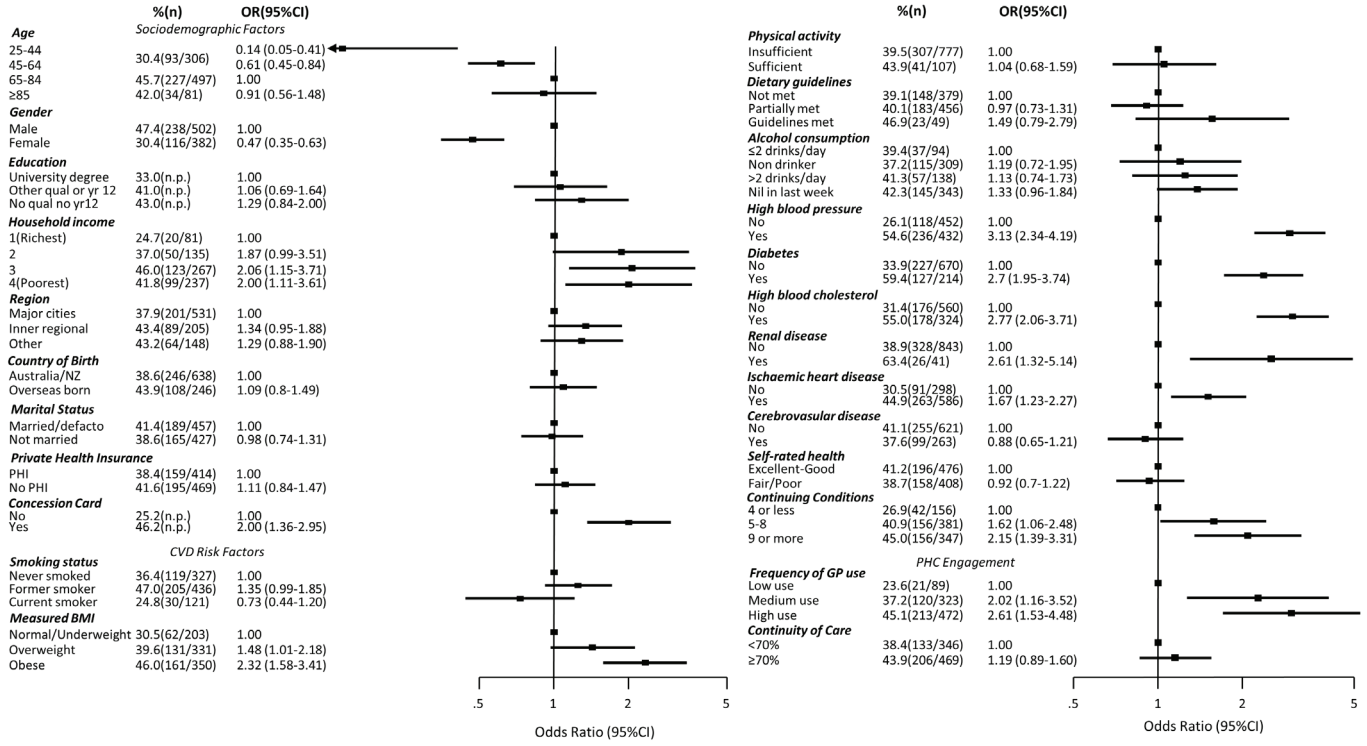
accounting for how frequently people saw a GP or whether they possessed a healthcare concession card.

The overall levels of under-treatment for people with CVD observed in this study are consistent with what has previously been reported in Australia using self-report medication data.[7,15,26] Consistent with previous findings,[8,11,12,26] we show that women are more likely to have suboptimal therapy than men, and expand on this to show that this occurs irrespective of their underlying health status or engagement with GP services. While not previously reported for secondary prevention, our finding that those with individual CVD risk factors were more likely to use preventative medications is consistent with data from 2008 on CVD primary prevention in Australia.[17] This is despite changes to medication subsidy criteria to support an absolute risk approach to therapy, as opposed to individual risk factors as was the case for this earlier study. Our study is the first to report that concession status may also influence use of recommended CVD medications, as concession card holders were more likely to be on preventive medications. This is consistent with studies of statin use in primary care and older populations, which have found that concessional status and measures to limit out-of-pocket costs were important for continued use.[27,28]

There are likely to be multiple reasons for overall low levels of treatment, relating to the healthcare system, patient, therapy, and provider.[9,29] System factors such as finance arrangements, including copayments and full prescription coverage,[30] have been found to improve adherence to secondary preventive therapy. We found that concession card holders were more likely to use preventive medications, but this did not fully account for variation in use. Similarly, engagement with primary healthcare mattered for the likelihood of preventive medication use but did not fully explain the variation in treatment levels.

Patient and provider factors may also determine use and prescribing of therapy. In terms of patient factors, the presence of comorbidities[29] and patient education/counselling[30] have been associated with increased use of cardiovascular medications, while barriers to adherence include limited health literacy[29,31] and patient perceptions about medications (in terms of relative benefits and risks).[29] On the other hand, GPs have reported a reluctance to prescribe or a tendency to rationalise preventive medication when patients have multiple conditions to contend with,[16] related to cost and medication burden reasons. Regardless, our findings indicate that those with more health conditions were still more likely to use preventive medications. Other reasons for not prescribing CVD preventive medications includes provider beliefs regarding patient motivation, respect for patient autonomy

Figure 1: Sample proportions, odds ratios and 95% confidence intervals of use for guideline recommended therapy among those with self-reported CVD in the year following completion of the NHS survey, for sociodemographic and health characteristics.



Notes:

Age- and sex-adjusted, tables with additional adjustment for health status available in Supplementary Table 2.

Income, quartiles of equivalised weekly household income. Height and weight (used to estimate body mass index [BMI]) were measured directly during interviews. Physical activity was determined in line with the Active Australia Survey[26] and classified as sufficient/insufficient according to Australia's Physical Activity and Sedentary Behaviour Guidelines for specified age groups.[27]

Continuity of care was defined as at least 70% of their services were with the most frequent provider (categorised as yes/no).[24]

Proportions for the 25-44 and 45-64 age group have been collapsed due to low counts, n.p. indicates that the count in that cell was <10 and has been suppressed, as have associated cells in that group. Proportions have been perturbed in these instances to preserve confidentiality e.g. <10%.

% with outcome in missing data: income 37.8; continuity of care 21.7; education missing not reported as counts <10.

Abbrev. BMI, body mass index; CVD, cardiovascular disease; GP, general practitioner; NZ, New Zealand; PHC, primary healthcare; PHI, private health insurance.

or a desire to avoid over-medicalisation[16]; the latter particularly of concern for young patients or those who were otherwise well. This may explain our finding that younger age groups and those without comorbidities were at high-risk of non-use of preventive medications. Primary care providers have also reported a preference for treating according to individual risk factors, rather than accepting overall or absolute risk score,[16] with evidence from dispensing data supporting this for primary prevention,[17] which may partly explain our findings in relation to CVD risk factors.

Therapy-related factors such as a lack of fixed-dosed combination therapy, medications with poorly tolerated side effects and polypharmacy have been shown to influence adherence[29,30] and prescribing behaviour.[16] Exploring this further was beyond the scope of the current study.

To the best of our knowledge, this is the first study in Australia to examine use of secondary preventative medications using dispensing data in relation to a range of self-reported sociodemographic and health factors, using objective measures of primary healthcare engagement. Medication dispensing data allowed us to estimate medication use over time, which better indicates actual use compared with prescribing data and likely has less risk of misclassification compared with self-report data. All but two participant characteristics, including CVD risk factors and prior CVD, were self-reported. As is common to all survey-based data, this may have resulted in a degree of misclassification. We aimed to minimise this by including only those who self-reported specific conditions known to be atherosclerotic. Previous studies have validated self-reported CVD, demonstrating that self-reported MI and stroke are highly specific (>99%) and sensitive (81.1–90.1%).[32–34] Given this, our sample may include a small number of people without atherosclerotic CVD, in which case resulting in an underestimate of absolute treatment levels; the magnitude of this underestimation is likely to be small. The effect of misclassification on self-reported CVD risk factors used for internal comparisons will depend on the extent to which misclassification is differential with respect to the outcome (use of preventative medications). It is unclear the extent to which this might be the case and therefore the direction and extent to which this would bias the results is uncertain.

Dispensing data were available at person level aggregated by quarter. As such, we were unable to account for different pack sizes and stockpiling. However, supplementary analysis examining factors associated with 12–month coverage of both medications and non-use of medications, were similar to the main findings, suggesting that pack sizes and stockpiling were unlikely to alter our findings. While the NHS is designed to be representative of the Australian population, the CVD population in the NHS may not be representative of the Australian CVD population. As such, absolute proportions should be interpreted with caution, although internal associations likely remain valid. While subsequent waves of the NHS have been completed, these were not linked to PBS data (at least at the time of this study). Regardless, given that guidelines for recommended preventative treatment for CVD have not changed in the intervening time, more recent data are unlikely to alter the current findings substantially.

Conclusion and implications for public health

This study shows the large overall magnitude of suboptimal therapy for secondary prevention of CVD and provides important insights into factors associated with particularly low use–including treatment according to individual CVD risk factors rather than absolute risk. These findings highlight opportunities for further risk reduction and prevention of CVD morbidity and mortality. Given that nearly all people living with CVD had at least one visit with a GP in a year, primary care remains a critical avenue for addressing gaps in use of guideline-recommended medications. In addition to addressing overall low treatment levels, further research into the drivers for undertreatment in key groups of people, including younger people, women and smokers, would help to target policy initiatives and maximise public health gains.

Data availability statement

Multi-Agency Data Integration Project data are available for approved projects to approved government and non-government users. https://www.abs.gov.au/websitedbs/D3310114.nsf/home/Statistical+Data+Integration+-+MADIP

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References

1. Australian Institute of Health and Welfare. *Australian Burden of Disease Study: Impact and Causes of Illness and Death in Australia 2015*. Canberra (AUST): AIHW; 2019.
2. Australian Institute of Health and Welfare. *Cardiovascular Disease* [Internet]. Canberra (AUST): AIHW; 2020 [2021 Mar 28]. Available from: https://www.aihw.gov.au/reports/heart-stroke-vascular-diseases/cardiovascular-health-compendium/contents/how-many-australians-have-cardiovascular-disease
3. Ma T-T, Wong ICK, Man KKC, Chen Y, Crake T, Ozkor MA, et al. Effect of evidence-based therapy for secondary prevention of cardiovascular disease: Systematic review and meta-analysis. *PloS One*. 2019;14(1):e0210988.
4. Chew DP, Scott IA, Cullen L, French JK, Briffa TG, Tideman PA, et al. National Heart Foundation of Australia & Cardiac Society of Australia and New Zealand: Australian clinical guidelines for the management of acute coronary syndromes. *Heart Lung Circ*. 2016;25(9):895-951.
5. National Heart Foundation of Australia and the Cardiac Society of Australia and New Zealand. *Reducing Risk in Heart Disease: An Expert Guide to Clinical Practice for Secondary Prevention of Coronary Heart Disease*. Melbourne (AUST): National Heart Foundation of Australia; 2012.
6. National Stroke Foundation. *Clinical Guidelines for Stroke Management*. Melbourne (AUST): Stroke Foundation; 2017.
7. Banks E, Crouch SR, Korda RJ, Stavreski B, Page K, Thurber KA, et al. Absolute risk of cardiovascular disease events, and blood pressure- and lipid-lowering therapy in Australia. *Med J Aust*. 2016;204(8):320.
8. Banks E, Welsh J, Joshy G, Martin M, Paige E, Korda RJ. Comparison of cardiovascular disease risk factors, assessment and management in men and women, including consideration of absolute risk: A nationally representative cross-sectional study. *BMJ Open*. 2020;10(12):e038761.
9. Ferdinand KC, Senatore FF, Clayton-Jeter H, Cryer DR, Lewin JC, Nasser SA, et al. Improving medication adherence in cardiometabolic disease: Practical and regulatory implications. *J Am Coll Cardiol*. 2017;69(4):437-51.
10. Hyun K, Negrone A, Redfern J, Atkins E, Chow C, Kilian J, et al. Gender difference in secondary prevention of cardiovascular disease and outcomes following the survival of acute coronary syndrome. *Heart Lung Circ*. 2021;30(1):121-7.
11. Lee CMY, Mnatzaganian G, Woodward M, Chow CK, Sitas F, Robinson S, et al. Sex disparities in the management of coronary heart disease in general practices in Australia. *Heart*. 2019;105(24):1898-904.
12. Barrett E, Paige E, Welsh J, Korda RJ, Joshy G, Martin M, et al. Differences between men and women in the use of preventive medications following a major cardiovascular event: Australian prospective cohort study. *Prev Med Rep*. 2021;22:101342.

13. Stocks N, Ryan P, Allan J, Williams S, Willson K. Gender, socioeconomic status, need or access? Differences in statin prescribing across urban, rural and remote Australia. *Aust J Rural Health*. 2009;17(2):92-6.
14. Australian Institute of Health and Welfare. *Cardiovascular Medicine and Primary Health Care: A Regional Analysis*. Canberra (AUST): AIHW; 2010.
15. Paige E, Welsh J, Agostino J, Calabria B, Banks E, Korda RJ. Socioeconomic variation in absolute cardiovascular disease risk and treatment in the Australian population. *Prev Med*. 2018;114:217-22.
16. Ju I, Banks E, Calabria B, Ju A, Agostino J, Korda RJ, et al. General practitioners' perspectives on the prevention of cardiovascular disease: Systematic review and thematic synthesis of qualitative studies. *BMJ Open*. 2018;8(11):e021137.
17. Schilling C, Knight J, Mortimer D, Petrie D, Clarke P, Chalmers J, et al. Australian general practitioners initiate statin therapy primarily on the basis of lipid levels; New Zealand general practitioners use absolute risk. *Health Policy*. 2017;121(12):1233-9.
18. Australia Bureau of Statistics. *1700.0 - Microdata: Multi-agency Data Integration Project, Australia.* Canberra (AUST): ABS; 2018.
19. Australia Bureau of Statistics. *4363.0 - National Health Survey: Users' Guide, 2014-15*. Canberra (AUST): ABS; 2017.
20. World Health Organization Collaborating Centre for Drug Statistics Methodology. *ATC/DDD Index 2020*. Geneva (CHE): WHO; 2020.
21. Australia Bureau of Statistics. *3303.0 - Causes of Death, Australia, 2017*. Canberra (AUST): ABS; 2018.
22. Australia Bureau of Statistics. *4321.0 - Research Paper: Integration of the National Health Survey with the Multi-Agency Data Integration Project (MADIP) 2014-15*. Canberra (AUST): ABS; 2020.
23. Andrade SE, Kahler KH, Frech F, Chan KA. Methods for evaluation of medication adherence and persistence using automated databases. *Pharmacoepidemiol Drug Saf*. 2006;15(8):565-74; discussion 75-7.
24. Jee SH, Cabana MD. Indices for continuity of care: A systematic review of the literature. *Med Care Res Rev*. 2006;63(2):158-88.
25. Australian Institute of Health and Welfare. *Medicare-subsided GP, Allied Health and Specialist Care Across Local Areas: Technical Note*. Canberra (AUST): AIHW; 2019.
26. Hyun KK, Redfern J, Patel A, Peiris D, Brieger D, Sullivan D, et al. Gender inequalities in cardiovascular risk factor assessment and management in primary healthcare. *Heart*. 2017;103(7):492.
27. McRae I, van Gool K, Hall J, Yen L. Role of cost on failure to access prescribed pharmaceuticals: The case of Statins. *Appl Health Econ Health Policy*. 2017;15(5):625-34.
28. Knott RJ, Petrie DJ, Heeley EL, Chalmers JP, Clarke PM. The effects of reduced co-payments on discontinuation and adherence failure to statin medication in Australia. *Health Policy*. 2015;119(5):620-7.
29. Leslie KH, McCowan C, Pell JP. Adherence to cardiovascular medication: A review of systematic reviews. *J Public Health (Oxf)*. 2019;41(1):e84-e94.
30. Banerjee A, Khandelwal S, Nambiar L, Saxena M, Peck V, Moniruzzaman M, et al. Health system barriers and facilitators to medication adherence for the secondary prevention of cardiovascular disease: A systematic review. *Open Heart*. 2016;3(2):e000438.
31. Magnani JW, Mujahid MS, Aronow HD, Cené CW, Dickson VV, Havranek E, et al. Health literacy and cardiovascular disease: Fundamental relevance to primary and secondary prevention: A scientific statement from the American Heart Association. *Circulation*. 2018;138(2):e48-e74.
32. Machón M, Arriola L, Larrañaga N, Amiano P, Moreno-Iribas C, Agudo A, et al. Validity of self-reported prevalent cases of stroke and acute myocardial infarction in the Spanish cohort of the EPIC study. *J Epidemiol Community Health*. 2013;67(1):71-5.
33. Eliassen B-M, Melhus M, Tell GS, Borch KB, Braaten T, Broderstad AR, et al. Validity of self-reported myocardial infarction and stroke in regions with Sami and Norwegian populations: The SAMINOR 1 Survey and the CVDNOR project. *BMJ Open*. 2016;6(11):e012717.
34. Barr EL, Tonkin AM, Welborn TA, Shaw JE. Validity of self-reported cardiovascular disease events in comparison to medical record adjudication and a statewide hospital morbidity database: The AusDiab Study. *Intern Med J*. 2009;39(1):49-53.

Supporting Information

Additional supporting information may be found in the online version of this article:

Supplementary Table 1: Outcomes by participant characteristics, main and supplementary analyses.

Supplementary Table 2: Odds ratios, 95% confidence intervals, and p-values for association of sample characteristics with use of blood pressure- or lipid-lowering medication.

Supplementary Table 3: Odds ratios, 95% confidence intervals, and p-values for association of sample characteristics with non-use of blood pressure- or lipid-lowering medication.

Supplementary Table 4: Odds ratios, 95% confidence intervals, and p-values for association of sample characteristics with use of blood pressure- or lipid-lowering medication (3 months).

Supplementary Table 5: Odds ratios, 95% confidence intervals, and p-values for association of sample characteristics with 80% of days coverage over 12 months of blood pressure- or lipid-lowering medication.

Supplementary Sensitivity Table 1: Odds ratios, 95% confidence intervals, and p-values for association of sample characteristics with use of blood pressure- or lipid-lowering medication over 12 months.