

## Obesity Comorbidities

# Chronic disease trends due to excess body weight in Australia

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### Summary

Trends in chronic diseases provide insights into strategies required to improve population health. The authors determined prevalence and multiple-adjusted population attributable risk (PAR) estimates of chronic diseases because of lifestyle factors among Australian adults between 1989–90 and 2004–5, accounting for demographic factors. Between 1989–90 and 2004–5, prevalence increased for diabetes (3.8–6.0%,  $P < 0.001$ ) and high cholesterol (11.3–13.9%,  $P < 0.001$ ), but decreased for high blood pressure (21.4–20.4%,  $P = 0.003$ ) and cardiovascular disease (CVD, 6.2–5.4%,  $P < 0.001$ ). Prevalence increased for body mass index (BMI) 25–29.9 (30.3–34.9%,  $P < 0.001$ ), BMI 30–34.9 (7.4–13.5%,  $P < 0.001$ ) and BMI 35+ (2.1–5.4%,  $P < 0.001$ ), but decreased for metabolic equivalent-hours per week (MET-hr/week) 0 (36.8–33.1%,  $P < 0.001$ ) and current smokers (27.6–24.4%,  $P < 0.001$ ). Diabetes, high cholesterol and high blood pressure burden increased mostly for 60+ years, lowest income quintiles and high BMI (30–34.9 and 35+). Diabetes and CVD burden increased mostly for MET-hr/week 0. Many chronic disease cases would have been theoretically prevented if adults had no prior exposure to BMI 25–29.9 (PAR 9–17%), BMI 30+ (PAR 1–14%) and MET-hr/week 0 (PAR 6–14%). Reducing exposure to lifestyle hazards across the lifespan is required for reversing the rising burden of chronic diseases. Decreases in CVD and high blood pressure prevalence were likely due to targeted improvements in health care, indicating that more can and should be done.

**Keywords:** Cardiovascular disease, diabetes, population trends, risk factors.

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### Introduction

Excess body weight, physical inactivity and smoking are considered the leading modifiable risk factors for the most prevalent chronic non-communicable diseases worldwide (1). Cohort studies have shown a strong and continuous effect of the body mass index (BMI) on incident diabetes mellitus (2) and fatal cardiovascular disease (CVD) events (3). Cohort studies have also shown a continuous (inverse) association between physical activity and incident diabetes mellitus (4) and CVD events (5,6), with some effect modification after adjustment for BMI and smoking status. Strong and continuous associations have been observed

between cigarette smoking and CVD events (7), which were largely unchanged after adjustment for BMI and physical activity (6,8). Accordingly, there is a compelling case for public health interventions targeting unhealthy lifestyle factors to reduce the burden of chronic disease.

Population trends provide important epidemiologic information for estimating changes in the burden of chronic diseases according to demographic and preventable lifestyle factors. For Australian adults, obesity prevalence has more than doubled since 1980 (9), whereas current smoking (10) and, to a lesser degree, physical inactivity (no leisure-time physical activity) (11) have decreased over recent decades. Whether long-term changes in chronic

disease prevalence occurred differentially, in relation to demographic and lifestyle factors, is unclear. Using available data from the earliest (1989–90) and the most recent (2004–05) Australian National Health Surveys (NHS), the authors determined the prevalence and population attributable risk (PAR%) of self-reported medically diagnosed diabetes, high blood pressure, high cholesterol and CVD according to demographic and lifestyle factors.

## Methods

### Samples

The information source for this report was the series of data collections from the Australian NHS 1989–90 (12) ( $N = 54\,576$ ) and 2004–05 (13) ( $N = 19\,501$ ), nationally representative surveys conducted by the Australian Bureau of Statistics approximately every 5 years. A multistage area sampling method was used in each survey, however, in NHS 1989–90, some non-private dwellings (e.g. hotels, motels and hostels) were also selected using a list sample. Information about health status, use of health services, health-related lifestyle factors, demographic and socioeconomic characteristics of participants was obtained from residents of sampled special and/or private dwellings by trained interviewers. A private dwelling was predefined as a 'house, flat, home unit, caravan, garage, tent and any other structure being used as a private place of residence'. Response rates of 96% (54 576/56 803 persons) for NHS 1989–90 and 89% (19 501/21 808 dwellings) for NHS 2004–5 were computed as the number of persons (for NHS 1989–90) or dwellings (for NHS 2004–5) with fully or partly completed interviews divided by the total number of sampled persons or dwellings. Complete data for adults aged 20+ years were available for 90% of the NHS 1989–90 sample and 96% of the NHS 2004–5 sample.

### Chronic diseases

Total diabetes was assessed by asking 'Have you ever been told by a doctor or nurse that you have diabetes?' High cholesterol was assessed by asking 'Have you ever been told by a doctor or nurse that you have high cholesterol?' High blood pressure was assessed by asking 'Have you ever been told by a doctor or nurse that you have high blood pressure?' Present CVD was assessed by asking participants if they have ever been told by a doctor or nurse that they had a heart 'attack, stroke or angina'. Identical question items and descriptors were used in both surveys.

The NHS 1989–90 data were adjusted to account for different Australian guidelines for the diagnosis of diabetes between the two survey periods (fasting plasma glucose  $\geq 7.8$  mmol L<sup>-1</sup> for 1989–90, and  $\geq 7.0$  mmol L<sup>-1</sup> for 2004–5) (14). To estimate the potential effect of the

different diagnostic criteria, we determined the prevalence of diabetes in a regionally representative cohort of Australian men aged 35–81 years ( $N = 1195$ ) (15) using both fasting plasma glucose cut-offs. Results suggested that the prevalence of diabetes would have been overestimated by approximately 2% using the lower  $\geq 7.0$  mmol L<sup>-1</sup> cut-off, and that the magnitude of this error was positively associated with BMI category. The appropriate number of non-diabetic cases was therefore randomly selected for each BMI category from the NHS 1989–90 dataset and re-classified as diabetic cases, for all statistical analyses.

### Lifestyle risk factors

The BMI was derived from self-report height and weight values and computed as weight in kilograms divided by height in metres squared. Standard international cut-offs were used to define healthy weight reference (BMI < 25) and exposure categories for overweight (BMI 25–29.9), obesity I (BMI 30–34.9) and obesity II+ (BMI 35+). Although reliable across surveys, overweight and obesity prevalence estimates derived from self-report data were previously shown to be approximately 20% lower than estimates derived from measured data as a result of tendencies for height to be overestimated among shorter and older men and women and for weight to be underestimated most notably among women across the age spectrum (16). Smoking status was assessed by asking 'Do you smoke?' and 'Do you currently smoke?' for NHS 1989–90 and NHS 2004–5 respectively.

Physical activity data were derived from self-reported duration and intensity of physical exercise (including walking) for recreation, sport or health/fitness during the past 2 weeks, at the time of the interview. Question items and descriptors used in the NHS to assess physical activity duration, frequency and intensity were identical for both surveys and are similar to those in the International Physical Activity Questionnaire, which showed good repeatability coefficients and criterion validity for classifying those who achieved sufficient physical activity for health benefits compared with accelerometer methodology (17). Total time spent in physical activity was multiplied by intensity weights (3.5 for walking, 5.0 for moderate and 7.5 for vigorous intensity exercise) to compute metabolic equivalent-hours per week (MET-hr/week). The MET is a proxy estimate of total energy expenditure during exercise, expressed as multiples of standard resting energy expenditure (equivalent to one MET unit) (18). MET-hr/week cut-offs were used to define sufficient physical activity as the reference (MET-hr/week 9+,  $\approx 108$  min/week of at least moderate intensity physical activity, broadly consistent with Australian guidelines for 'health benefits') (19) and exposure categories for physical inactivity (MET-hr/week 0) and insufficient physical activity (MET-hr/week >0–9).

## Statistical analyses

Statistical analyses were performed using SPSS 15.0 (SPSS Inc. Chicago, IL, US). All data were age-standardized to the Australian population distribution according to the 2001 Census of Population and Housing. Prevalence estimates with 99% confidence intervals (99% CI) were computed for demographic and lifestyle factors, and chronic diseases in 1989–90 and 2004–5. Multiple-adjusted PAR% of chronic disease because of demographic and lifestyle risk factor categories were computed as  $PAR\% = P_d (RR_{adj} - 1) / RR_{adj}$ , where  $P_d$  was the proportion of exposed cases among the diseased, and  $RR_{adj}$  was the relative risk of disease adjusted for all demographic and lifestyle factors (20). Adjusted relative risks were calculated from multivariable log-binomial regressions (21) and 99% CI for PAR% were derived using the Bonferroni method (22). The PAR% measure has been defined as the percentage of all cases of disease associated with the risk factor, and estimates the proportional reduction in the disease load that would occur if exposure were prevented (eradicated) (20). The PAR% presented in this report can be generalized to the entire population as prevalence estimates were determined using nationally representative samples. Chi-squared tests were used to determine significant changes in prevalence over time.

## Results

Tables 1 and 2 present prevalence estimates for self-reported chronic diseases between 1989–90 and 2004–5 for Australian adults, by demographic and lifestyle factors respectively. Prevalence estimates between 1989–90 and 2004–5 increased for diabetes (3.8–6.0%,  $P < 0.001$ ) and high cholesterol (11.3–13.9%,  $P < 0.001$ ), and decreased for high blood pressure (21.4–20.4%,  $P = 0.003$ ) and CVD (6.2–5.4%,  $P < 0.001$ ). Prevalence estimates increased for BMI 25–29.9 (30.3–34.9%,  $P < 0.001$ ), BMI 30–34.9 (7.4–13.5%,  $P < 0.001$ ), BMI 35+ (2.1–5.4%,  $P < 0.001$ ), MET-hr/week >0–9+ (25.1–27.6%,  $P < 0.001$ ) and MET-hr/week 9+ (38.1–39.4%,  $P = 0.004$ ), and decreased for BMI < 25 (60.2–46.2%,  $P < 0.001$ ), MET-hr/week 0 (36.8–33.1%,  $P < 0.001$ ) and current smoker (27.6–24.4%,  $P < 0.001$ ) categories. Trends indicate that a large proportion of the population shifted from healthy weight to overweight and obese categories. Small, but potentially clinically important proportions shifted from low (physical inactivity and insufficient physical activity) to sufficient physical activity categories and from current to non-current smoker categories.

Figures 1–4 present the multiple-adjusted PAR% of diabetes, high cholesterol, high blood pressure and CVD because of demographic and lifestyle factors (comparing 1989–90 with 2004–5). Figure 1 shows PAR% of diabetes

decreased for BMI 25–29.9 (17.3–12.2%) and current smoker categories (–2.2 to –3.4%), remained stable for female sex (–9.3 to –9.8%) and for 40–59 years (15.6–15.8%), but increased for 60+ years (32.8–39.1%), first, second and third income quintiles (5.9–11.5%, 8.9–19.2% and 2.1–5.7%), BMI 30–34.9 and 35+ (8.6–13.8% and 5.9–9.9%), and for MET-hr/week 0 and >0–9 (6.0–9.0% and 4.6–6.3%). Point estimates for fourth income quintile and current smoker categories were small with considerable uncertainty. Therefore, the burden of diabetes increased in the past 15 years mostly for 60+ years, lowest income quintiles (first and second), high BMI (30–34.9 and 35+) and lowest physical activity categories. A substantial proportion of diabetic cases would have been theoretically prevented if adults had no prior exposure to obesity or to low physical activity (PAR% ranged from 5 to 17%).

Figure 2 shows PAR% of high cholesterol decreased for 40–59 years (32.1–29.2%), remained stable for female sex (–3.1 to –3.4%) and current smoker (–2.9 to –2.1%), but increased for 60+ years (27.7–40.8%), first, second and third income quintiles (–2.7 to 1.6%, –4.1 to 3.6% and –3.3% to –0.1%), BMI 30–34.9 and 35+ (3.1–7.0% and 0.6–2.4%), and for MET-hr/week 0 and >0–9 (–0.5 to 2.5% and –6.3 to –1.9%). Point estimates for female sex, income quintiles, MET-hr/week and current smoker categories were small with considerable uncertainty. Therefore, the burden of high cholesterol increased in the past 15 years mostly for 60+ years, first and second income quintiles and high BMI (30–34.9 and 35+) categories. A substantial proportion of high cholesterol cases would have been theoretically prevented if adults had no prior exposure to overweight or obesity (PAR% ranged from 1 to 10%).

Figure 3 shows PAR% of high blood pressure decreased for female sex (11.0–3.6%), remained stable for BMI 25–29.9 (12.4–13.2%), first and third income quintiles (3.5–3.0% and 2.0–2.6%) and current smoker (–2.3 to –3.0%), but increased for 40–59 years (20.5–23.5%), 60+ years (34.2–41.9%), second income quintile (4.6–7.8%), and for BMI 30–34.9 and 35+ (6.3–10.3% and 2.3–5.0%). Point estimates for fourth income quintile and MET-hr/week were small with considerable uncertainty. Therefore, the burden of high blood pressure increased in the past 15 years mostly for 60+ years, second income quintile and high BMI (30–34.9 and 35+) categories. A substantial proportion of high blood pressure cases would have been theoretically prevented if adults had no prior exposure to overweight or obesity (PAR% ranged from 2 to 13%).

Figure 4 shows PAR% of CVD decreased for female sex (–18.0 to –35.0%), remained stable for 40–59 years (20.0–18.5%), 60+ years (71.2–72.7%), but increased for first, second and third income quintiles (10.6–13.1%, 17.6–34.3% and 3.8–6.5%) and MET-hr/week 0 (–1.1 to 14.3%). Point estimates for fourth income quintile, BMI, MET-hr/week >0–9 and current smoker categories were

**Table 1** Prevalence of Australian adults reporting chronic diseases in National Health Surveys (NHS) 1989–90 and 2004–5, by demographic factors

NHS	Demographic factors			Diabetes		High cholesterol		High blood pressure		CVD		
	Weighted n	%	(99% CI)	%	(99% CI)	%	(99% CI)	%	(99% CI)	%	(99% CI)	
1989–90	Sex											
	Male	18 167	48.8	(48.0, 49.5)	4.1	(3.7, 4.5)	11.8	(11.2, 12.5)	18.8	(18.0, 19.5)	6.8	(6.3, 7.3)
	Female	19 097	51.2	(50.5, 52.0)	3.7	(3.3, 4.0)	10.9	(10.3, 11.5)	24.0	(23.2, 24.8)	5.6	(5.2, 6.1)
	Total	37 264	100		(3.6, 4.1)	11.3	(10.9, 11.8)	21.4	(20.9, 22.0)	6.2	(5.9, 6.6)	
2004–5	Male	8 692	45.7	(44.7, 46.7)	5.8	(5.2, 6.4)	14.4	(13.5, 15.4)	19.2	(18.2, 20.3)	6.4	(5.8, 7.1)
	Female	10 326	54.3	(53.3, 55.3)	6.2	(5.6, 6.8)	13.4	(12.6, 14.3)	21.3	(20.3, 22.4)	4.5	(4.0, 5.0)
	Total	19 018	100		(5.6, 6.4)	13.9*	(13.3, 14.5)	20.4†	(19.6, 21.1)	5.4*	(5.0, 5.8)	
1989–90	Age (years)											
	60+	8 626	23.1	(22.7, 23.6)	7.7	(7.0, 8.5)	18.1	(17.0, 19.2)	42.4	(41.0, 43.8)	19.7	(18.6, 20.9)
	40–59	13 630	36.6	(35.9, 37.3)	3.7	(3.3, 4.2)	14.7	(13.9, 15.6)	21.7	(20.8, 22.7)	3.9	(3.5, 4.4)
	20–39	15 009	40.3	(39.6, 41.0)	1.8	(1.5, 2.0)	4.4	(4.0, 4.8)	9.1	(8.5, 9.7)	0.5	(0.4, 0.7)
	Total	37 264	100		(3.6, 4.1)	11.3	(10.9, 11.8)	21.4	(20.9, 22.0)	6.2	(5.9, 6.6)	
2004–5	60+	4 402	23.1	(22.4, 23.9)	13.4	(12.3, 14.7)	28.9	(27.3, 30.5)	44.8	(43.0, 46.6)	17.5	(16.2, 18.9)
	40–59	6 956	36.6	(35.6, 37.5)	5.3	(4.6, 6.0)	15.3	(14.2, 16.4)	20.2	(19.0, 21.4)	3.1	(2.6, 3.7)
	20–39	7 660	40.3	(39.3, 41.3)	2.4	(1.9, 2.9)	3.9	(3.4, 4.6)	6.5	(5.8, 7.3)	0.4	(0.3, 0.7)
	Total	19 018	100		(5.6, 6.4)	13.9	(13.3, 14.5)	20.4	(19.6, 21.1)	5.4	(5.0, 5.8)	
1989–90	Income quintile											
	5th (highest)	8 490	24.4	(23.7, 25.0)	2.7	(2.3, 3.2)	12.0	(11.1, 13.0)	16.0	(14.9, 17.1)	2.8	(2.3, 3.3)
	4th	7 445	21.4	(20.8, 22.0)	2.8	(2.3, 3.3)	9.8	(8.9, 10.8)	16.5	(15.4, 17.7)	2.9	(2.4, 3.4)
	3rd	6 738	19.3	(18.8, 19.9)	3.3	(2.8, 3.9)	9.6	(8.7, 10.6)	19.0	(17.7, 20.2)	4.6	(4.0, 5.3)
	2nd	7 126	20.5	(19.9, 21.1)	6.0	(5.3, 6.8)	13.5	(12.5, 14.7)	30.8	(29.3, 32.3)	12.5	(11.5, 13.6)
	1st	5 033	14.5	(13.9, 15.0)	5.4	(4.6, 6.3)	12.0	(10.9, 13.3)	28.4	(26.7, 30.1)	10.1	(9.1, 11.3)
	Total	34 831	100		(3.6, 4.2)	11.4	(10.9, 11.9)	21.5	(20.9, 22.1)	6.2	(5.9, 6.5)	
2004–5	5th (highest)	3 891	22.8	(21.9, 23.7)	3.1	(2.4, 3.9)	11.5	(10.2, 12.9)	13.9	(12.5, 15.4)	1.6	(1.2, 2.2)
	4th	3 292	19.3	(18.5, 20.2)	3.7	(3.0, 4.7)	9.7	(8.5, 11.1)	13.4	(12.0, 15.1)	1.8	(1.3, 2.4)
	3rd	3 525	20.7	(19.8, 21.5)	5.0	(4.1, 6.0)	11.5	(10.2, 12.9)	17.7	(16.1, 19.4)	3.6	(2.9, 4.5)
	2nd	3 908	22.9	(22.1, 23.8)	10.4	(9.2, 11.6)	20.9	(19.4, 22.5)	32.4	(30.6, 34.3)	12.2	(11.0, 13.5)
	1st	2 432	14.3	(13.6, 15.0)	9.1	(7.7, 10.6)	17.0	(15.2, 19.0)	25.2	(23.1, 27.5)	8.0	(6.8, 9.5)
	Total	17 048	100		(5.7, 6.6)	14.1	(13.4, 14.8)	20.5	(19.7, 21.2)	5.4	(5.0, 5.8)	

All values were age-standardized (weighted) to the Australian population distribution according to the 2001 Census of Population and Housing. Diabetes prevalence estimates for NHS 1989–90 were adjusted by body mass index (BMI) category to account for different national diagnostic fasting plasma glucose cut-offs between surveys (detailed in methods).

\* $P < 0.001$  and † $P < 0.01$  for chi-squared test for change in prevalence over time. CVD, cardiovascular disease; CI, confidence interval.

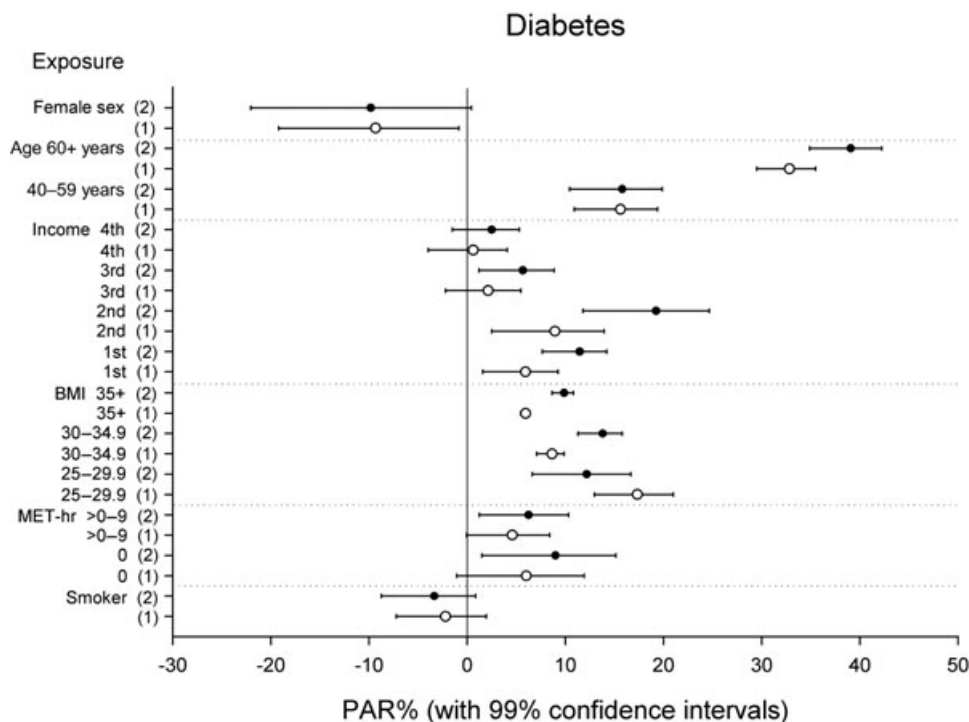
**Table 2** Prevalence of Australian adults reporting chronic diseases in National Health Surveys (NHS) 1989–90 and 2004–5, by lifestyle factors

NHS	Lifestyle factors		Diabetes		High cholesterol		High blood pressure		CVD	
	Weighted <i>n</i>	% (99% CI)	% (99% CI)	% (99% CI)	% (99% CI)	% (99% CI)	% (99% CI)	% (99% CI)	% (99% CI)	
1989-90	BMI (kg m <sup>-2</sup> )									
	35+	752	2.1 (1.9, 2.3)	13.7 (10.7, 17.3)	13.0 (10.1, 16.6)	43.1 (38.4, 47.9)	7.1 (5.0, 10.1)			
	30–34.9	2 657	7.4 (7.0, 7.8)	7.5 (6.2, 9.0)	15.9 (14.1, 17.9)	37.6 (35.1, 40.1)	7.8 (6.5, 9.3)			
	25–29.9	10 892	30.3 (29.7, 31.0)	5.0 (4.5, 5.6)	14.2 (13.4, 15.1)	26.5 (25.4, 27.6)	7.5 (6.8, 8.2)			
2004-5	<25	21 616	60.2 (59.5, 60.9)	2.5 (2.2, 2.8)	9.4 (8.9, 10.0)	15.9 (15.2, 16.5)	5.2 (4.9, 5.7)			
	Total	35 917	100	3.9 (3.6, 4.1)	11.4 (11.0, 11.9)	21.3 (20.7, 21.8)	6.2 (5.8, 6.5)			
	35+	922	5.4* (4.9, 5.9)	15.5 (12.7, 18.8)	19.0 (15.9, 22.5)	35.9 (32.0, 40.1)	6.4 (4.7, 8.6)			
	30–34.9	2 324	13.5* (12.8, 14.2)	10.4 (8.9, 12.1)	19.7 (17.7, 21.9)	32.0 (29.6, 34.5)	6.1 (5.0, 7.5)			
1989-90	25–29.9	5 997	34.9* (33.9, 35.9)	6.1 (5.4, 6.9)	16.1 (15.0, 17.4)	22.5 (21.1, 23.8)	6.2 (5.4, 7.0)			
	<25	7 946	46.2* (45.2, 47.3)	3.5 (3.1, 4.1)	10.3 (9.5, 11.2)	13.0 (12.1, 14.0)	4.2 (3.7, 4.8)			
	Total	17 190	100	6.0 (5.6, 6.5)	14.1 (13.4, 14.8)	20.1 (19.3, 20.9)	5.3 (4.9, 5.7)			
	MET-hr/week									
2004-5	9+	14 204	38.1 (37.4, 38.8)	3.3 (3.0, 3.8)	11.7 (11.0, 12.4)	20.1 (19.2, 21.0)	5.7 (5.2, 6.3)			
	>0–9	9 358	25.1 (24.5, 25.7)	3.9 (3.4, 4.4)	11.7 (10.9, 12.6)	20.9 (19.8, 22.0)	5.2 (4.7, 5.9)			
	0	13 702	36.8 (36.1, 37.5)	4.4 (3.9, 4.9)	10.7 (10.0, 11.4)	23.1 (22.0, 24.1)	7.4 (6.8, 8.0)			
	Total	37 264	100	3.8 (3.6, 4.1)	11.3 (10.9, 11.8)	21.4 (20.9, 22.0)	6.2 (5.9, 6.6)			
1989-90	9+	7 491	39.4† (38.4, 40.4)	4.5 (4.0, 5.2)	13.0 (12.1, 14.0)	18.1 (17.0, 19.2)	3.9 (3.4, 4.5)			
	>0–9	5 240	27.6* (26.7, 28.5)	5.9 (5.1, 6.8)	14.0 (12.9, 15.3)	20.3 (18.9, 21.7)	4.4 (3.7, 5.1)			
	0	6 287	33.1* (32.1, 34.0)	7.8 (7.0, 8.7)	14.8 (13.7, 15.9)	23.1 (21.8, 24.5)	7.9 (7.1, 8.8)			
	Total	19 018	100	6.0 (5.6, 6.4)	13.9 (13.3, 14.5)	20.4 (19.6, 21.1)	5.4 (5.0, 5.8)			
2004-5	Current smoker									
	No	26 994	72.4 (71.8, 73.1)	4.2 (3.9, 4.5)	12.3 (11.8, 12.9)	23.3 (22.6, 24.0)	6.9 (6.5, 7.3)			
	Yes	10 270	27.6 (26.9, 28.2)	3.0 (2.6, 3.5)	8.7 (8.0, 9.5)	16.5 (15.6, 17.5)	4.5 (3.9, 5.0)			
	Total	37 264	100.0	3.8 (3.6, 4.1)	11.3 (10.9, 11.8)	21.4 (20.9, 22.0)	6.2 (5.9, 6.6)			
2004-5	No	14 375	75.6 (74.7, 76.4)	6.6 (6.1, 7.1)	15.2 (14.5, 16.0)	22.6 (21.7, 23.5)	5.8 (5.4, 6.3)			
	Yes	4 643	24.4* (23.6, 25.3)	4.2 (3.5, 5.0)	9.8 (8.7, 10.9)	13.4 (12.2, 14.8)	3.9 (3.2, 4.6)			
	Total	19 018	100	6.0 (5.6, 6.4)	13.9 (13.3, 14.5)	20.4 (19.6, 21.1)	5.4 (5.0, 5.8)			

All values were age-standardized (weighted) to the Australian population distribution according to the 2001 Census of Population and Housing. Diabetes prevalence estimates for NHS 1989–90 were adjusted by body mass index (BMI) category to account for different national diagnostic fasting plasma glucose cut-offs between surveys (detailed in methods).

\**P* < 0.001 and †*P* < 0.01, for chi-square test for change in prevalence over time.

CVD, cardiovascular disease; CI, confidence interval; MET-hr, metabolic equivalent hours.



**Figure 1** Multiple-adjusted PAR% of diabetes because of demographic and lifestyle risk factors in the Australian population aged 20+ years for National Health Surveys (1) open circles = 1989–90 and (2) closed circles = 2004–5. Exposure is in comparison with the following reference categories: male sex, aged 20–30 years, fifth income (highest) quintile, BMI < 25 kg m<sup>-2</sup>, MET 9+, non-smoker. The PAR% estimates the proportion of disease cases that would have been theoretically prevented if there was no prior exposure to that risk factor (eradicated).

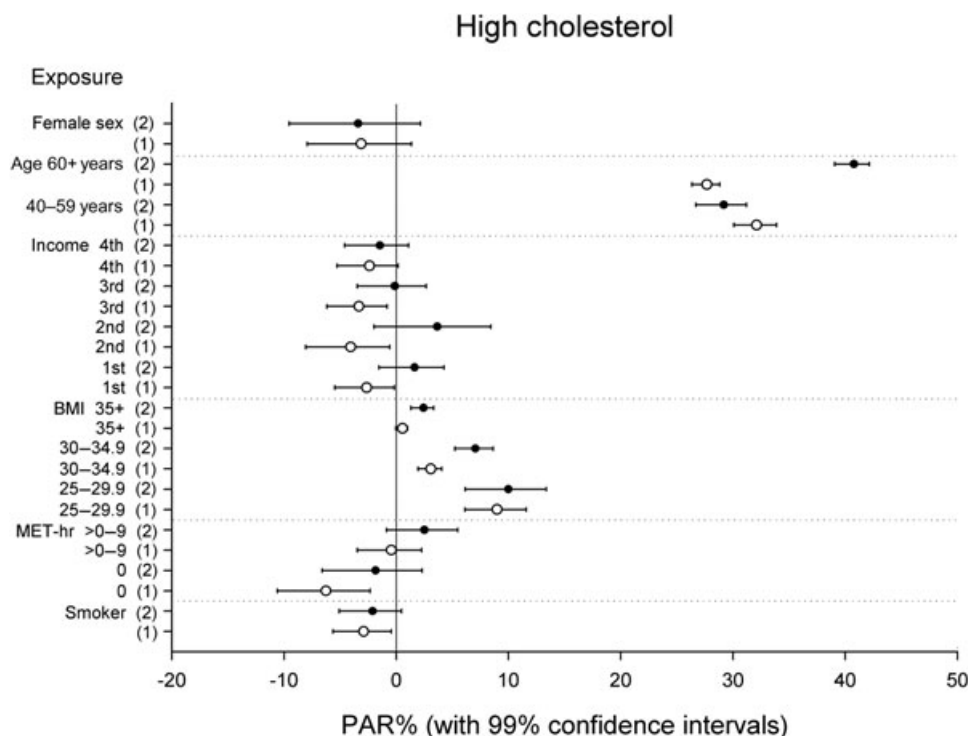
small with considerable uncertainty. Therefore, the burden of CVD increased in the past 15 years mostly for second income quintile and MET-hr/week 0 categories. A substantial proportion of CVD cases would have been theoretically prevented if adults had no prior exposure to low physical activity (PAR% ranged from 4 to 14%).

## Discussion

This report was based on two nationally representative surveys of the Australian adult population for 1989–90 and 2004–5. In the 15-year period between the surveys, the prevalence of diabetes and high cholesterol increased by 2.2 (1.6-fold) and 2.1 (1.2-fold) percentage points, and the prevalence of high blood pressure and CVD decreased by 1.0 (5%) and 0.8 (13%) percentage points. These changes are consistent with trends for most of the populations reported in the WHO MONICA Project for mid-1980s and mid-1990s (23), and closely approximate trends reported in the Australian Diabetes, Obesity and Lifestyle Study (AusDiab) for 1980 and 2000 (24). The largest increases in diabetes, high cholesterol and high blood pressure occurred among older adults. Similarly, the AusDiab reported the highest metabolic syndrome incidence (a clustering of several abovementioned chronic diseases) among adults

aged 65–74 years (25). Given that the number of Australians aged 60+ years is projected to more than double by 2031 (26), the public health implications of these trends are substantial.

Increases in the number of people with all chronic diseases were highest for those in the bottom 40% for household income distribution, independent of lifestyle factors, and are likely due to several factors including relative inequality of healthcare benefits despite Australia's universal healthcare system (27,28), as well as limited education and health literacy (29). Diets rich in nutrient-dense foods, such as those high in fibre have shown small protective effects against developing fatal/non-fatal CVD events independent of other lifestyle risk factors (30). Nutrient-dense foods are least likely to be consumed by people with socioeconomic disadvantage, who preferentially select or have access to cheaper energy-dense foods (less costly per energy unit) such as those high in fats and sugars (31). Thus, population-based interventions that focus simultaneously on improving healthcare benefits for those in the lowest income distribution, education and health literacy, particularly in relation to nutrition and chronic diseases, combined with economic policies that increase the consumption and substitutability (32) of healthy (nutrient-dense) food choices are urgently needed to enhance population health equity.

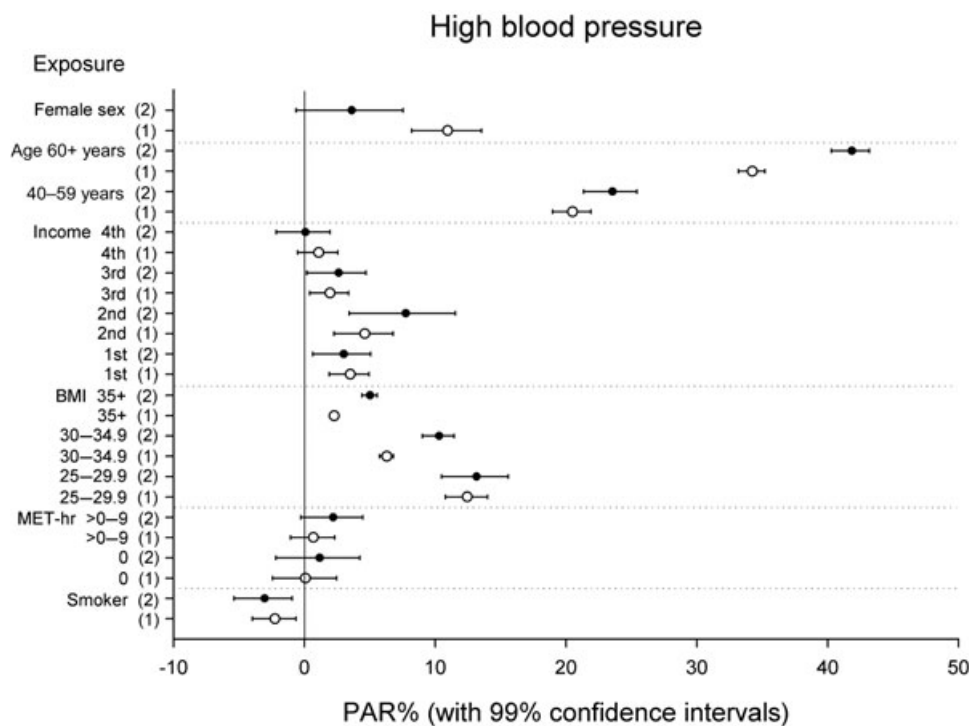


**Figure 2** Multiple-adjusted PAR% of high cholesterol because of demographic and lifestyle risk factors in the Australian population aged 20+ years for National Health Surveys (1) open circles = 1989–90 and (2) closed circles = 2004–5. Exposure is in comparison with the following reference categories: male sex, aged 20–30 years, fifth income (highest) quintile, BMI < 25 kg m<sup>-2</sup>, MET 9+, non-smoker. The PAR% estimates the proportion of disease cases that would have been theoretically prevented if there was no prior exposure to that risk factor (eradicated).

The prevalence of obesity I and obesity II+ increased by 2.9 (1.6-fold) and 3.3 (2.6-fold) percentage points, consistent with trends in the WHO MONICA Project (23) and AusDiab (24,25). Independent of demographic factors, the authors estimate that a substantial proportion of the population with diabetes, high cholesterol and high blood pressure, and a smaller proportion of the population with CVD would have been theoretically prevented if adults had no prior exposure to overweight (PAR% ranged from 9 to 17%), obesity (PAR% ranged from 1 to 14%) and physical inactivity (PAR% ranged from 6 to 14%), respectively. Increases in the number of people with diabetes, high cholesterol and high blood pressure occurred mostly for obesity I and obesity II+ categories during this 15-year period. In fact, the burden of diabetes for obesity I and obesity II+ exposures increased so dramatically that the relative burden for overweight consequentially decreased (PAR% from 17.3 to 12.2%). Although trends for physical activity were favourable, these were small and would not have sufficiently compensated for the increased energy intake during this period (33). Excess body weight was shown to be a stronger risk factor for developing chronic disease than physical inactivity and is arguably a more important intervention

target given that the number of people with a BMI 25+ was approximately double the number of people with reported physical inactivity for 2004–5. Nevertheless, the potential impact for improving population health with physical activity interventions should not be underestimated considering that the number of people with CVD increased mostly for physical inactivity, and because sufficient levels of physical activity are associated with a decreased risk of CVD independent of obesity and other lifestyle factors (6). Despite a decrease in the prevalence of physical inactivity by 3.7 (10%) percentage points, one-third of Australian adults remained physically inactive and approximately two-thirds did not meet national physical activity guidelines for 2004–5.

The decrease in CVD prevalence was partly due to the decrease in high blood pressure prevalence between surveys. The decrease in both CVD and high blood pressure prevalence was most likely due to improved health care in terms of increases in screening, detection and management of chronic diseases, particularly for diabetes and dyslipidaemia. According to Medicare (Australia's healthcare system), requests for pathology tests increased approximately 1.8-fold for glucose, total cholesterol and triglycerides from 1989–90 to 2004–5, 2.5-fold for glucose during



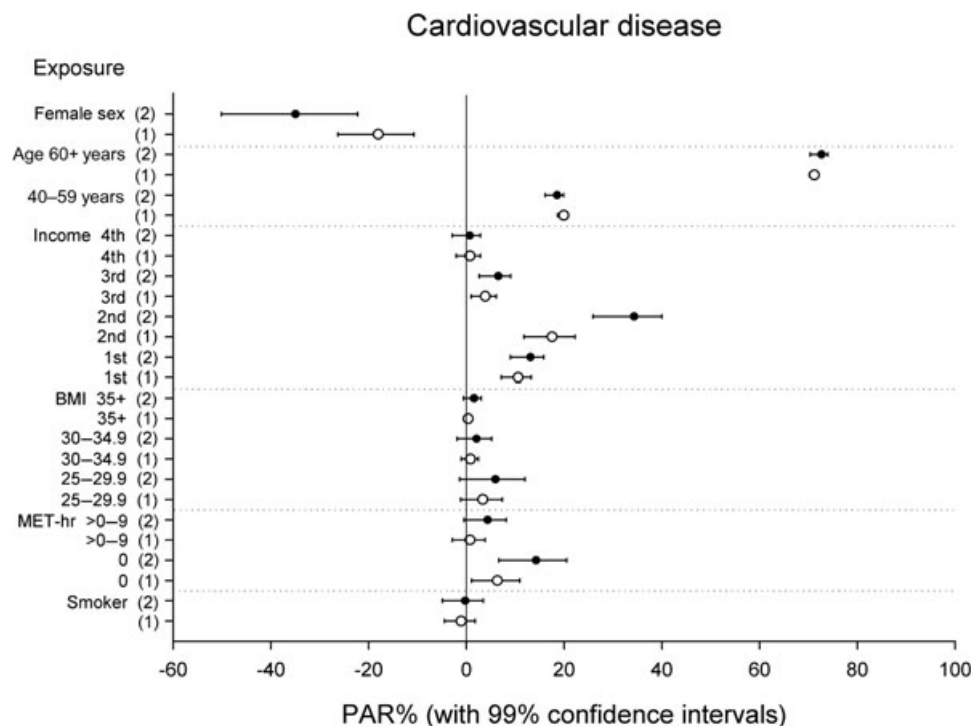
**Figure 3** Multiple-adjusted PAR% of high blood pressure because of demographic and lifestyle risk factors in the Australian population aged 20+ years for National Health Surveys (1) open circles = 1989–90 and (2) closed circles = 2004–5. Exposure is in comparison to the following reference categories: male sex, aged 20–30 years, fifth income (highest) quintile, BMI < 25 kg m<sup>-2</sup>, MET 9+, non-smoker. The PAR% estimates the proportion of disease cases that would have been theoretically prevented if there was no prior exposure to that risk factor (eradicated).

pregnancy from 1998–99 to 2004–5, 3.3-fold for glycosylated haemoglobin from 1993–4 to 2004–5, 14.9-fold for glycosylated haemoglobin during pregnancy from 1996–7 to 2004–5, and requests for oral glucose tolerance tests increased approximately 6.8-fold from 1994–5 to 2004–5 (available at: [https://www.medicareaustralia.gov.au/statistics/mbs\\_item.shtml](https://www.medicareaustralia.gov.au/statistics/mbs_item.shtml)). And according to Australia's Pharmaceutical Benefits Scheme (the list of government-subsidized dispensable medicines available at: [https://www.medicareaustralia.gov.au/statistics/pbs\\_item.shtml](https://www.medicareaustralia.gov.au/statistics/pbs_item.shtml)), requests for lipid-lowering prescriptions (statins) increased from 176 912 to 11 957 832 (68-fold) from 1992 to 2005. Similar trends have been observed for European countries, where the management of dyslipidaemia became incrementally more aggressive in terms of prescribed daily doses (34). Trends reported herein also revealed substantial increases in national healthcare dependency, many times over and above trends in chronic disease prevalence. However, more aggressive management of dyslipidaemia as well as hypertension, in terms of targets for CVD risk reduction, results in greater treatment efficacy and better clinical outcomes (35). In addition to improvements in national health care, the decreased prevalence of high blood pressure may have been partly due to small reductions in daily sodium intake during this period (36).

Smoking was consistently found to be protective against high blood pressure for 1989–90 and 2004–5 (PAR ranged from –3 to –2%), possibly because of lower body weight as risk ratios were lower and stronger (narrower CI) for unadjusted (not presented) than multiple-adjusted models, and because smokers have less per cent body fat than non-smokers (37). Nevertheless, smoking is a well-established and strong risk factor for developing CVD as well as lung disease, cancer and other chronic diseases and needs to be completely eradicated. Although the prevalence of smokers decreased by 3.2 (12%) percentage points compared with 1989–90, approximately one-quarter of Australian adults reported to be current smokers for 2004–5, indicating that much more can and should be achieved.

### Strengths and limitations

The principle strength of this report is that findings were based on two high-quality nationally representative surveys using almost identical methodologies. Information was collected by trained interviewers and both achieved high response rates (88+%). This report's principle limitation is that PAR% estimates because of risk factors were based on assumptions of causality using serial cross-sectional data. This stated, our multiple-adjusted risk ratios for prevalent



**Figure 4** Multiple-adjusted PAR% of cardiovascular disease because of demographic and lifestyle risk factors in the Australian population aged 20+ years for National Health Surveys (1) open circles = 1989–90 and (2) closed circles = 2004–5. Exposure is in comparison to the following reference categories: male sex, aged 20–30 years, fifth income (highest) quintile, BMI < 25 kg m<sup>-2</sup>, MET 9+, non-smoker. The PAR% estimates the proportion of disease cases that would have been theoretically prevented if there was no prior exposure to that risk factor (eradicated).

diabetes because of demographic, physical activity and obesity factors in 2004–5 were consistent with, and lower than those for 5-year diabetes incidence reported in AusDiab for 2004–5 (a nationally representative cohort study) (38). And several trends were consistent with both the AusDiab (24) and WHO MONICA Project (23).

Other limitations include a small responder bias, confounding because of increases in screening and detection of chronic diseases between surveys, reliance of self-report for chronic diseases and lifestyle factors, and our inability to account for other potentially important covariate factors. However, a recent report found that population prevalence estimates for chronic diseases based on NHS 2004–5 data were reliable, even though they tended to be lower for high cholesterol (hyperlipidaemia) and diabetes compared with estimates derived from an Australian national survey of the general practice patient population in 2005 (39). Although impossible to quantify, confounding because of increased screening and detection of chronic diseases between surveys was likely small because the prevalence of high blood pressure would have increased rather than decreased. The proportion of the population meeting national physical activity guidelines for health benefits was likely underestimated because information for domestic and workplace-related physical activity was not accounted for (40). Exposure to

work-related physical inactivity may in fact be more toxic for developing chronic diseases than recreational physical inactivity (41).

In conclusion, trends for and high rates of obesity, and high physical inactivity and smoking prevalence combined with population ageing argue strongly for reducing exposure to lifestyle hazards across the lifespan. This will be strategic for preventing the costly burden of chronic diseases and healthcare dependency particularly among lowest-income Australians. Modest decreases in smoking, physical inactivity, CVD and high blood pressure prevalence between surveys are noteworthy successes, however, dramatic increases in obesity and diabetes prevalence highlight our biggest failures in, and opportunities for, achieving optimal population health outcomes.

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