Comparing population attributable risks for heart disease across the adult lifespan in women

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ABSTRACT

Background Recent estimates suggest that high body mass index (BMI), smoking, high blood pressure (BP) and physical inactivity are leading risk factors for the overall burden of disease in Australia. The aim was to examine the population attributable risk (PAR) of heart disease for each of these risk factors, across the adult lifespan in Australian women.

Methods PARs were estimated using relative risks (RRs) for each of the four risk factors, as used in the Global Burden of Disease Study, and prevalence estimates from the Australian Longitudinal Study on Women's Health, in 15 age groups from 22–27 (N=9608) to 85–90 (N=3901).

Results RRs and prevalence estimates varied across the lifespan. RRs ranged from 6.15 for smoking in the younger women to 1.20 for high BMI and high BP in the older women. Prevalence of risk exposure ranged from 2% for high BP in the younger women to 79% for high BMI in mid-age women. In young adult women up to age 30, the highest population risk was attributed to smoking. From age 31 to 90, PARs were highest for physical inactivity.

Conclusions From about age 30, the population risk of heart disease attributable to inactivity outweighs that of other risk factors, including high BMI. Programmes for the promotion and maintenance of physical activity deserve to be a much higher public health priority for women than they are now, across the adult lifespan.

INTRODUCTION

The 'top 10' risk factors contributing to global disability adjusted life years (morbidity) and deaths (mortality) are shown in table 1. These estimates were based on comprehensive efforts to identify risk factor exposure (prevalence) by year, sex and age group globally, and relative risks (RRs) per unit of exposure, for 67 independent risk factors, through systematic reviews and syntheses of published and unpublished data.[1]

The burden attributable to each risk factor varies considerably across regions. For example, in Australasia, childhood undernutrition and pollution from solid fuel and particulate matter are rare, so that the 'top 10' risk factors are different from those in the global list (see table 1). Understanding the relative importance of the leading risk factors in any region is important, as burden of disease (BoD) data are often used to advocate for national and regional health promotion action.

Understanding variation in the burden attributable to each risk factor *across the lifespan* is also important, because this can help to identify the population subgroups most in need of policy action. In this paper, we use the concept of population attributable risk (PAR) to estimate the changing contributions of the four leading Australasian risk factors (high body mass index (BMI), smoking, high blood pressure (BP) and physical inactivity, see table 1) for ischaemic heart disease (IHD) across the adult lifespan in Australian women. Each of these risk factors accounts for 6–8% of the Australian BoD,[2] and together they account for 23–53% of the global burden attributable to IHD.[1] IHD (which includes all forms of heart-related disorders) is the leading cause of death in high-income countries, and the second leading cause of death in Australian women.[2 3]

METHODS

Participants

The Australian Longitudinal Study on Women's Health (ALSWH) is a prospective study of women (born in 1973–1978, 1946–1951 and 1921–1926), recruited from the national Medicare health insurance database.[4] All participants completed mailed surveys in 1996, then each cohort was surveyed once every 3 years, on a rolling basis, beginning with the middle-age cohort in 1998. At baseline, the women were largely representative of women in their age group in the Australian population.[4] More details can be found at http://www.alswh.org.au. The study was approved by the Universities of Newcastle and Queensland Research Ethics Committees and all participating women provided informed consent.

As the physical activity (PA) questions in survey 1 differed from the other surveys (and because PA is a focus of this paper), survey 2 was taken as the starting point for the current study, with data also drawn from surveys 3 to 6 for each cohort. The dates of each survey, with the corresponding ages of participants, are shown in tables 2 and 3, and the numbers of participants completing each survey are shown in table 3. Response rates varied between 72% and 99% of the numbers completing each preceding survey, and overall, from 42% in the older cohort to 86% in the mid-age cohort, between the first and last surveys. The larger loss to follow-up in the older cohort is explained by serious illness or death.[5] For all variables, data were retrieved from surveys 2 to 6 using the same methods, except where indicated.

Estimation of PARs

PAR is an epidemiological metric used to define the proportion of a disease in a defined population that would be eliminated if exposure to a specific risk factor was eliminated.[6 7]

Estimation of individual and combined PARs involved three steps.

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Table 1 Top 10 risk factors ranked by attributable burden of disease globally and in Australasia[1]

Global		Australasia	
1	High blood pressure	1	High body mass index
2	Tobacco smoking (including second hand smoke)	2	Tobacco smoking (including second hand smoke)
3	Household air pollution from solid fuels	3	High blood pressure
4	Diet low in fruits	4	Physical inactivity and low physical activity
5	Alcohol use	5	High plasma fasting glucose
6	High body mass index	6	Diet low in fruits
7	High plasma fasting glucose	7	Diet low in nuts and seeds
8	Childhood underweight	8	High total cholesterol
9	Ambient particulate matter pollution	9	Alcohol use
10	Physical inactivity and low physical activity	10	Drug use

Step 1: Extraction of RR estimates for each risk factor

RR is defined as the ratio of disease incidence rate in those exposed to each risk factor, and the disease incidence rate in the unexposed; estimates vary according to age and sex, as well as the definition used to define 'exposure'.[8]

RRs for IHD morbidity and mortality were sourced from the large database used in the global BoD study. Values were based on existing or new meta-analyses of epidemiological studies,[1] and are published as an appendix to the US BoD report.[9] Age-specific and, where possible, women-specific RRs for IHD (with 95% CIs) were extracted for physical inactivity, high BMI, smoking and high BP.

As outlined in the BoD report, for BMI, RRs were based on 'high' (>23) versus 'low' (≤23) BMI, RRs for smoking were for current smokers versus non-smokers and RRs for high BP were for high (>115 mm Hg mean BP) versus low (<115) BP. For physical inactivity, RRs were extracted for three levels of activity: none, low (1 to <600 MET-min/week) and moderate (600 to <1600 MET-min/week); relative to high (≥1600 MET-min/week).[8]

Step 2: Estimation of prevalence estimates for each of the risk factors, from the three ALSWH cohorts over 12 years

High BMI was based on BMI (kg/m^2), calculated using the women's self-reported weight and height, and categorised as: low (BMI ≤23) or high (BMI >23).[1]

Smoking status was categorised as never, ex-smoker or current smoker. Prevalence was defined as the proportion of women who were current smokers at each survey.

High BP was assessed by asking "in the past 3 years have you been diagnosed or treated for hypertension," with responses of 'yes' or 'no'. Prevalence of hypertension was defined as the proportion reporting 'yes' at each survey. Women in the mid-age and older cohorts were also asked whether they had taken medication for high BP in the past 4 weeks (survey 4 for mid-age and 3 for older cohorts). Correlations (r) between the diagnosis and medication response were 0.81 (mid-aged) and 0.85 (older).

PA was measured using a modified version of the Active Australia survey, which has acceptable measurement properties for population surveys.[10] PA scores (MET-min/week) were derived from reported time spent walking briskly (for recreation and to and from places; 3.33 METs) and in moderate (eg, golf, recreational swimming, gardening; 3.33 METs) and vigorous (eg, competitive sport, running, aerobics; 6.66 METs) leisure time activities in the last week. Scores were summed and categorised as: *none* (no PA reported); *low* (1 to <600 MET-mins/week), *moderate* (600 to <1600 MET-mins/week) or *high* (≥1600 MET-mins/week), in order to correspond with the categories used by the BoD researchers.[1]

Step 3: Calculation of PARs

Individual PARs from the RR and prevalence data obtained in steps 1 and 2 were estimated using the equation

$$\mathrm{PAR} = \mathrm{P}(\mathrm{RR} - 1)/1 + \mathrm{P}(\mathrm{RR} - 1) \quad (1)$$

where P is the prevalence of the modifiable risk factor and RR the relative risk of the outcome (IHD).[7]

For high BMI, smoking and high BP, PAR estimates were derived using the RR and prevalence estimates for each survey/age group. For physical inactivity, separate PAR estimates were produced for each of the none and low PA categories, which were then combined to provide a single overall estimate for each age group/survey. The 'indicative range' of the PAR estimates was calculated using the low and high CI values for each RR/prevalence pair, to provide an indication of the dispersion of PARs for each age group.

RESULTS

The RR estimates (and 95% CIs) for each level of risk, for each age group of women, are shown in table 2. For all four risk factors, RRs declined with age. The highest RRs were for smoking in the younger women and the lowest were for high BMI and high BP in the older women.

Prevalence estimates (and 95% CIs) for the four IHD risk factors in the younger cohort (age 22–27 to 34–39 years) are shown in table 3 (left hand panel). Although some young women quit and started again, the overall prevalence of smoking declined from 28% in 2000 to 11% in 2012. In contrast, the prevalence of most other risk factors increased over time. Notably, between the ages of 22–27 and 34–39, the proportion with high BMI increased from 46% to 66% and the proportion reporting none/low physical inactivity increased from 48% to 56%. The prevalence of high BP increased slightly, but remained below 5% at all surveys.

Prevalence estimates for the mid-age women are also shown in table 3 (centre panel). The prevalence of smoking almost halved, from 17% at age 47–52 to 9% at age 59–64. In contrast with the younger cohort, the prevalence of 'no' activity remained constant (18%), but the prevalence of 'low' activity decreased, from 35% to 28% over 12 years. The highest prevalence of any risk factor was seen in this cohort for high BMI, which increased from 71% to 79% over time, with increases also in the prevalence of high BP, from 19% to 31%.

Prevalence estimates for the older women are shown in table 3 (right hand panel). The prevalence of smoking was 5% at age 73–78 and smoking was not measured again in this cohort. The prevalence of inactivity (none/low) increased markedly over time, from 65% at age 73–78 to 81% at age 85–90. The prevalence of high BMI was lower in the older cohort than in the mid-age cohort; it declined from 68% at age 73–78 to 62% at age 85–90. The prevalence of high BP was highest in this cohort, ranging from 34% to 47% over the 12-year period.

Individual PARs (with indicative ranges based on the CIs for RR and prevalence) are shown for each survey/age group in

Table 2 Age-specific relative risks for ischaemic heart disease (IHD) for four risk factors in women (extracted from the Global Burden of Disease reports, 2012 and 2013[1 9])

Cohort	Younger					Mid-age					Older				
Survey year	**2000**	**2003**	**2006**	**2009**	**2012**	**1998**	**2001**	**2004**	**2007**	**2010**	**1999**	**2002**	**2005**	**2008**	**2011**
Age range	**22–27**	**25–30**	**28–33**	**31–36**	**34–39**	**47–52**	**50–55**	**53–58**	**56–61**	**59–64**	**73–78**	**76–81**	**79–84**	**82–87**	**85–90**
Smoking															
Never (ref)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Current	6.15	6.15	6.15	6.15	5.46	3.84	3.84	3.42	3.42	3.04	2.14	2.14	1.79	1.79	1.79
95% CI	5.06 to 7.41	5.06 to 7.41	5.06 to 7.41	5.06 to 7.41	4.56 to 6.51	3.33 to 4.42	3.33 to 4.42	3.00 to 3.88	3.00 to 3.88	2.70 to 3.41	1.97 to 2.32	1.97 to 2.32	1.69 to 1.91	1.69 to 1.91	1.69 to 1.91
Physical inactivity (MET-mins/week)															
≥1600 (high) (ref)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
600 to <1600 (moderate)	1.25	1.25	1.24	1.24	1.22	1.17	1.17	1.15	1.15	1.14	1.09	1.09	1.07	1.07	1.07
95% CI	1.11 to 1.42	1.11 to 1.42	1.10 to 1.39	1.10 to 1.39	1.10 to 1.36	1.07 to 1.28	1.07 to 1.28	1.07 to 1.25	1.07 to 1.25	1.06 to 1.23	1.04 to 1.15	1.04 to 1.15	1.03 to 1.11	1.03 to 1.11	1.03 to 1.11
>0 to <600 (low)	2.22	2.22	2.12	2.12	2.01	1.74	1.74	1.65	1.65	1.58	1.36	1.36	1.27	1.27	1.27
95% CI	1.44 to 3.35	1.44 to 3.35	1.41 to 3.11	1.41 to 3.11	1.38 to 2.89	1.29 to 2.32	1.29 to 2.32	1.26 to 2.16	1.26 to 2.16	1.23 to 2.00	1.15 to 1.61	1.15 to 1.61	1.12 to 1.44	1.12 to 1.44	1.12 to 1.44
0 (none)	2.87	2.87	2.69	2.69	2.52	2.08	2.08	1.95	1.95	1.83	1.51	1.51	1.37	1.37	1.37
95% CI	2.20 to 3.68	2.20 to 3.68	2.10 to 3.40	2.10 to 3.40	2.00 to 3.14	1.73 to 2.48	1.73 to 2.48	1.65 to 2.29	1.65 to 2.29	1.58 to 2.12	1.36 to 1.67	1.36 to 1.67	1.27 to 1.48	1.27 to 1.48	1.27 to 1.48
High body mass index															
≤23 (ref)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
>23 kg/m^2	1.85	1.85	1.78	1.78	1.71	1.53	1.53	1.48	1.48	1.42	1.27	1.27	1.20	1.20	1.20
95% CI	1.76 to 1.93	1.76 to 1.93	1.70 to 1.85	1.70 to 1.85	1.65 to 1.78	1.49 to 1.58	1.49 to 1.58	1.44 to 1.52	1.44 to 1.52	1.39 to 1.46	1.25 to 1.29	1.25 to 1.29	1.19 to 1.22	1.19 to 1.22	1.19 to 1.22
High blood pressure (mm Hg)															
<115 (ref)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
>115	1.76	1.76	1.70	1.70	1.65	1.48	1.48	1.43	1.43	1.39	1.25	1.25	1.19	1.19	1.19
95% CI	1.64 to 1.89	1.64 to 1.89	1.59 to 1.69	1.59 to 1.69	1.54 to 1.75	1.41 to 1.56	1.41 to 1.56	1.37 to 1.50	1.37 to 1.50	1.33 to 1.44	1.22 to 1.29	1.22 to 1.29	1.16 to 1.21	1.16 to 1.21	1.16 to 1.21

Table 3 Prevalence estimates (%) for each risk factor at each survey of the three Australian Longitudinal Study on Women's Health (ALSWH) cohorts (1998–2012)

	Younger					Mid-age cohort					Older (Numbers of respondents to each survey (N) are shown in italics)				
Survey year	**2000**	**2003**	**2006**	**2009**	**2012**	**1998**	**2001**	**2004**	**2007**	**2010**	**1999**	**2002**	**2005**	**2008**	**2011**
Age range	**22–27**	**25–30**	**28–33**	**31–36**	**34–39**	**47–52**	**50–55**	**53–58**	**56–61**	**59–64**	**73–78**	**76–81**	**79–84**	**82–87**	**85–90**
Smoking															
N	*9608*	*9048*	*9098*	*8182*	*7172*	11 566	11 173	10 867	10 592	*9976*	*9653*	–	–	–	–
Current (%)	28.0	24.3	19.7	14.6	11.3	17.2	14.5	13.5	11.0	8.9	4.9	–	–	–	–
95% CI	27.1 to 28.9	23.4 to 25.2	18.9 to 20.5	13.8 to 15.4	10.6 to 12.0	16.5 to 17.9	13.9 to 15.2	12.9 to 14.1	10.4 to 11.6	8.3 to 9.5	4.5 to 5.3	–	–	–	–
Physical inactivity (MET-mins/week)															
N	*9545*	*8985*	*8992*	*8048*	*6969*	11 319	11 009	10 553	10 392	*9719*	*9314*	*8392*	*6795*	*5392*	*3901*
None (%)	9.6	8.7	11.2	13.7	14.9	18.2	18.2	17.5	17.4	18.1	32.8	38.9	43.5	48.8	55.1
95% CI	9.0 to 10.2	8.1 to 9.3	10.6 to 11.7	13.0 to 14.5	14.1 to 15.7	17.5 to 18.9	17.5 to 18.9	16.8 to 18.2	16.7 to 18.1	17.3 to 18.9	31.9 to 33.8	37.4 to 39.9	42.3 to 44.7	47.5 to 50.1	53.5 to 56.7
<600 (low) (%)	38.6	39.9	41.7	42.4	41.5	35.1	39.2	31.0	28.2	28.4	32.5	30.2	28.6	28.7	26.2
95% CI	37.6 to 39.6	38.9 to 40.9	40.7 to 42.7	41.3 to 43.5	40.3 to 42.7	34.2 to 36.0	38.3 to 40.1	30.1 to 31.9	27.3 to 29.1	27.5 to 29.3	31.6 to 33.5	29.2 to 31.2	27.5 to 29.7	27.5 to 29.9	24.8 to 27.6
600 to <1600 (%)	32.4	32.3	31.3	30.1	28.5	29.4	27.7	31.6	31.4	31.4	23.0	19.4	18.5	15.1	13.2
95% CI	31.5 to 33.3	31.3 to 33.3	30.3 to 32.3	29.1 to 31.1	27.4 to 29.6	28.6 to 30.2	26.9 to 28.7	30.7 to 32.5	30.5 to 32.3	30.5 to 32.3	22.2 to 23.9	18.6 to 20.3	17.6 to 19.4	14.1 to 16.1	12.1 to 14.3
≥1600 (high) (%)	19.4	19.1	15.8	13.8	15.1	17.3	14.9	19.9	23.0	22.2	11.8	11.5	9.3	7.5	5.5
95% CI	18.6 to 20.2	18.3 to 19.9	15.1 to 16.6	13.1 to 14.6	14.3 to 15.9	16.6 to 18.0	14.2 to 15.6	19.1 to 20.7	22.2 to 23.8	21.4 to 23.0	11.1 to 12.5	10.8 to 12.2	8.6 to 10.0	6.8 to 8.2	4.8 to 6.2
Body mass index															
N	*8713*	*7983*	*8771*	*7910*	*6961*	10 811	10 479	10 253	10 347	*9748*	*9044*	*7501*	*6305*	*4611*	*3116*
>23 kg/m^2 (%)	46.1	53.1	57.6	62.3	65.6	70.6	74.7	76.9	78.9	79.2	68.1	68.4	67.3	65.9	62.4
95% CI	45.1 to 47.2	52.0 to 54.2	56.6 to 58.6	61.2 to 63.4	64.5 to 66.7	69.7 to 71.5	73.9 to 75.5	76.0 to 77.7	78.1 to 79.7	78.4 to 80.0	67.1 to 69.1	67.4 to 69.5	66.1 to 68.5	64.5 to 67.3	60.7 to 64.1
High blood pressure															
N	*9585*	*8935*	*8612*	*7569*	*7112*	12 338	11 097	10 618	10 509	*9902*	10 208	*8467*	*7072*	*5501*	*4011*
Yes (%)	2.7	2.1	2.3	4.5	4.0	19.2	18.2	20.8	28.0	30.6	33.7	47.3	43.6	41.4	40.6
95% CI	2.4 to 3.0	1.8 to 2.4	2.0 to 2.6	4.0 to 5.0	3.5 to 4.5	18.5 to 19.9	17.5 to 18.9	20.0 to 21.6	27.1 to 28.9	29.7 to 31.5	32.8 to 34.6	46.2 to 48.4	42.4 to 44.8	40.1 to 42.7	39.1 to 42.1

All estimates are derived from self-report data.
Physical activity scores (MET-min/week) were derived from reported time spent walking briskly (for recreation and to and from places) and in moderate (eg, golf, recreational swimming and gardening) and vigorous (eg, competitive sport, running and aerobics) leisure time activities.[10]

Table 4 Population attributable risk (%) (and indicative range) for four risk factors for IHD in women across the adult lifespan

	Younger					Mid-age					Older				
Survey year	**2000**	**2003**	**2006**	**2009**	**2012**	**1998**	**2001**	**2004**	**2007**	**2010**	**1999**	**2002**	**2005**	**2008**	**2011**
Age range	**22–27**	**25–30**	**28–33**	**31–36**	**34–39**	**47–52**	**50–55**	**53–58**	**56–61**	**59–64**	**73–78**	**76–81**	**79–84**	**82–87**	**85–90**
Smoking															
PAR	59	56.6	46.8	39.4	33.5	32.8	29.2	24.6	21	15.2	5.3	–	–	–	–
Indicative range	52.4–64.9	48.7–61.8	43.4–56.8	35.9–49.7	27.4–39.8	27.8–38.0	24.5–34.2	20.5–28.9	17.2–25.0	12.4–18.6	4.2–6.5	–	–	–	–
Physical inactivity															
None PAR	15.2	14.0	15.9	18.8	18.5	16.4	16.4	14.3	14.2	13.1	14.3	16.6	13.8	15.3	16.9
95% CI	9.7 to 21.4	8.9 to 20.0	10.4 to 21.9	12.5 to 25.8	12.4 to 25.1	11.3 to 21.9	11.3 to 21.9	9.8 to 21.9	9.8 to 18.9	9.1 to 17.5	10.3 to 18.5	12.0 to 21.1	10.3 to 17.7	11.4 to 19.4	12.6 to 21.4
Low PAR	32.0	32.7	31.8	32.1	29.5	20.6	22.5	16.8	15.5	14.1	10.5	9.8	7.1	7.2	6.6
Indicative range	14.2–48.2	14.6–49.0	21.9–47.4	14.5–47.5	13.3–44.7	9.0–32.2	10.0–34.6	7.3–27.0	6.6–25.2	5.9–22.7	4.5–17.0	4.2–16.0	3.4–11.6	3.4–11.6	2.9–10.8
High body mass index															
PAR	27.9	30.8	31	32.7	31.8	27.2	28.3	26.9	27.4	24.9	15.5	15.6	11.9	11.6	11.1
Indicative range	25.5–30.5	28.3–33.5	28.4–33.2	30.0–35.0	29.5–34.2	25.5–29.3	26.6–30.5	25.1–28.8	25.6–29.3	23.4–26.9	14.4–16.7	14.4–16.8	11.2–13.1	10.9–12.9	10.3–12.4
High blood pressure															
PAR	2	1.6	1.6	3.1	2.5	8.4	8	8.2	10.7	10.7	7.8	10.6	7.7	7.3	7.2
Indicative range	1.5–2.6	1.1–2.1	1.2–2.1	2.3–3.9	1.9–3.3	7.1–10.0	6.7–9.6	6.9–9.7	9.1–12.6	8.9–12.2	6.7–9.1	9.2–12.3	6.4–8.6	6.0–8.3	5.9–8.1

Indicative range derived from PAR calculated using high and low CI estimates for RR and prevalence.
Physical inactivity = none = 0 MET-mins/week; low = 1-<600 MET-min/week.
High body mass index ≥23 kg/m^2.
High blood pressure ≤115 mm Hg.
All estimates derived from self-reported prevalence data.
IHD, ischaemic heart disease; PAR, population attributable risk; RR, relative risk.

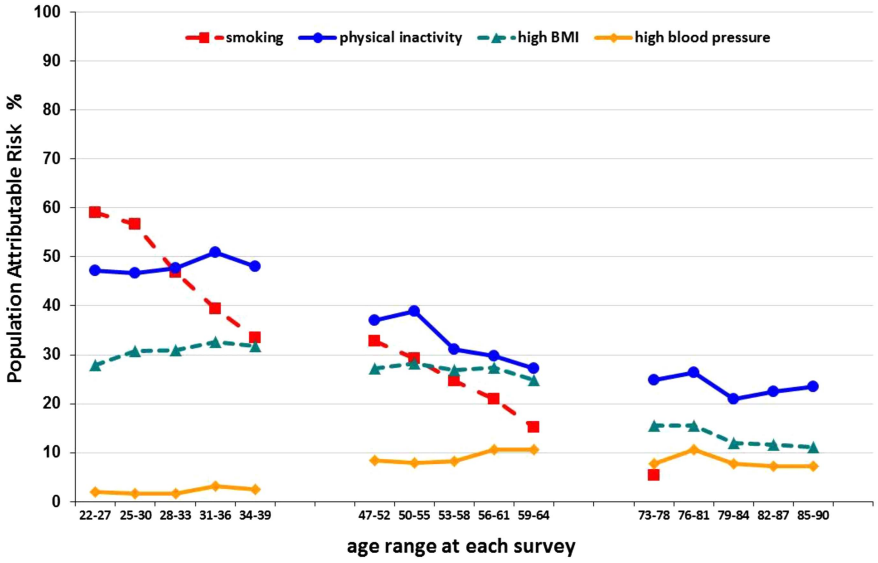

Figure 1 Population attributable risk for four risk factors for ischaemic heart disease (IHD) in women across the adult lifespan. BMI, body mass index.

table 4. The data are displayed graphically in figure 1, with a single estimate for inactivity PAR based on a combination of the none/low categories.

Smoking

The highest attributable fraction for risk of IHD was for smoking in the younger cohort at ages 22–27 and 25–30. The PAR for smoking decreased markedly across the lifespan, from 59% at age 22–27 to 5% at age 70–75.

Physical inactivity

In the younger cohort the PAR for 'no' physical inactivity remained constant across the lifespan, while the estimate for 'low' activity was lower in the older than in the young and mid-age cohorts. When these estimates were combined, overall PAR was around 48% in the young cohort, 33% in the mid-age cohort and 24% in the older cohort.

High BMI

At baseline, PAR for high BMI was similar in the younger and older cohorts. Over time there was an upward trend in the younger cohort, and a downward trend in the mid-age cohort. In the older cohort the PAR for high BMI declined with age from 15% at age 73–78 to 11% at age 85–90.

High BP

The PARs for hypertension were very low in the younger cohort (from 2% to 3% at all surveys) increasing to 7–11% in the mid-age and older cohorts.

DISCUSSION

The aim of this paper was to compare the PAR estimates for the leading four risk factors for IHD (high BMI, smoking, high BP and physical inactivity) across the adult lifespan in Australian women. To do this we used RR data from the Global BoD study[1 9] combined with prevalence estimates from the ALSWH, for women in 15 different age groups.

In contrast with the order of these factors in the BoD report (for global BoD in Australia, see table 1), we found that when using a lifespan approach, PARs for heart disease were highest for physical inactivity at every age from the early 30s to late 80s. High BMI was the third most important risk factor for IHD in young women, for whom the highest PAR was attributable to smoking.

These data highlight the fact that PARs for IHD change across the adult lifespan, and that the relative importance of individual risk factors may vary at different life stages. However, as advised by Rockhill *et al*,[6] care should be taken in interpreting these data. First, the data only apply to risks for IHD and it is acknowledged that risks, and their relative importance, may differ for other diseases. Second, as there are only 64 deaths from IHD in young Australian women each year,[11] the results do not imply that smoking *causes* more IHD in young women, but that smoking is comparatively more important at this age than the other risk factors, in terms of the fraction of IHD that could be prevented if young women did not smoke. Importantly, the risk attributable to smoking declined rapidly with age, especially as smoking prevalence declines at the life stage during which many women become mothers.[12]

From age 31–36 to 85–90, the highest proportion of IHD risk was attributable to physical inactivity. PARs for physical inactivity were highest in the younger women, and declined in the mid-aged as women they reached retirement. We have previously reported increasing levels of activity around retirement, when women appear to have more free time as children leave home and work hours are decreased.[13] This increase in activity is also implicated in a slowing of the rate of weight gain in this cohort over the 2007–2010 surveys, compared with that seen between previous surveys.[14]

The inactivity PARs suggest that if women of every age from 30 to 90 who are currently 'inactive' (ie, doing <600 MET-mins, or 150 min of moderate intensity activity per week at 4 METs) could achieve the level of theoretical minimum risk (1600 MET-mins, or about 1 h/day of moderate intensity activity); this would prevent more IHD than changes to any of the other risks examined here. Given our average PARs for inactivity of around 33% and 24% in the mid-aged and older women, and that approximately 1261 mid-aged and 9151 older women die from IHD each year,[11] our estimates suggest a reduction in IHD deaths of around 2612 per annum in these age groups. This is greater than the number of women who die in road accidents each year (370).[15]

Direct comparison of our PAR estimates with those from other studies is difficult, because others have tended to rely on RR and prevalence estimates from middle-age and young–old

samples. Our estimates for inactivity PAR are higher than those reported in a Canadian and a 'worldwide' study, which found 1.45 and 1.33 for RR, and 53% and 35% for prevalence, respectively.[16 17] The low prevalence of inactivity in the latter study may reflect the inclusion of many samples from developing countries where levels of activity tend to be higher. These values contrast with our RR estimates of 1.33 in the oldest to 2.54 in the youngest women, and our prevalence estimates of up to 81% in the oldest women.

The strengths of this study reflect the innovative use of sex-specific and age-specific RR estimates (from the results of comprehensive systematic reviews and meta-analyses conducted by the BoD researchers), and the use of age-specific prevalence estimates to assess changes in PAR across the adult life course. Prevalence data were taken from repeated surveys over 12 years, when the women were aged between 22–27 and 85–90 years. No other studies have included data from women over such a large age range.

The data have several limitations. As in all cohort studies, attrition over time has resulted in some biases towards inclusion of healthy women, so our prevalence data may be underestimates of the proportions of women at risk.[5] Another limitation is that we did not have the data or resources required to adjust our estimates for their synergistic interactions in individuals, so the combined PARs from these four risk factors explain more than 100% of the theoretical reductions in total risk of IHD. Adjustment would affect the absolute PAR estimates, but not the age-related trends, which are the focus of this paper.

Our PAR estimates reflect the BoD RR values, which are based on the thresholds used to define the theoretical minimum exposure distribution; in this case, not smoking, PA>1600 MET-mins/week, BMI <23 kg/m^2 and mean BP <115 mm Hg. These theoretical minimal risk levels affect the prevalence estimates and explain much of the current discord surrounding PARs, especially for inactivity.[18]

The RRs for physical inactivity, which ranged from 1.3 to 2.9, were based on a minimal risk category of >1600 MET-mins/week, which equates with 400 min of walking or moderate intensity activity (4 METs) per week, or about 1 h/day. This is in line with the upper limit of recent PA guidelines,[19 20] and is defensible, based on dose–response relationships between inactivity and health outcomes.[21] However, we chose to include only those women who reported 'none' or 'low' levels of physical inactivity in our exposure estimates, even though moderate levels of activity are associated with slightly increased IHD risk (RR 1.07–1.25, as shown in table 2). Inclusion of the women in the moderate PA category would have increased our PAR estimates for physical inactivity by 2–7% across cohorts.

Similarly, the RRs for high BMI were based on a minimal risk category of <23 kg/m^2, with RRs from 1.2 to 1.85. This meant that the prevalence estimates for 'high BMI' were high, with between half and three-quarters of the women categorised as 'at risk' at all ages, except at the first survey of the younger cohort. Had a higher cut point been used, as suggested in a recent meta-analysis,[22] the RR may have been higher, but the prevalence would have been lower, with little change to the PAR estimates.

For smoking we used RR values for 'current smoking' which were high for the young women, reflecting the hazards of smoking in young adulthood. Smoking history was not included in our exposure estimates, because recent data suggest that smokers who stop at about 30 years of age (as many of the younger cohort did) avoid about 97% of the excess hazard of continuing to smoke.[23]

A major limitation is that we did not have any objective measure of BP, so we relied on self-reported diagnosis of hypertension, which is likely to have resulted in low prevalence estimates, especially as the minimal risk threshold on which RRs were based was low. The PARs for high BP are therefore likely to be significantly underestimated, especially in the older women.

Conclusion

Our results illustrate the changing contribution of different risk factors to IHD at different stages of the adult lifespan in women. They show that continuing efforts to reduce smoking rates in young adult women are warranted, especially during the 20s. However, from about age 30, the PAR for inactivity outweighs that of the other leading risk factors, including high BMI, which is currently receiving much more attention in Australia than the 'Cinderella' risk factor, physical inactivity.[24] Our data suggest that national programmes for the promotion and maintenance of PA, across the adult lifespan, but especially in young adulthood, deserve to be a much higher public health priority for women than they are now.

What are the new findings?

- Population attributable risks (PAR) were used to estimate the changing contributions of high body mass index (BMI), smoking, high blood pressure (BP) and physical inactivity to ischaemic heart disease (IHD) across the adult lifespan in Australian women.
- Relative risks (RRs) for all four risk factors decline with age, while prevalence of inactivity, high BMI and high BP increase and prevalence of smoking decreases. PARs for smoking, physical inactivity and high BMI decline with age, while PAR for high BP increases.
- The highest PARs of IHD were attributable to smoking in young women aged 22–27. From about age 30, the PARs for physical inactivity were higher than those for the other risk factors, across the lifespan to age 85–90.
- These data highlight the fact that PARs may differ across the adult lifespan, and that the relative importance of individual risk factors may vary at different life stages.

How might it impact on clinical practice in the near future?

- The results emphasise the importance of continuing efforts to reduce smoking rates in young adult women, and of enhanced efforts to promote physical activity to women of all ages.

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