Lifetime risk of developing coronary heart disease in Aboriginal Australians: a cohort study

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Lifetime risk of developing coronary heart disease in Aboriginal Australians: a cohort study

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Abstract

Objectives Lifetime risk of coronary heart disease (CHD) is an important yardstick by which policy makers, clinicians and the general public can assess and promote awareness and prevention of CHD. The lifetime risk in Aboriginal people is not known. Using a cohort with up to 20 years of follow-up, we estimated the lifetime risk of CHD in Aboriginal people.

Design A cohort study.

Setting A remote Aboriginal community.

Participants 1115 Aboriginal people who were free from CHD at baseline were followed for up to 20 years.

Main Outcome Measures During the follow-up period, new CHD incident cases were identified through hospital and death records. We estimated the lifetime risks of CHD with and without adjusting for the presence of competing risk of death from non-CHD causes.

Results Participants were followed up for 17126 person years, during which 185 developed CHD and 144 died from non-CHD causes. The average age at which the first CHD event occurred was 48 years for men and 49 years for women. The risk of developing CHD increased with age until 60 years and then decreased with age. Lifetime cumulative risk without adjusting for competing risk was 70.7% for men and 63.8% for women. Adjusting for the presence of competing risk of death from non-CHD causes, the lifetime risk of CHD was 52.6% for men and 49.2% for women.

Conclusion Even after adjusting for the presence of competing risk, lifetime risk of CHD is still high in Aboriginal people, one in two in both Aboriginal men and women. Our findings may promote the awareness of CHD and efforts in health education, screening and prevention of CHD in Aboriginal people.

Article summary

Article focus

- With long-term follow-up data, we estimated the lifetime CHD risk for Aboriginal men and women with adjustment for the presence of competing risk of death from non-CHD causes.

Key Messages

- Lifetime risk is high in Aboriginal men and women, with one in two developing CHD during their lifetime.
- The average age at which the first CHD event occurs is under 50 years (48 years for men and 49 women), which is much younger than those reported in other populations (65 years in men and 70 years women in the Framingham study).
- Unlike in some other populations, the female gender is not protective against CHD in this group of Aboriginal people. Aboriginal women have a similar lifetime CHD risk as their male counterparts.

Major strengths and limitations

- Major strengths of the study include the long term follow-up and the high response rate.
- Major limitations include:

  1) Because this is a single community based study, the generalizability of the findings needs to be further assessed;

  2) As CHD events were determined based on hospital records and under-reporting was possible, the lifetime risks in this study might have underestimated the true lifetime risk of the study population.

INTRODUCTION

The lifetime risk of a condition is defined as the probability that a person who is currently free of the condition will acquire it at some time during the remainder of their life time.[1] It can be used to define risk from either birth or from a specific age. The lifetime risk estimates of coronary heart disease (CHD) [2] have been widely publicised to promote public awareness, screening and prevention of CHD disease. We have shown that Aboriginal Australians in one remote community have a higher risk of CHD than that predicted using the Framingham function.[3] They also have different levels of CHD risk factors from the general Australian population.[4] The lifetime risks of CHD in Aboriginal men and women are still not known, even though CHD incidence rates have been reported in several studies.[3 5-7] At an individual level, a person should be aware of the risk of CHD at any point in their life; similarly, at the population level, such lifetime risks are essential for public health planners to estimate the projected CHD burden with a long-term perspective in specific populations. Estimating lifetime risk requires a long term follow-up and a consideration of the competing risk of death from non-CHD causes.[2] There is a compelling need to generate estimates of lifetime risk of CHD in Aboriginal people, so that we may inform the public, clinicians and policy makers to take appropriate clinic and public health measures accordingly. In this cohort study, we estimated the lifetime risk of coronary heart disease for Aboriginal men and women originally free from CHD events at different ages.

METHODS

Participants and CHD events

Participants were recruited from a remote community in the Northern Territory of Australia from 1992 to 1995. One thousand one hundred and fifteen (1115) participants, aged 10 to 75 years and free from clinically apparent CHD at baseline, representing over 80% of those age groups in the community, were included in this study. Measurements of baseline variables were described previously.[4 8-12] All participants were followed up until 31 May 2012. During the follow-up period, new CHD events were identified through hospital records using codes of the *International classification of diseases* (*ICD 9* codes 410–414, and *ICD 10* codes I20–I25), including myocardial infarction (410, I21), angina

pectoris (411, I20) and other ischaemic heart disease (413, 414, I22, I23, I24 and I25). Deaths and their causes during the follow-up period were determined through a list of death records maintained at the community clinics. Figure 1 shows the details of follow-up of the study participants. Only the first-ever CHD incidents (fatal or non-fatal) were included in the analysis. For those participants who reached a CHD event or died from non-CHD causes during the follow-up, their follow-up time was the age of their initial screening visit to the age of the first CHD event or death. Others who survived the follow-period were censored at 31 May 2012. Hospital or death records were identified for 1010 of 1115 (91%) study participants, and those without hospital and death records were regarded as free from CHD during the follow-up period.

Statistical analysis

The data were partitioned into age bands of <20, 20-29, 30-39, 40-49, 50-59, 60-69 and 70+ years throughout the follow-up. For those whose age fell into two or more age bands during the follow-up period, their total follow-up time was subdivided and allocated into corresponding age bands as described by Clayton and Hills.[13] We calculated incidence, cumulative incidence and lifetime risk. Cumulative incidence of CHD was estimated using the Kaplan-Meir product-limit method. For calculation of lifetime risk, we used a modified technique of survival analysis and its computational technique has been described elsewhere in detail.[14 15] Briefly, the lifetime risk differs from the conventional cumulative risk estimated using the Kaplan-Meir method whenever there is a high risk of competing events. In this study, the competing evens are the deaths from non-CHD causes which would remove people from at risk of CHD. Although estimates of the theoretical cumulative risk assume that people who died of non-CHD causes would have developed CHD at the same rate as those who survived, estimates of the actual lifetime risk recognise that the risk of CHD after death is zero.[5] We adjusted for the competing risk of death from non-CHD causes and calculated risk separately for men and women at each of the index ages of 30, 40, 50, 60 and 70 years. All analyses were done with Stata 12.0.[16]

RESULTS

1115 participants were followed up for 17126 person years. During the follow-up period, 185 participants developed at least one new identifiable CHD event including 26 of them died when having the first CHD event, and 144 died from non-CHD causes. The mean age at the first CHD event was 48 for men and 49 for women. Table 1 and Table 2 show the baseline characteristics of the study participants with different endpoints. Those who developed CHD events were older at baseline, and had higher levels of body mass index, blood pressure, cholesterol, triglycerides, urine albumin to creatinine ratio and C-reactive protein than those who did not develop CHD events. They also had higher prevalences of known diabetes, low estimated glomerular filtration rate, smoking and drinking than the non-CHD group at baseline.

The incidence rate of developing CHD increased with age until 60 years and then decreased with age (Table 3). In men, the incidence rate of CHD was less than 1 per 1000 person-years for those under 30 years, increased to 5 per 1000 person-years for those 30-39 years and to 57 per 1000 person-years for 60 to 69 years, but dropped to 21 per 1000 person-years after 70 years.

Theoretical cumulative risk without adjusting for competing risk of death from non-CHD causes was 71% (95% CI: 59, 81) for men and 64% (95% CI: 52, 75) for women (Figure 2). After adjusting for the presence of competing risk of death from non-CHD causes, the lifetime risk of CHD was 53% (95% CI: 44, 61) for men and 49% (95% CI: 40, 57) for women.

We estimated the remaining lifetime risk of CHD adjusted for non-CHD deaths for those starting at 30, 40, 50, 60 and 70 years (Table 4). Since the numbers of participants aged 70 years or older were relatively small, the 95% confidence intervals were wide. As expected, the remaining lifetime risk of a first CHD decreased as age free of CHD increased, from about one in two at 30 years to one in four in men or one in five in women at 70 years (Figure 3).

DISCUSSION

Without adjusting for the competing effect of deaths of non-CHD causes, about two in three people in this cohort would theoretically suffer a CHD event in their life time. However, after adjusting for the presence of competing risk of deaths due to non-CHD causes, the actual lifetime risk of in Aboriginal people was estimated as one in two for both Aboriginal men and women.

The lifetime risk of CHD in this population was substantially lower than the theoretical cumulative risk. The conventional calculation of theoretical cumulative risk in this study was based on the assumption that people who died of non-CHD causes would have had the same rate as those who had survived, while estimates of lifetime risk or remaining lifetime risk recognised the fact that their risk of CHD after death was zero. The high competing risk of death from non-CHD causes in the study population and shorter life expectancies explain the substantially lower value in lifetime risk than that of the theoretical cumulative risk. Even so, the lifetime risks of CHD in Aboriginal people, particularly in Aboriginal women, were still higher than those of reported in some other populations.[4 5] The lifetime risk CHD estimated in the Framingham study was one in two in men and one in three in women. Few participants reached 75 years in participants of our study while a large proportion of study participants in the Framingham study reached much older age.

The average age among those having the first CHD events was much lower in these Aboriginal people than that reported in non-Aboriginal populations. It was around 50 years in Aboriginal people, which is over 15 years earlier than in American men (65 years) and 20 years earlier than in American women (70 years).[17] Unlike in some of other western populations in which female gender is protective against CHD or cardiovascular disease, Aboriginal women in this cohort had a similar lifetime risk as their male counterparts. Such a phenomenon of females having equal or higher risk has also been observed in Asian Indians.[18]

Lifetime risk and remaining lifetime risk estimates at different ages are more easily understood than incidence rates by the general public. Lifetime risks of CHD estimated in

the Framingham study have often been publicised as headline figures in the media and have increased public awareness of, and interest in, the importance and prevention of CHD.[2 19] In this study, estimates of lifetime risk of CHD have been estimated for the first time in Aboriginal people. Those estimates can be useful for promoting public interest in prevention of CHD, particularly in Aboriginal younger people and females. Our lifetime and remaining lifetime risk estimates can also be used to guide the allocation of resources to improve public health services for CHD in this population. They may improve the preventive efforts from both clinicians and the general public. For example, in other settings, it was found that providing lifetime risk improved the prescription of aspirin or lipid-lowering medication.[20]

The use of lifetime risks in clinical setting has been debated recently,[21-23] particularly for individual risk prediction. First, lifetime risks do not distinguish between immediate and remote risks, and should be used in combination with short term risk estimates such as incidence rates and ten year risks when counselling young people.[1] Second, lifetime risk levels are heavily driven by the remaining life expectancy due to the competing risk of deaths from non-CHD causes. Shorter life expectancy will result in a lower lifetime risk even though the incidence rate of CHD is high during the lifetime and at a specific time point. For example, the lifetime risk is one in two for Aboriginal men in our study is similar to the lifetime risk for non-Aboriginal men reported in the Framingham study,[2] but our estimates were mainly based on data from those participants who were under 75 years while the estimates in the Framingham study were based on data from those under 95 years. Therefore, when we compare the remaining lifetime CHD risks between two populations, their differences in life expectancy must be taken into consideration. The lifetime risk up to 50 years of age for Aboriginal people in this study is equivalent to that of non-Aboriginal people up to 70 years in men and up to 80 years in women in the Framingham study.[2]

There are several limitations of the present study. First, we obtained the follow-up data from a single remote Aboriginal community in the Northern Territory of Australia. It is possible that CHD risks are heterogeneous among different communities. It remains to be

verified if the findings are generalizable to the broader Aboriginal population in Australia. Second, our lifetime risk estimates represent average values for a specific population. Lifetime risks vary according to risk factors levels.[24-28] In Aboriginal people, factors such as the urinary albumin to creatinine ratio, C-reactive protein and obesity have been reported to be associated with coronary heart disease and mortality.[8 9 12 29] Due to a relatively small sample size, we did not calculate risk factor specific lifetime risks in this study. Further investigation is needed as we collect more data with longer follow-up. Third, the participants entered at different age points and we did not started to follow all participants from birth (Figure 1), cohort effects might have existed. The 70 year- old man today could have a different CHD risk from that of a 20 year- old man when he reaches the age of 70 years 50 years later. Finally, CHD events were determined based on routinely documented diagnosis information in hospital records during the follow-up period. Under-reporting is possible some participants with minor CHD events might not have been hospitalised or not diagnosed as such. The lifetime risks in this study might have underestimated the true lifetime risk in the study population.

In summary, even adjusting for the high competing risk of deaths from non-CHD causes, Aboriginal people still have a high lifetime risk of CHD, and one in two men and women will have CHD during their lifetime. The average age of having first CHD events was under 50 years, much younger than that reported in non-Aboriginal populations. The female gender protective against CHD observed in other populations does not exist in Aboriginal people as the risk of CHD in Aboriginal women is just as high as that in their men counterparts.

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Contributors

WH and ZW conceived the idea of the study and were responsible for the design of the study. WH provided input into the data analysis and was responsible for the acquisition of the baseline data. ZW was responsible for linking baseline and hospital data and for undertaking for the data analysis. Both WH and ZW contributed to the first draft, and read and approved the final version.

Data Sharing Statement: There is no additional data available.

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Competing interests: None

Ethical approval: The project was approved by the University of Queensland Behavioural & Social Science Ethical Review Committee (#2011001232).

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Table 1 Baseline characteristics of participants by CHD outcome: men

	Non-CHD	CHD	Deaths of non-CHD causes
Number	408	98	85
Age (years) at baseline	24.4 (10.5)	37.1 (12.4)	34.6 (16.8)
Age (years) at end*	42.8 (10.5)	47.5 (11.0)	42.4 (16.5)
BMI (kg/m^2)	21.1 (4.8)	24.6 (5.2)	21.7 (4.8)
Waist circ. (cm)	82.3 (12.7)	92.5 (14.5)	84.8 (13.1)
Systolic BP (mmHg)	120.4 (15.0)	128.0 (21.5)	128.2 (18.1)
Diastolic BP (mmHg)	71.9 (11.9)	82.2 (16.8)	79.2 (16.3)
Total cholesterol (mmol/L)	4.4 (1.1)	5.3 (1.2)	4.7 (1.3)
Triglycerides (mmol/L)	1.9 (1.4)	2.8 (1.9)	2.6 (3.3)
HDL (mmol/L)	1.11 (0.24)	1.06 (0.22)	1.13 (0.29)
Urine ACR, mg/mmol	1.4 (1.2, 1.6)	11.5 (7.5, 17.8)	4.5 (2.8, 7.1)
C-reactive protein, mg/l	2.7 (2.4, 3.1)	6.1 (4.6, 8.1)	3.9 (3.0, 5.1)
Smoking, n (%)	232 (56.9)	69 (70.4)	57 (67.1)
Drinking, n (%)	223 (54.7)	74 (75.5)	64 (75.3)
Known diabetes, n (%)	11 (2.7)	22 (22.4)	8 (9.4)
Low eGFR, n (%)	5 (1.3)	9 (9.6)	7 (8.2)

*Age at the time of the first CHD event, death of non-CHD causes or the end of study.

CHD: Coronary heart disease.

HDL: High-density lipoprotein.

ACR: Albumin to creatinine ratio.

eGFR: estimated Glomerular Filtration Rate.

Table 2 Baseline characteristics of participants by CHD outcome: women

	Non-CHD	CHD	Deaths of non-CHD causes
Number	378	87	59
Age (years) at baseline	28.1 (12.2)	41.5 (13.0)	45.3 (16.1)
Age (years) at end*	46.1 (12.0)	49.1 (11.3)	53.8 (16.3)
BMI (kg/m^2)	23.3 (6.0)	26.1 (6.0)	22.3 (6.1)
Waist circ. (cm)	88.6 (14.6)	96.8 (13.0)	89.8 (15.0)
Systolic BP (mmHg)	113.3 (16.3)	124.7 (20.5)	120.9 (22.0)
Diastolic BP (mmHg)	67.9 (12.9)	76.0 (14.1)	72.6 (15.4)
Total cholesterol (mmol/L)	4.1 (1.0)	5.0 (1.1)	4.5 (1.0)
Triglycerides (mmol/L)	1.9 (1.3)	2.7 (1.6)	2.0 (1.1)
HDL (mmol/L)	1.06 (0.25)	0.98 (0.18)	1.09 (0.26)
Urine ACR, mg/mmol	2.7 (2.2, 3.2)	19.4 (12.3, 30.4)	17.4 (10.4, 29.3)
C-reactive protein, mg/l	4.7 (4.1, 5.4)	8.3 (6.6, 10.4)	8.6 (6.3, 11.8)
Smoking, n (%)	196 (51.9)	59 (67.8)	48 (81.4)
Drinking, n (%)	93 (24.6)	25 (28.7)	22 (37.3)
Known diabetes, n (%)	19 (5.0)	25 (28.7)	10 (16.9)
Low eGFR, n (%)	4 (1.2)	11 (14.7)	12 (23.5)

*Age at the time of the first CHD event, death of non-CHD causes or the end of study.

CHD: Coronary heart disease.

HDL: High-density lipoprotein.

ACR: Albumin to creatinine ratio.

eGFR: estimated Glomerular Filtration Rate.

Table 3 Incidence rates by age and sex in Aboriginal people

Age (years)	Person-years	Number of participants	Number of CHD	Rate (/1000 pys)	95% CI
Male					
10-	985.5	184	0	0	
20-	2617.1	367	2	0.8	0.2, 3.1
30-	2782.0	444	22	7.9	5.2, 12.0
40-	1733.9	295	36	20.8	15.0, 28.8
50-	722.5	143	22	30.4	20.0, 46.2
60-	245.2	55	14	57.1	33.8, 96.4
70+	94.9	18	2	21.1	5.3, 84.3
Female					
10-	594.0	115	0	0	
20-	1855.1	255	2	1.1	0.3, 4.3
30-	2207.3	346	18	8.2	5.1, 12.9
40-	1716.6	286	28	16.3	11.3, 23.6
50-	1019.2	181	24	23.5	15.8, 35.1
60-	383.2	87	11	28.7	15.9, 51.8
70+	169.3	29	4	23.6	8.9, 63.0

Table 4 Lifetime risk of a first CHD event at different ages reached free of CHD in Aboriginal men and women

	Lifetime risk (95% CI)	
Age (years)	Men	Women
30	58% (48, 67)	50% (42, 59)
40	58% (47, 68)	48% (39, 57)
50	54% (40, 66)	40% (30, 51)
60	45% (27, 62)	31% (18, 44)
70+	27% (4, 60)	20% (6, 39)

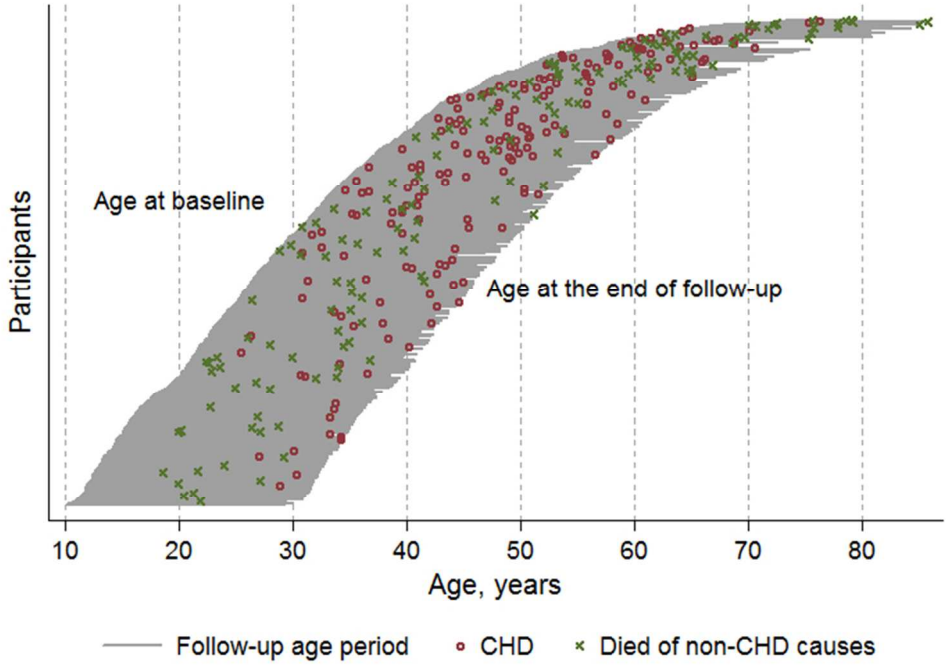

Figure 1. CHD events and deaths of non-CHD causes between baseline and the end of follow-up
60x44mm (300 x 300 DPI)

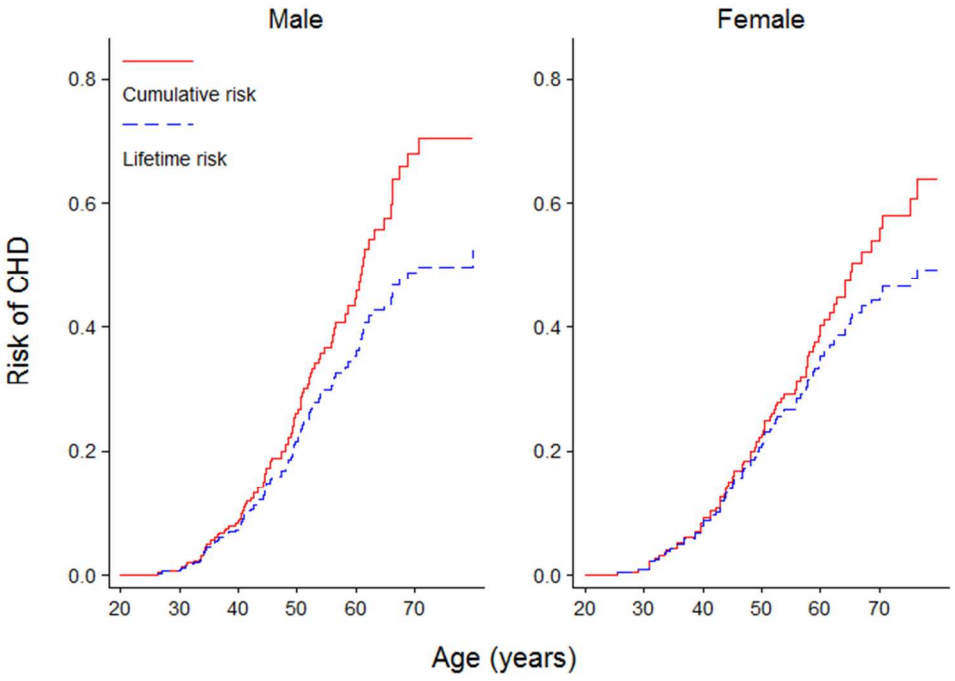

Figure 2. Lifetime risk of coronary heart disease in Aboriginal people
60x44mm (300 x 300 DPI)

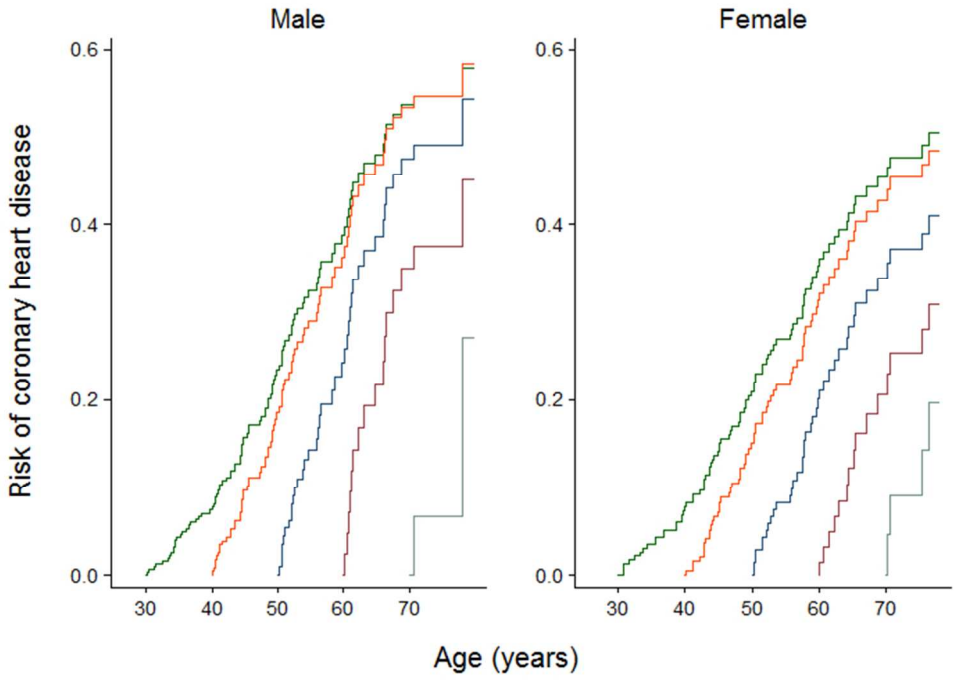

Figure 3. Lifetime risk of coronary heart disease for Aboriginal men and women for baseline ages of 30, 40, 50, 60 and 70 years reached free from coronary heart disease
60x44mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4, 5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4, 5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	4, 5
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4, 5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*4,5*
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5
		(*b*) Describe any methods used to examine subgroups and interactions	5
		(*c*) Explain how missing data were addressed	5
		(*d*) If applicable, explain how loss to follow-up was addressed	5
		(*e*) Describe any sensitivity analyses	5
Results			n/a

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6, 18, Figure 1.
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	n/a, see 18, Figure 1.
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	14, Table 1.
		(b) Indicate number of participants with missing data for each variable of interest	14, Table 1.
		(c) Summarise follow-up time (eg, average and total amount)	6.
Outcome data	15*	Report numbers of outcome events or summary measures over time	6
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	6
		(*b*) Report category boundaries when continuous variables were categorized	6
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	6
Discussion			
Key results	18	Summarise key results with reference to study objectives	7
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	7-9
Generalisability	21	Discuss the generalisability (external validity) of the study results	8,9
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	10

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Lifetime risk of developing coronary heart disease in Aboriginal Australians: a cohort study

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Lifetime risk of developing coronary heart disease in Aboriginal Australians: a cohort study

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Abstract

Objectives Lifetime risk of coronary heart disease (CHD) is an important yardstick by which policy makers, clinicians and the general public can assess and promote awareness and prevention of CHD. The lifetime risk in Aboriginal people is not known. Using a cohort with up to 20 years of follow-up, we estimated the lifetime risk of CHD in Aboriginal people.

Design A cohort study.

Setting A remote Aboriginal region.

Participants 1115 Aboriginal people from one remote tribal group who were free from CHD at baseline were followed for up to 20 years.

Main Outcome Measures During the follow-up period, new CHD incident cases were identified through hospital and death records. We estimated the lifetime risks of CHD with and without adjusting for the presence of competing risk of death from non-CHD causes.

Results Participants were followed up for 17126 person years, during which 185 developed CHD and 144 died from non-CHD causes. The average age at which the first CHD event occurred was 48 years for men and 49 years for women. The risk of developing CHD increased with age until 60 years and then decreased with age. Lifetime cumulative risk without adjusting for competing risk was 70.7% for men and 63.8% for women. Adjusting for the presence of competing risk of death from non-CHD causes, the lifetime risk of CHD was 52.6% for men and 49.2% for women.

Conclusion Lifetime risk of CHD is as high as one in two in both Aboriginal men and women. The average age of having first CHD events was under 50 years, much younger than that reported in non-Aboriginal populations. Our data provide useful knowledge for health education, screening, and prevention of CHD in Aboriginal people.

Article summary

Article focus

- With long-term follow-up data, we estimated the lifetime CHD risk for Aboriginal men and women with adjustment for the presence of competing risk of death from non-CHD causes.

Key Messages

- Lifetime risk is high in Aboriginal men and women, with one in two developing CHD during their lifetime.
- The average age at which the first CHD event occurs is under 50 years (48 years for men and 49 women), which is much younger than those reported in other populations (65 years in men and 70 years women in the Framingham study).
- Unlike in some other populations, the female gender is not protective against CHD in this group of Aboriginal people. Aboriginal women have a similar lifetime CHD risk as their male counterparts.

Major strengths and limitations

- Major strengths of the study include the long term follow-up and the high response rate.
- Major limitations include:

  1) Because this is a single region based study, the generalizability of the findings needs to be further assessed;

  2) As CHD events were determined based on hospital records and under-reporting was possible, the lifetime risks in this study might have underestimated the true lifetime risk of the study population.

INTRODUCTION

The lifetime risk of a condition is defined as the probability that a person who is currently free of the condition will acquire it at some time during the remainder of their expected life time.[1] It can be used to define risk from either birth or from a specific age. The lifetime risk estimates of coronary heart disease (CHD) [2] have been widely publicised to promote public awareness, screening and prevention of CHD disease. We have shown that Aboriginal Australians in one remote region have a higher risk of CHD than that predicted using the Framingham function.[3] They also have different levels of CHD risk factors from the general Australian population.[4] The lifetime risks of CHD in Aboriginal men and women are still not known, even though CHD incidence rates have been reported in several studies.[3 5-7] At an individual level, a person should be aware of the risk of CHD at any point in their life; similarly, at the population level, such lifetime risks are essential for public health planners to estimate the projected CHD burden with a long-term perspective in specific populations. Estimating lifetime risk requires a long term follow-up and a consideration of the competing risk of death from non-CHD causes.[2] There is a compelling need to generate estimates of lifetime risk of CHD in Aboriginal people, so that we may inform the public, clinicians and policy makers to take appropriate clinic and public health measures accordingly. Using cohort data with up to 20 years of follow-up, we estimated the lifetime risk of CHD in Aboriginal people of one tribal group living in a remote region of the Northern Territory of Australia, who have been experiencing a lifestyle transition from a hunter gathering way of life to a sedentary lifestyle. In this cohort study, we also estimated the lifetime risk of coronary heart disease for Aboriginal men and women originally free from CHD events at different ages separately.

METHODS

Participants and CHD events

Participants were recruited from a remote tribal group living in an isolated island setting in the Northern Territory of Australia from 1992 to 1995. Only people who self-identified as belonging to the group, who had two parents of the same tribal group, were included. One thousand one hundred and fifteen (1115) participants, aged 10 to 75 years and free

from clinically apparent CHD at baseline, representing over 80% of those age groups in the region, were included in this study. Measurements of baseline variables were described previously.[4 8-12] All participants were followed up until 31 May 2012. During the follow-up period, new CHD events were identified through hospital records using codes of the *International classification of diseases* (*ICD 9* codes 410–414, and *ICD 10* codes I20–I25), including myocardial infarction (410, I21), angina pectoris (411, I20) and other ischaemic heart disease (413, 414, I22, I23, I24 and I25). Deaths and their causes during the follow-up period were determined through a list of death records maintained at the community clinics. Figure 1 shows the details of follow-up of the study participants. Only the first-ever CHD incidents (fatal or non-fatal) were included in the analysis. For those participants who reached a CHD event or died from non-CHD causes during the follow-up, their follow-up time was the age of their initial screening visit to the age of the first CHD event or death. Others who survived the follow-period were censored at 31 May 2012. Because individual hospital registration numbers which we used to track study participants were unique throughout the Northern Territory, we were able to capture their hospitalisation records even if our study participants had moved outside the local region. The chance of being hospitalised outside the Northern Territory was extremely low, if any, for people in this remote isolated region. Hospital or death records were identified for 1010 of 1115 (91%) study participants, and those without hospital and death records were regarded as free from CHD during the follow-up period.

Statistical analysis

The data were partitioned into age bands of <20, 20-29, 30-39, 40-49, 50-59, 60-69 and 70+ years throughout the follow-up. For those whose age fell into two or more age bands during the follow-up period, their total follow-up time was subdivided and allocated into corresponding age bands as described by Clayton and Hills.[13] We calculated incidence, cumulative incidence and lifetime risk. Cumulative incidence of CHD was estimated using the Kaplan-Meir product-limit method. For calculation of lifetime risk, we used a modified technique of survival analysis and its computational technique has been described elsewhere in detail.[14 15] Briefly, the lifetime risk differs from the conventional cumulative risk estimated using the Kaplan-Meir method whenever there is a high risk of

competing events. In this study, the competing evens are the deaths from non-CHD causes which would remove people from at risk of CHD. Although estimates of the theoretical cumulative risk assume that people who died of non-CHD causes would have developed CHD at the same rate as those who survived, estimates of the actual lifetime risk recognise that the risk of CHD after death is zero.[5] We adjusted for the competing risk of death from non-CHD causes and calculated risk separately for men and women at each of the index ages of 30, 40, 50, 60 and 70 years. All analyses were done with Stata 12.0.[16]

RESULTS

1115 participants who were free from CHD at baseline were followed up for 17126 person years. During the follow-up period, 185 participants developed at least one CHD event, including 26 participants in whom the first CHD event was fatal. Among those who were free from CHD during the study period, 144 died from non-CHD causes. The mean age at the first CHD event was 48 for men and 49 for women. Table 1 and Table 2 show the baseline characteristics of the study participants with different endpoints. Those who developed CHD events were older at baseline, and had higher levels of body mass index, blood pressure, cholesterol, triglycerides, urine albumin to creatinine ratio and C-reactive protein than those who did not develop CHD events. They also had higher prevalences at baseline of known diabetes, low estimated glomerular filtration rate, smoking, and drinking than the non-CHD group.

The incidence rate of developing new onset CHD increased with age until 60 years and then decreased with age (Table 3). In men, the incidence rate of CHD was less than 1 per 1000 person-years for those under 30 years, increased to 5 per 1000 person-years for those 30-39 years and to 57 per 1000 person-years for 60 to 69 years, but dropped to 21 per 1000 person-years after 70 years of age.

Theoretical cumulative risk without adjusting for competing risk of death from non-CHD causes was 71% (95% CI: 59, 81) for men and 64% (95% CI: 52, 75) for women (Figure 2). After adjusting for the presence of competing risk of death from non-CHD causes, the

lifetime risk of CHD was 53% (95% CI: 44, 61) for men and 49% (95% CI: 40, 57) for women.

We estimated the remaining lifetime risk of CHD adjusted for non-CHD deaths for those starting at 30, 40, 50, 60 and 70 years (Table 4). Since the numbers of participants aged 70 years or older were relatively small, the 95% confidence intervals were wide. As expected, the remaining lifetime risk of a first CHD decreased as age free of CHD increased, from about one in two at 30 years to one in four in men or one in five in women at 70 years (Figure 3).

DISCUSSION

Without adjusting for the competing effect of deaths of non-CHD causes, about two in three people in this cohort would theoretically suffer a CHD event in their life time. However, after adjusting for the presence of competing risk of deaths due to non-CHD causes, the actual lifetime risk of in Aboriginal people was estimated as one in two for both Aboriginal men and women.

The lifetime risk of CHD in this population was substantially lower than the theoretical cumulative risk. The conventional calculation of theoretical cumulative risk in this study was based on the assumption that people who died of non-CHD causes would have had the same rate as those who had survived, while estimates of lifetime risk or remaining lifetime risk recognised the fact that their risk of CHD after death was zero. The high competing risk of death from non-CHD causes in the study population and shorter life expectancies explain the substantially lower value in lifetime risk than that of the theoretical cumulative risk. Even so, the lifetime risks of CHD in Aboriginal people, particularly in Aboriginal women, were still higher than those of reported in some other populations.[4 5] The lifetime risk CHD estimated in the Framingham study was one in two in men and one in three in women. Only a small proportion of participants reached 75 years in our study while a large proportion of study participants in the Framingham study reached much older ages.

The average age among those having the first CHD events was much lower in these Aboriginal people than that reported in non-Aboriginal populations. It was around 50 years in Aboriginal people, which is over 15 years earlier than in American men (65 years) and 20 years earlier than in American women (70 years).[17] Unlike in some of other populations in which female gender is protective against CHD or cardiovascular disease,[2 18] Aboriginal women in this cohort had a similar lifetime risk as their male counterparts. Such a phenomenon of females having equal or higher risk has also been observed in Asian Indians.[19]

Lifetime risk and remaining lifetime risk estimates at different ages are more easily understood than incidence rates by the general public. Lifetime risks of CHD estimated in the Framingham study have often been publicised as headline figures in the media and have increased public awareness of, and interest in, the importance and prevention of CHD.[2 20] In this study, the lifetime risks of CHD have been estimated for the first time in Aboriginal people. Those estimates can be useful for promoting public interest in prevention of CHD, particularly in Aboriginal younger people and females. Our lifetime and remaining lifetime risk estimates can also be used to guide the allocation of resources to improve public health services for CHD in this population. They may improve the preventive efforts from both clinicians and the general public. For example, in other settings, it was found that providing lifetime risk improved the prescription of aspirin or lipid-lowering medication.[21] It has been anticipated that the lifetime risk will be incorporated in the next generation of guidelines related to medical therapy and lifestyle interventions for cardiovascular disease since it should impact positively on conveyance of CHD risk to the public.[17] In this study, we started to provide some epidemiological evidence for developing relevant guidelines for Aboriginal people.

The use of lifetime risks in the clinical setting has been debated recently,[22-24] particularly for individual risk prediction. First, lifetime risks do not distinguish between immediate and remote risks, and should be used in combination with short term risk estimates such as incidence rates and ten year risks when counselling young people.[1] Second, lifetime risk levels are heavily driven by the remaining life expectancy due to the competing risk

of deaths from non-CHD causes. Shorter life expectancy will result in a lower lifetime risk even though the incidence rate of CHD is high during the lifetime and at a specific time point. For example, the lifetime risk is one in two for Aboriginal men in our study is similar to the lifetime risk for non-Aboriginal men reported in the Framingham study,[2] but our estimates were mainly based on data from those participants who were under 75 years while the estimates in the Framingham study were based on data from those under 95 years. Therefore, when we compare the remaining lifetime CHD risks between two populations, their differences in life expectancy must be taken into consideration. The lifetime risk up to 50 years of age for Aboriginal people in this study is equivalent to that of non-Aboriginal people up to 70 years in men and up to 80 years in women in the Framingham study.[2]

There are several limitations of the present study. First, we obtained the follow-up data from one remote tribal group in a remote Aboriginal region in the Northern Territory of Australia. It is possible that CHD risks are heterogeneous among different regions. It remains to be verified if the findings are generalizable to the broader Aboriginal population in Australia. Second, our lifetime risk estimates represent average values for a specific population. Lifetime risks vary according to risk factor levels.[18 25-28] In Aboriginal people, factors such as the urinary albumin to creatinine ratio, C-reactive protein and obesity have been reported to be associated with coronary heart disease and mortality.[8 9 12 29] Due to a relatively small sample size, we did not calculate risk factor specific lifetime risks in this study. Further investigation is needed as we collect more data with longer follow-up. Third, since the participants entered at different age points and they were not followed from birth (Figure 1), cohort effects might have existed. The 70 year- old man today could have a different CHD risk from that of a 20 year- old man when he reaches the age of 70 years 50 years later. Finally, CHD events were determined based on routinely documented diagnosis information in hospital records during the follow-up period. Under-reporting is possible as some participants with minor CHD events might not have been hospitalised or not diagnosed as such. Therefore, lifetime risks in this study might have underestimated the true lifetime risk in the study population.

In summary, even adjusting for the high competing risk of deaths from non-CHD causes, Aboriginal people still have a high lifetime risk of CHD, and one in two men and women will have CHD during their lifetime. The average age of having first CHD events was under 50 years, much younger than that reported in non-Aboriginal populations. The female gender protective against CHD observed in other populations does not exist in Aboriginal people as the risk of CHD in Aboriginal women is just as high as that in their men counterparts.

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Contributors

WH and ZW conceived the idea of the study and were responsible for the design of the study. WH provided input into the data analysis and was responsible for the acquisition of the baseline data. ZW was responsible for linking baseline and hospital data and for undertaking for the data analysis. Both WH and ZW contributed to the first draft, and read and approved the final version.

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Competing interests: None

Ethical approval: The project was approved by the University of Queensland Behavioural & Social Science Ethical Review Committee (#2011001232).

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Table 1 Baseline characteristics of participants by CHD outcome: men

	Non-CHD	CHD	Deaths of non-CHD causes
Number	408	98	85
Age (years) at baseline	24.4 (10.5)	37.1 (12.4)	34.6 (16.8)
Age (years) at end*	42.8 (10.5)	47.5 (11.0)	42.4 (16.5)
BMI (kg/m^2)	21.1 (4.8)	24.6 (5.2)	21.7 (4.8)
Waist circ. (cm)	82.3 (12.7)	92.5 (14.5)	84.8 (13.1)
Systolic BP (mmHg)	120.4 (15.0)	128.0 (21.5)	128.2 (18.1)
Diastolic BP (mmHg)	71.9 (11.9)	82.2 (16.8)	79.2 (16.3)
Total cholesterol (mmol/L)	4.4 (1.1)	5.3 (1.2)	4.7 (1.3)
Triglycerides (mmol/L)	1.9 (1.4)	2.8 (1.9)	2.6 (3.3)
HDL (mmol/L)	1.11 (0.24)	1.06 (0.22)	1.13 (0.29)
Urine ACR, mg/mmol	1.4 (1.2, 1.6)	11.5 (7.5, 17.8)	4.5 (2.8, 7.1)
C-reactive protein, mg/l	2.7 (2.4, 3.1)	6.1 (4.6, 8.1)	3.9 (3.0, 5.1)
Smoking, n (%)	232 (56.9)	69 (70.4)	57 (67.1)
Drinking, n (%)	223 (54.7)	74 (75.5)	64 (75.3)
Known diabetes, n (%)	11 (2.7)	22 (22.4)	8 (9.4)
Low eGFR, n (%)	5 (1.3)	9 (9.6)	7 (8.2)

*Age at the time of the first CHD event, death of non-CHD causes or the end of study.

CHD: Coronary heart disease.

HDL: High-density lipoprotein.

ACR: Albumin to creatinine ratio.

eGFR: estimated Glomerular Filtration Rate.

Table 2 Baseline characteristics of participants by CHD outcome: women

	Non-CHD	CHD	Deaths of non-CHD causes
Number	378	87	59
Age (years) at baseline	28.1 (12.2)	41.5 (13.0)	45.3 (16.1)
Age (years) at end*	46.1 (12.0)	49.1 (11.3)	53.8 (16.3)
BMI (kg/m^2)	23.3 (6.0)	26.1 (6.0)	22.3 (6.1)
Waist circ. (cm)	88.6 (14.6)	96.8 (13.0)	89.8 (15.0)
Systolic BP (mmHg)	113.3 (16.3)	124.7 (20.5)	120.9 (22.0)
Diastolic BP (mmHg)	67.9 (12.9)	76.0 (14.1)	72.6 (15.4)
Total cholesterol (mmol/L)	4.1 (1.0)	5.0 (1.1)	4.5 (1.0)
Triglycerides (mmol/L)	1.9 (1.3)	2.7 (1.6)	2.0 (1.1)
HDL (mmol/L)	1.06 (0.25)	0.98 (0.18)	1.09 (0.26)
Urine ACR, mg/mmol	2.7 (2.2, 3.2)	19.4 (12.3, 30.4)	17.4 (10.4, 29.3)
C-reactive protein, mg/l	4.7 (4.1, 5.4)	8.3 (6.6, 10.4)	8.6 (6.3, 11.8)
Smoking, n (%)	196 (51.9)	59 (67.8)	48 (81.4)
Drinking, n (%)	93 (24.6)	25 (28.7)	22 (37.3)
Known diabetes, n (%)	19 (5.0)	25 (28.7)	10 (16.9)
Low eGFR, n (%)	4 (1.2)	11 (14.7)	12 (23.5)

*Age at the time of the first CHD event, death of non-CHD causes or the end of study.

CHD: Coronary heart disease.

HDL: High-density lipoprotein.

ACR: Albumin to creatinine ratio.

eGFR: estimated Glomerular Filtration Rate.

Table 3 Incidence rates by age and sex in Aboriginal people

Age (years)	Person-years	Number of participants	Number of CHD	Rate (/1000 pys)	95% CI
Male					
10-	985.5	184	0	0	
20-	2617.1	367	2	0.8	0.2, 3.1
30-	2782.0	444	22	7.9	5.2, 12.0
40-	1733.9	295	36	20.8	15.0, 28.8
50-	722.5	143	22	30.4	20.0, 46.2
60-	245.2	55	14	57.1	33.8, 96.4
70+	94.9	18	2	21.1	5.3, 84.3
Female					
10-	594.0	115	0	0	
20-	1855.1	255	2	1.1	0.3, 4.3
30-	2207.3	346	18	8.2	5.1, 12.9
40-	1716.6	286	28	16.3	11.3, 23.6
50-	1019.2	181	24	23.5	15.8, 35.1
60-	383.2	87	11	28.7	15.9, 51.8
70+	169.3	29	4	23.6	8.9, 63.0

Table 4 Lifetime risk of a first CHD event at different ages reached free of CHD in Aboriginal men and women

	Lifetime risk (95% CI)	
Age (years)	Men	Women
30	58% (48, 67)	50% (42, 59)
40	58% (47, 68)	48% (39, 57)
50	54% (40, 66)	40% (30, 51)
60	45% (27, 62)	31% (18, 44)
70+	27% (4, 60)	20% (6, 39)

Lifetime risk of developing coronary heart disease in Aboriginal Australians: a cohort study

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Abstract

Objectives Lifetime risk of coronary heart disease (CHD) is an important yardstick by which policy makers, clinicians and the general public can assess and promote awareness and prevention of CHD. The lifetime risk in Aboriginal people is not known. Using a cohort with up to 20 years of follow-up, we estimated the lifetime risk of CHD in Aboriginal people.

Design A cohort study.

Setting A remote Aboriginal ~~community~~region.

Participants 1115 Aboriginal people from one remote tribal group who were free from CHD at baseline were followed for up to 20 years.

Main Outcome Measures During the follow-up period, new CHD incident cases were identified through hospital and death records. We estimated the lifetime risks of CHD with and without adjusting for the presence of competing risk of death from non-CHD causes.

Results Participants were followed up for 17126 person years, during which 185 developed CHD and 144 died from non-CHD causes. The average age at which the first CHD event occurred was 48 years for men and 49 years for women. The risk of developing CHD increased with age until 60 years and then decreased with age. Lifetime cumulative risk without adjusting for competing risk was 70.7% for men and 63.8% for women. Adjusting for the presence of competing risk of death from non-CHD causes, the lifetime risk of CHD was 52.6% for men and 49.2% for women.

Conclusion ~~Even after adjusting for the presence of competing risk, l~~Lifetime risk of CHD ~~is still high in Aboriginal people~~is as high as~~,~~ one in two in both Aboriginal men and women. The average age of having first CHD events was under 50 years, much younger than that reported in non-Aboriginal populations. Our data provide useful knowledge for health education, screening, and prevention of CHD in Aboriginal people. ~~Our findings may promote the awareness of CHD and efforts in health education, screening and prevention of CHD in Aboriginal people.~~

Article summary

Article focus

- With long-term follow-up data, we estimated the lifetime CHD risk for Aboriginal men and women with adjustment for the presence of competing risk of death from non-CHD causes.

Key Messages

- Lifetime risk is high in Aboriginal men and women, with one in two developing CHD during their lifetime.
- The average age at which the first CHD event occurs is under 50 years (48 years for men and 49 women), which is much younger than those reported in other populations (65 years in men and 70 years women in the Framingham study).
- Unlike in some other populations, the female gender is not protective against CHD in this group of Aboriginal people. Aboriginal women have a similar lifetime CHD risk as their male counterparts.

Major strengths and limitations

- Major strengths of the study include the long term follow-up and the high response rate.
- Major limitations include:

  1) Because this is a single region~~community~~ based study, the generalizability of the findings needs to be further assessed;

  2) As CHD events were determined based on hospital records and under-reporting was possible, the lifetime risks in this study might have underestimated the true lifetime risk of the study population.

INTRODUCTION

The lifetime risk of a condition is defined as the probability that a person who is currently free of the condition will acquire it at some time during the remainder of their expected life time.[1] It can be used to define risk from either birth or from a specific age. The lifetime risk estimates of coronary heart disease (CHD) [2] have been widely publicised to promote public awareness, screening and prevention of CHD disease. We have shown that Aboriginal Australians in one remote ~~community~~region have a higher risk of CHD than that predicted using the Framingham function.[3] They also have different levels of CHD risk factors from the general Australian population.[4] The lifetime risks of CHD in Aboriginal men and women are still not known, even though CHD incidence rates have been reported in several studies.[3 5-7] At an individual level, a person should be aware of the risk of CHD at any point in their life; similarly, at the population level, such lifetime risks are essential for public health planners to estimate the projected CHD burden with a long-term perspective in specific populations. Estimating lifetime risk requires a long term follow-up and a consideration of the competing risk of death from non-CHD causes.[2] There is a compelling need to generate estimates of lifetime risk of CHD in Aboriginal people, so that we may inform the public, clinicians and policy makers to take appropriate clinic and public health measures accordingly. Using cohort data with up to 20 years of follow-up, we estimated the lifetime risk of CHD in Aboriginal people of one tribal group living in a remote region of the Northern Territory of Australia, who have been experiencing a lifestyle transition from a hunter gathering way of life to a sedentary lifestyle. In this cohort study, we also estimated the lifetime risk of coronary heart disease for Aboriginal men and women originally free from CHD events at different ages separately.

METHODS

Participants and CHD events

Participants were recruited from a remote tribal group living in an isolated island setting~~community~~ in the Northern Territory of Australia from 1992 to 1995. Only people who self-identified as belonging to the group, who had two parents of the same tribal group, were included. One thousand one hundred and fifteen (1115) participants, aged 10

to 75 years and free from clinically apparent CHD at baseline, representing over 80% of those age groups in the ~~community~~region, were included in this study. Measurements of baseline variables were described previously.[4 8-12] All participants were followed up until 31 May 2012. During the follow-up period, new CHD events were identified through hospital records using codes of the *International classification of diseases* (*ICD 9* codes 410–414, and *ICD 10* codes I20–I25), including myocardial infarction (410, I21), angina pectoris (411, I20) and other ischaemic heart disease (413, 414, I22, I23, I24 and I25). Deaths and their causes during the follow-up period were determined through a list of death records maintained at the community clinics. Figure 1 shows the details of follow-up of the study participants. Only the first-ever CHD incidents (fatal or non-fatal) were included in the analysis. For those participants who reached a CHD event or died from non-CHD causes during the follow-up, their follow-up time was the age of their initial screening visit to the age of the first CHD event or death. Others who survived the follow-period were censored at 31 May 2012. Because individual hospital registration numbers which we used to track study participants were unique throughout the Northern Territory, we were able to capture their hospitalisation records even if our study participants had moved outside the local region. The chance of being hospitalised outside the Northern Territory was extremely low, if any, for people in this remote isolated region. Hospital or death records were identified for 1010 of 1115 (91%) study participants, and those without hospital and death records were regarded as free from CHD during the follow-up period.

Statistical analysis

The data were partitioned into age bands of <20, 20-29, 30-39, 40-49, 50-59, 60-69 and 70+ years throughout the follow-up. For those whose age fell into two or more age bands during the follow-up period, their total follow-up time was subdivided and allocated into corresponding age bands as described by Clayton and Hills.[13] We calculated incidence, cumulative incidence and lifetime risk. Cumulative incidence of CHD was estimated using the Kaplan-Meir product-limit method. For calculation of lifetime risk, we used a modified technique of survival analysis and its computational technique has been described elsewhere in detail.[14 15] Briefly, the lifetime risk differs from the conventional

cumulative risk estimated using the Kaplan-Meir method whenever there is a high risk of competing events. In this study, the competing evens are the deaths from non-CHD causes which would remove people from at risk of CHD. Although estimates of the theoretical cumulative risk assume that people who died of non-CHD causes would have developed CHD at the same rate as those who survived, estimates of the actual lifetime risk recognise that the risk of CHD after death is zero.[5] We adjusted for the competing risk of death from non-CHD causes and calculated risk separately for men and women at each of the index ages of 30, 40, 50, 60 and 70 years. All analyses were done with Stata 12.0.[16]

RESULTS

1115 participants who were free from CHD at baseline were followed up for 17126 person years. During the follow-up period, 185 participants developed at least one ~~new identifiable~~ CHD event, including 26 participants in whom the first CHD event was fatal. Among those who were free from CHD during the study period, ~~of them died when having the first CHD event, and~~ 144 died from non-CHD causes. The mean age at the first CHD event was 48 for men and 49 for women. Table 1 and Table 2 show the baseline characteristics of the study participants with different endpoints. Those who developed CHD events were older at baseline, and had higher levels of body mass index, blood pressure, cholesterol, triglycerides, urine albumin to creatinine ratio and C-reactive protein than those who did not develop CHD events. They also had higher prevalences at baseline of known diabetes, low estimated glomerular filtration rate, smoking, and drinking than the non-CHD group ~~at baseline~~.

The incidence rate of developing new onset CHD increased with age until 60 years and then decreased with age (Table 3). In men, the incidence rate of CHD was less than 1 per 1000 person-years for those under 30 years, increased to 5 per 1000 person-years for those 30-39 years and to 57 per 1000 person-years for 60 to 69 years, but dropped to 21 per 1000 person-years after 70 years of age.

Theoretical cumulative risk without adjusting for competing risk of death from non-CHD causes was 71% (95% CI: 59, 81) for men and 64% (95% CI: 52, 75) for women (Figure 2). After adjusting for the presence of competing risk of death from non-CHD causes, the lifetime risk of CHD was 53% (95% CI: 44, 61) for men and 49% (95% CI: 40, 57) for women.

We estimated the remaining lifetime risk of CHD adjusted for non-CHD deaths for those starting at 30, 40, 50, 60 and 70 years (Table 4). Since the numbers of participants aged 70 years or older were relatively small, the 95% confidence intervals were wide. As expected, the remaining lifetime risk of a first CHD decreased as age free of CHD increased, from about one in two at 30 years to one in four in men or one in five in women at 70 years (Figure 3).

DISCUSSION

Without adjusting for the competing effect of deaths of non-CHD causes, about two in three people in this cohort would theoretically suffer a CHD event in their life time. However, after adjusting for the presence of competing risk of deaths due to non-CHD causes, the actual lifetime risk of in Aboriginal people was estimated as one in two for both Aboriginal men and women.

The lifetime risk of CHD in this population was substantially lower than the theoretical cumulative risk. The conventional calculation of theoretical cumulative risk in this study was based on the assumption that people who died of non-CHD causes would have had the same rate as those who had survived, while estimates of lifetime risk or remaining lifetime risk recognised the fact that their risk of CHD after death was zero. The high competing risk of death from non-CHD causes in the study population and shorter life expectancies explain the substantially lower value in lifetime risk than that of the theoretical cumulative risk. Even so, the lifetime risks of CHD in Aboriginal people, particularly in Aboriginal women, were still higher than those of reported in some other populations.[4 5] The lifetime risk CHD estimated in the Framingham study was one in two in men and one in three in women. Only a small proportion ~~Few~~of participants reached

75 years in ~~participants of~~ our study while a large proportion of study participants in the Framingham study reached much older ages.

The average age among those having the first CHD events was much lower in these Aboriginal people than that reported in non-Aboriginal populations. It was around 50 years in Aboriginal people, which is over 15 years earlier than in American men (65 years) and 20 years earlier than in American women (70 years).[17] Unlike in some of other ~~western~~ populations in which female gender is protective against CHD or cardiovascular disease,[2 18] Aboriginal women in this cohort had a similar lifetime risk as their male counterparts. Such a phenomenon of females having equal or higher risk has also been observed in Asian Indians.[19]

Lifetime risk and remaining lifetime risk estimates at different ages are more easily understood than incidence rates by the general public. Lifetime risks of CHD estimated in the Framingham study have often been publicised as headline figures in the media and have increased public awareness of, and interest in, the importance and prevention of CHD.[2 20] In this study, the ~~estimates of~~ lifetime risks of CHD have been estimated for the first time in Aboriginal people. Those estimates can be useful for promoting public interest in prevention of CHD, particularly in Aboriginal younger people and females. Our lifetime and remaining lifetime risk estimates can also be used to guide the allocation of resources to improve public health services for CHD in this population. They may improve the preventive efforts from both clinicians and the general public. For example, in other settings, it was found that providing lifetime risk improved the prescription of aspirin or lipid-lowering medication.[21] It has been anticipated that the lifetime risk will be incorporated in the next generation of guidelines related to medical therapy and lifestyle interventions for cardiovascular disease since it should impact positively on conveyance of CHD risk to the public.[17] In this study, we started to provide some epidemiological evidence for developing relevant guidelines for Aboriginal people.

The use of lifetime risks in the clinical setting has been debated recently,[22-24] particularly for individual risk prediction. First, lifetime risks do not distinguish between immediate

and remote risks, and should be used in combination with short term risk estimates such as incidence rates and ten year risks when counselling young people.[1] Second, lifetime risk levels are heavily driven by the remaining life expectancy due to the competing risk of deaths from non-CHD causes. Shorter life expectancy will result in a lower lifetime risk even though the incidence rate of CHD is high during the lifetime and at a specific time point. For example, the lifetime risk is one in two for Aboriginal men in our study is similar to the lifetime risk for non-Aboriginal men reported in the Framingham study,[2] but our estimates were mainly based on data from those participants who were under 75 years while the estimates in the Framingham study were based on data from those under 95 years. Therefore, when we compare the remaining lifetime CHD risks between two populations, their differences in life expectancy must be taken into consideration. The lifetime risk up to 50 years of age for Aboriginal people in this study is equivalent to that of non-Aboriginal people up to 70 years in men and up to 80 years in women in the Framingham study.[2]

There are several limitations of the present study. First, we obtained the follow-up data from ~~a~~ one remote tribal group in a ~~single~~ remote Aboriginal ~~community~~region in the Northern Territory of Australia. It is possible that CHD risks are heterogeneous among different ~~communities~~regions. It remains to be verified if the findings are generalizable to the broader Aboriginal population in Australia. Second, our lifetime risk estimates represent average values for a specific population. Lifetime risks vary according to risk factor~~s~~ levels.[18 25-28] In Aboriginal people, factors such as the urinary albumin to creatinine ratio, C-reactive protein and obesity have been reported to be associated with coronary heart disease and mortality.[8 9 12 29] Due to a relatively small sample size, we did not calculate risk factor specific lifetime risks in this study. Further investigation is needed as we collect more data with longer follow-up. Third, since the participants entered at different age points and ~~we did not started to follow all participants~~they were not followed from birth (Figure 1), cohort effects might have existed. The 70 year- old man today could have a different CHD risk from that of a 20 year- old man when he reaches the age of 70 years 50 years later. Finally, CHD events were determined based on routinely documented diagnosis information in hospital records during the follow-up

period. Under-reporting is possible as some participants with minor CHD events might not have been hospitalised or not diagnosed as such. Therefore, lifetime risks in this study might have underestimated the true lifetime risk in the study population.

In summary, even adjusting for the high competing risk of deaths from non-CHD causes, Aboriginal people still have a high lifetime risk of CHD, and one in two men and women will have CHD during their lifetime. The average age of having first CHD events was under 50 years, much younger than that reported in non-Aboriginal populations. The female gender protective against CHD observed in other populations does not exist in Aboriginal people as the risk of CHD in Aboriginal women is just as high as that in their men counterparts.

ACKNOWLEDGEMENTS

We especially thank the Aboriginal people who participated in this study. The baseline data were collected by the renal research team led by WH at the Menzies School of Health Research, Darwin, Australia. Shuqin Li at the Northern Territory Department of Health assisted in the interpretation of hospital data ~~collection~~.

Contributors

WH and ZW conceived the idea of the study and were responsible for the design of the study. WH provided input into the data analysis and was responsible for the acquisition of the baseline data. ZW was responsible for linking baseline and hospital data and for undertaking for the data analysis. Both WH and ZW contributed to the first draft, and read and approved the final version.

Data Sharing Statement: There is no additional data available.

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Competing interests: None

Ethical approval: The project was approved by the University of Queensland Behavioural & Social Science Ethical Review Committee (#2011001232).

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Table 1 Baseline characteristics of participants by CHD outcome: men

	Non-CHD	CHD	Deaths of non-CHD causes
Number	408	98	85
Age (years) at baseline	24.4 (10.5)	37.1 (12.4)	34.6 (16.8)
Age (years) at end*	42.8 (10.5)	47.5 (11.0)	42.4 (16.5)
BMI (kg/m^2)	21.1 (4.8)	24.6 (5.2)	21.7 (4.8)
Waist circ. (cm)	82.3 (12.7)	92.5 (14.5)	84.8 (13.1)
Systolic BP (mmHg)	120.4 (15.0)	128.0 (21.5)	128.2 (18.1)
Diastolic BP (mmHg)	71.9 (11.9)	82.2 (16.8)	79.2 (16.3)
Total cholesterol (mmol/L)	4.4 (1.1)	5.3 (1.2)	4.7 (1.3)
Triglycerides (mmol/L)	1.9 (1.4)	2.8 (1.9)	2.6 (3.3)
HDL (mmol/L)	1.11 (0.24)	1.06 (0.22)	1.13 (0.29)
Urine ACR, mg/mmol	1.4 (1.2, 1.6)	11.5 (7.5, 17.8)	4.5 (2.8, 7.1)
C-reactive protein, mg/l	2.7 (2.4, 3.1)	6.1 (4.6, 8.1)	3.9 (3.0, 5.1)
Smoking, n (%)	232 (56.9)	69 (70.4)	57 (67.1)
Drinking, n (%)	223 (54.7)	74 (75.5)	64 (75.3)
Known diabetes, n (%)	11 (2.7)	22 (22.4)	8 (9.4)
Low eGFR, n (%)	5 (1.3)	9 (9.6)	7 (8.2)

*Age at the time of the first CHD event, death of non-CHD causes or the end of study.

CHD: Coronary heart disease.

HDL: High-density lipoprotein.

ACR: Albumin to creatinine ratio.

eGFR: estimated Glomerular Filtration Rate.

Table 2 Baseline characteristics of participants by CHD outcome: women

	Non-CHD	CHD	Deaths of non-CHD causes
Number	378	87	59
Age (years) at baseline	28.1 (12.2)	41.5 (13.0)	45.3 (16.1)
Age (years) at end*	46.1 (12.0)	49.1 (11.3)	53.8 (16.3)
BMI (kg/m^2)	23.3 (6.0)	26.1 (6.0)	22.3 (6.1)
Waist circ. (cm)	88.6 (14.6)	96.8 (13.0)	89.8 (15.0)
Systolic BP (mmHg)	113.3 (16.3)	124.7 (20.5)	120.9 (22.0)
Diastolic BP (mmHg)	67.9 (12.9)	76.0 (14.1)	72.6 (15.4)
Total cholesterol (mmol/L)	4.1 (1.0)	5.0 (1.1)	4.5 (1.0)
Triglycerides (mmol/L)	1.9 (1.3)	2.7 (1.6)	2.0 (1.1)
HDL (mmol/L)	1.06 (0.25)	0.98 (0.18)	1.09 (0.26)
Urine ACR, mg/mmol	2.7 (2.2, 3.2)	19.4 (12.3, 30.4)	17.4 (10.4, 29.3)
C-reactive protein, mg/l	4.7 (4.1, 5.4)	8.3 (6.6, 10.4)	8.6 (6.3, 11.8)
Smoking, n (%)	196 (51.9)	59 (67.8)	48 (81.4)
Drinking, n (%)	93 (24.6)	25 (28.7)	22 (37.3)
Known diabetes, n (%)	19 (5.0)	25 (28.7)	10 (16.9)
Low eGFR, n (%)	4 (1.2)	11 (14.7)	12 (23.5)

*Age at the time of the first CHD event, death of non-CHD causes or the end of study.

CHD: Coronary heart disease.

HDL: High-density lipoprotein.

ACR: Albumin to creatinine ratio.

eGFR: estimated Glomerular Filtration Rate.

Table 3 Incidence rates by age and sex in Aboriginal people

Age (years)	Person-years	Number of participants	Number of CHD	Rate (/1000 pys)	95% CI
Male					
10-	985.5	184	0	0	
20-	2617.1	367	2	0.8	0.2, 3.1
30-	2782.0	444	22	7.9	5.2, 12.0
40-	1733.9	295	36	20.8	15.0, 28.8
50-	722.5	143	22	30.4	20.0, 46.2
60-	245.2	55	14	57.1	33.8, 96.4
70+	94.9	18	2	21.1	5.3, 84.3
Female					
10-	594.0	115	0	0	
20-	1855.1	255	2	1.1	0.3, 4.3
30-	2207.3	346	18	8.2	5.1, 12.9
40-	1716.6	286	28	16.3	11.3, 23.6
50-	1019.2	181	24	23.5	15.8, 35.1
60-	383.2	87	11	28.7	15.9, 51.8
70+	169.3	29	4	23.6	8.9, 63.0

Table 4 Lifetime risk of a first CHD event at different ages reached free of CHD in Aboriginal men and women

	Lifetime risk (95% CI)	
Age (years)	Men	Women
30	58% (48, 67)	50% (42, 59)
40	58% (47, 68)	48% (39, 57)
50	54% (40, 66)	40% (30, 51)
60	45% (27, 62)	31% (18, 44)
70+	27% (4, 60)	20% (6, 39)

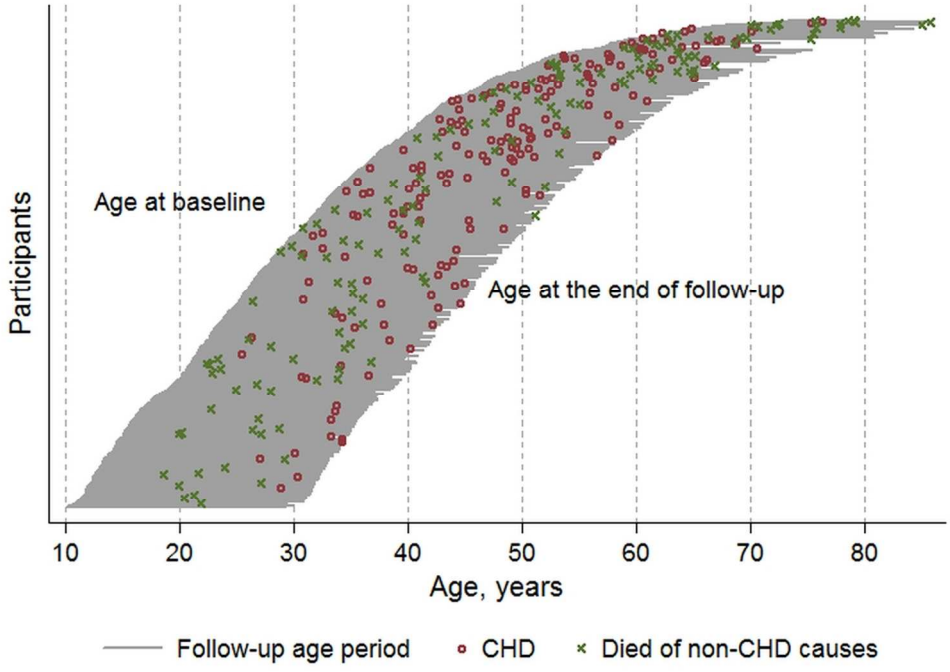

Figure 1. CHD events and deaths of non-CHD causes between baseline and the end of follow-up
123x90mm (300 x 300 DPI)

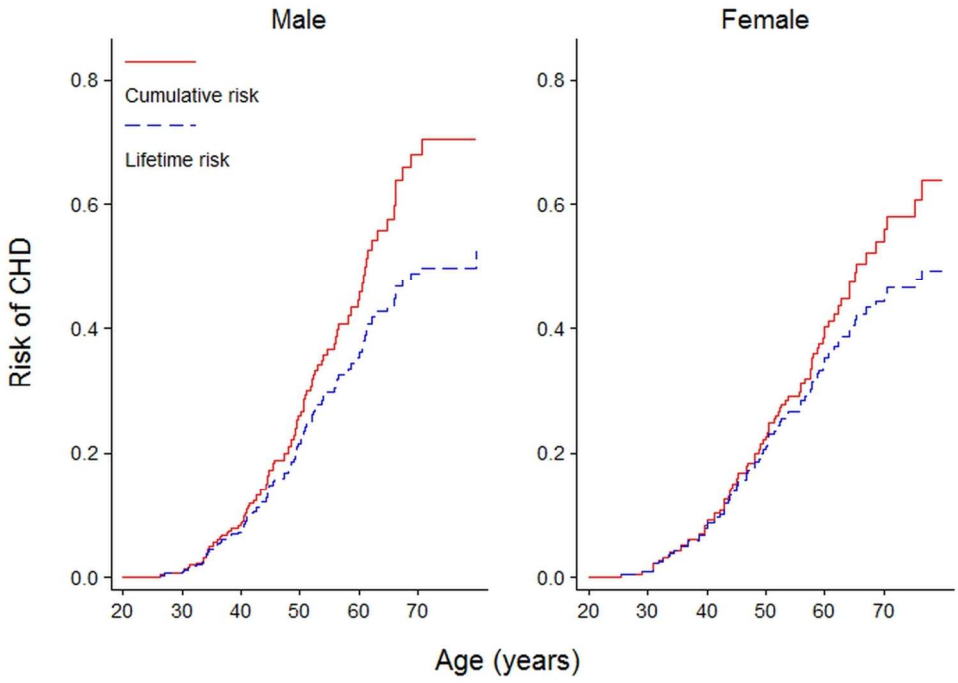

Figure 2. Lifetime risk of coronary heart disease in Aboriginal people
123x90mm (300 x 300 DPI)

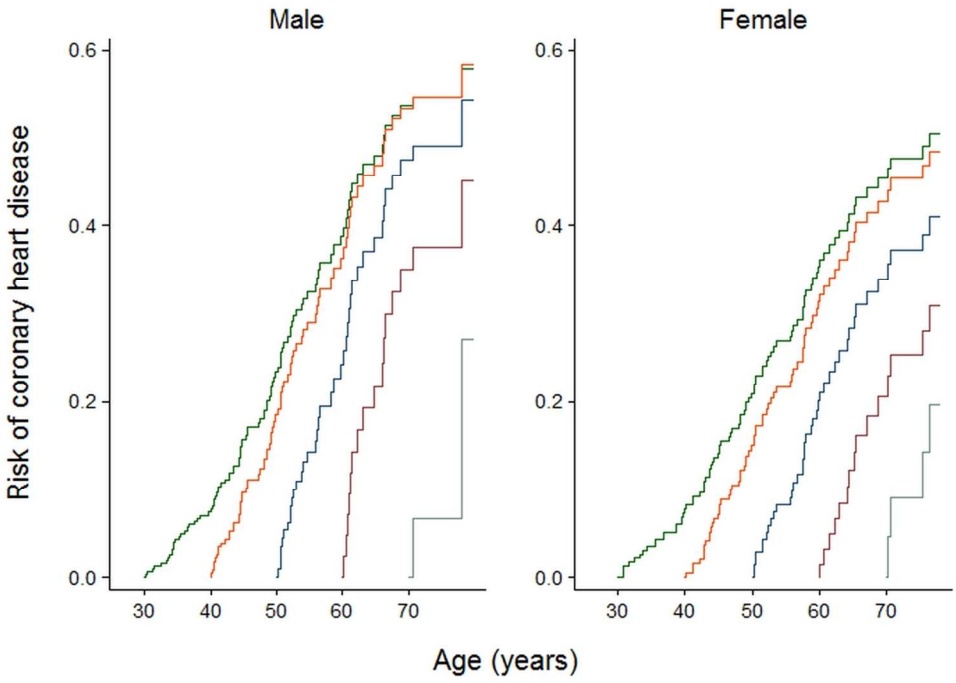

Figure 3. Lifetime risk of coronary heart disease for Aboriginal men and women for baseline ages of 30, 40, 50, 60 and 70 years reached free from coronary heart disease
123x90mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4, 5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4, 5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	4, 5
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4, 5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*4,5*
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5
		(*b*) Describe any methods used to examine subgroups and interactions	5
		(*c*) Explain how missing data were addressed	5
		(*d*) If applicable, explain how loss to follow-up was addressed	5
		(*e*) Describe any sensitivity analyses	5
Results			n/a

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6, 18, Figure 1.
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	n/a, see 18, Figure 1.
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	14, Table 1.
		(b) Indicate number of participants with missing data for each variable of interest	14, Table 1.
		(c) Summarise follow-up time (eg, average and total amount)	6.
Outcome data	15*	Report numbers of outcome events or summary measures over time	6
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	6
		(*b*) Report category boundaries when continuous variables were categorized	6
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	6
Discussion			
Key results	18	Summarise key results with reference to study objectives	7
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	7-9
Generalisability	21	Discuss the generalisability (external validity) of the study results	8,9
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	10

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.