Reporting of lifetime fractures: methodological considerations and results from the Thai Cohort Study

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Reporting of lifetime fractures: methodological considerations and results from the Thai Cohort Study

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Article summary

Article focus

- In developing and newly industrialised countries, epidemiological data on fracture incidence usually cannot be derived from large administrative datasets, and estimates must rely on other means.
- The primary aim of this study is to provide estimates of fracture incidence among young adults in Thailand, using the 2009 4-year follow-up survey of a large national Thai cohort study (TCS).
- The secondary aim of this study is to illustrate and to recommend a method for limiting the effect of recall bias.

Key messages

- The pattern of fracture incidence among adult Thai men and women between 20 and 60 years is similar to that reported for Western countries such as the US and the UK.
- Survey methods provide a feasible alternative for establishing fracture incidence; however, limiting analyses to fractures reported to have occurred recently minimises bias due to poor recall.

Strengths and limitations

- The strengths of the study are the sample size, the detailed survey question on fractures, and the careful consideration given to recall bias in the analysis.
- The accuracy of self-report studies is by definition limited by the accuracy of participant reporting.
- The gold standard for ascertaining fractures: X-rays and medical records; were not available.

Structured abstract

Objectives: To provide estimates of fracture incidence among young adults in Thailand

Design: cross-sectional analysis of a cohort

Setting: a national Thai Cohort Study (TCS)

Participants: 60,569 study participants responded to the 2009 follow up survey; 55% were women and median age was 34 years (range 19 to 92).

Primary and secondary outcome measures: Participants were asked if they had experienced fractures and if so, at what age. Fracture incidence was calculated from lifetime fracture reports, and again selecting only fractures reported to have taken place within the last year.

Results: 18010 lifetime fractures were reported; 11645 (65%) by men. Lifetime fracture prevalence was 30% for men and 15% for women. Lifetime incidence per 10^4 person years was 83; analysing only fractures from the last year yielded an incidence of 187. For ages 21 to 30, fractures were more common among men than women (283 [95%CI 244 to 326] and

150 [130 to 173] per 10^4 person-years, respectively); with increasing age, rates decreased among men and increased among women (for ages 51 to 60, 97 [58 to 151] and 286 [189 to 417], respectively).

Conclusions: The pattern of fracture incidence among Thais aged 20 to 60 was similar to that reported for Western countries. Survey methods provide a feasible alternative for establishing fracture incidence; however, limiting analyses to fractures reported to have occurred recently minimises bias due to poor recall.

Introduction

Fractures are an important public health burden. Descriptive epidemiological data on the incidence and distribution of fractures in the population is relevant for the provision of health services, identifying trends and informing preventative strategies. Fracture incidence has been described previously using administrative data, including X-ray reports,[1-4] and using survey data[5], with widely varying results. Administrative datasets of patients attending outpatient fracture clinics have the advantage of accurate fracture ascertainment, but do not capture patients admitted to hospital, patients treated in primary care or fractures that do not result in medical intervention[5]. Furthermore, to determine fracture incidence based on (administrative) hospital data, an estimate of the hospital catchment population is required, which may not be accurate. Survey data capture all fractures

regardless of medical intervention, but rely on accurate recall of the event by the study participants. Self-report of life events is prone to telescoping (inaccurately reporting distant events as having occurred more recently) and fall-off (events reported in previous surveys may, in subsequent surveys, not be reported as having ever occurred)[6].

In developing countries and newly industrialised countries, large administrative datasets of routinely collected medical information may not be readily available and estimates of fracture incidence must rely on other means. In this study we aim to provide estimates of fracture incidence among young adults in Thailand, using the 2009 4-year follow-up survey of a large national Thai cohort study (TCS). Recognising the importance of survey data in establishing fracture incidence in developing and newly industrialised countries, we present a method for quantifying and resolving the effect of poor recall on self-reported lifetime fracture incidence.

Methods

Study population and data collection

The data derived from the 2009 follow-up survey of the Thai Cohort Study (TCS), which is an ongoing community-based study of adult distance learning Sukhothai Thammathirat Open University (STOU) students residing throughout the country. In 2005 the STOU student register listed about 200,000 names and addresses: a baseline 20-page questionnaire was sent to each student and 87,134 (44%) replied. The baseline characteristics of cohort participants[7] and comparisons with the population of Thailand[8-9] have been reported previously: the STOU cohort has a higher proportion of females than the general Thai population (54.7 vs. 50.5%); more young adults (51.5 vs. 23.9% were aged between 21 and 30 years) and fewer people aged over 50 (2.0 vs. 24.7%)[8]; the age distribution of the Thai

population and the STOU cohort are shown in Figure 1. Study participants were also less likely to be married and more likely to have completed junior high school; geographically the main regions in Thailand are well represented in the STOU cohort[8]. Overall the cohort represents well the geo-demographic, ethnic, occupational and socioeconomic status of the young-adult Thai population. This is because most Open University students already have established jobs and because of their work and family responsibilities and modest economic circumstances are unable to leave their locations to attend an on-campus university fulltime. However, they are better educated than the general Thai population and thus are able to respond to complex health questionnaires. In 2009, a follow-up survey was sent and 60,569 (>70%) participants replied: 55% were women and the median age was 34 years (range 19 to 92). Data scanning, verifying, and correcting were conducted using Scandevet, a program developed by a research team from Khon Kaen University. Further data editing was completed using SQL and SPSS software.

Ethical considerations

Ethics approval was obtained from Sukhothai Thammathirat Open University Research and Development Institute (protocol 0522/10) and the Australian National University Human Research Ethics Committee (protocol 2004344). Informed written consent was obtained from all participants.

Measures

The core question asked was “In your life have you ever experienced a fracture to the areas of your body mentioned below? If so please place a cross in the Yes box and indicate the age at which the fracture occurred” followed by a list: Finger/toe; wrist; arm; collarbone; rib;

skull; face/jaw/nose; neck; back; pelvis; leg; ankle; other. Skull fractures may have been over-reported (by being confused with skull trauma) and as this is the subject of further investigation skull fractures are not included in this report. Other variables included in this analysis are age and gender. Participant age was divided into bands of 10 years (21-30, 31-40, 41-50, 51-60 and 61-70). Age-category analyses presented here excluded 7 cohort members aged less than 21 years as they were too few in number to reliably represent that age group; generally, age groups with very small numbers of people in them were not presented in the age-specific results to prevent distorting age effects by selection bias (i.e. only relatively healthy and active older persons participating in the study).

Analysis

Only fractures that were reported together with an age at the time of fracture were included in the analysis. Lifetime prevalence of fractures was calculated as the percentage of participants who reported ever having had a fracture. Lifetime incidence of fractures per 100,000 person-years was calculated by dividing the number of reported fractures by the sum of the ages of all study participants, and multiplying by 100,000. Fracture incidence was also calculated using a range of recall periods: for example, for a recall period of 10 years, only fractures that were reported to have occurred within the last 10 years were included in the incidence calculation, and the denominator was the number of study participants multiplied by 10 (to account for 10 years of recall). Confidence intervals for the incidence rates were calculated by first assuming fracture occurrence to have a Poisson distribution, and finding its related confidence interval[10]. Differences in recall for leg vs. finger/toe fractures were calculated using a Z-test for two proportions: the reported number of

fractures over 10 years divided by the expected number of fractures based on 1-year recall multiplied by 10. All analyses were conducted using SAS software, version 9.2.

Results

The 60569 Thai Cohort Study participants who responded to the 2009 survey reported a total of 18280 lifetime fractures; age at the time of fractures was included for 18010 (99%) of these. The overall lifetime prevalence of ever having sustained any fracture was 22%: there were 47445 (78%) participants who did not report any fracture; 9964 (16%) who reported a fracture at one site; 2146 (4%) who reported a fracture at two sites and 1014 (2%) who reported fractures at three or more sites. The distribution of the age-at-fracture as well as the overall study participant age distribution is shown in Figure 1. Among participants below the age of 40, women are in the majority; above 40 years men are in the majority. Although there are more women than men in the study, 65% (11645/18010) of all fractures were reported by men. There was over-reporting of fractures at rounded ages such as 25, 30, 35 and 40 as well as 18 years (Figure 1, bottom); a more natural distribution can be achieved by using a 5-year interval scale.

Table 1. Lifetime prevalence of fractures in Thai cohort members by age and sex.

	Lifetime prevalence of fractures			
	Men		Women	
Age group	Ever had a fracture / number of people	Prevalence (%)	Ever had a fracture / number of people	Prevalence (%)
21-30	1833 / 6688	27	1743 / 13003	13
31-40	3527 / 11519	31	2038 / 13174	15
41-50	2128 / 6883	31	948 / 5956	16
51-60	588 / 1965	30	197 / 943	21
61-70	89 / 300	30	18 / 74	24
Total	*8165 / 27355*	*30*	*4944 / 33150*	*15*

The prevalence of fractures among men in their 20s and 30s was twice as high as that of women of the same age group (Table 1). Having sustained a fracture was more common among women in their 50s and 60s than among younger women; among men, there was no marked difference between the age groups.

Table 2. Fracture incidence calculated from lifetime fractures and from fractures reported for the last year only

	Lifetime fractures		Fractures in the last year	
Fracture site	Number of fractures	Crude incidence *	Number of fractures	Crude incidence †
Finger/toe	3519	163	268	442
Wrist	1995	92	98	162
Arm	2967	137	76	125
Collarbone	1571	73	62	102
Rib	514	24	53	88
Face/Jaw/Nose	1006	47	47	78
Neck	213	10	21	35
Back	610	28	73	121
Pelvis	270	13	19	31
Leg	2007	93	108	178
Ankle	2051	95	171	282
Other	1287	60	134	221
Total	*18010*	*834*	*1130*	*1866*

* Calculated over 2159580 person years. †Calculated over 60569 person years.

Note: Fracture incidence expressed per 100,000 person-years. The lifetime fracture crude incidence includes childhood fractures; the fractures in the last year do not (as the youngest study participant is 19 years).

The fracture incidence per 100,000 person years by fractures site is given in Table 2. Finger/toe, arm and ankle fractures were the most common; pelvis and neck fractures the least common. Counting only fractures that occurred in the year prior to the survey resulted in a much higher fracture incidence for most fracture sites. Lifetime fracture incidence includes childhood fractures and relies on accurate recall over a lifetime; fractures over the

last year, on the other hand, are derived from recent events, and because the youngest participants were 19 years, childhood fractures are not included.

This is further illustrated in Figure 2: calculating fracture incidence over a longer recall period resulted in a lower fracture incidence; this effect is seen both in men and women, and across all age groups. The decline in incidence when calculated over longer recall periods is greater for less memorable fractures such as finger/toe, than for fractures associated with significance inconvenience such as leg fractures. If true fracture incidence remained constant over time then based on the number of fractures reported to have occurred in the last year, we might expect 268x10 years=2680 finger/toe fractures and 108x10 years=1080 leg fractures to have occurred over the preceding 10 years. The actual number of reported finger/toe fractures over the preceding 10 years was 1487; this is 55% (95% CI 54 to 57) of the expected number; the actual number of reported leg fractures over the preceding 10 years was 698; this is 65% (95%CI 62 to 67) of the expected number. Assuming steady fracture rates over time, 10-year recall was statistically significantly lower for finger/toe compared to leg fractures (z-value = 5.1).

Because the fracture incidence declined when calculated over increasing length of recall, for further analyses only fractures reported to have occurred in the last year were used. Fracture incidence per age group for men and women is shown in Figure 3: fractures were more common among young men than among young women; with increasing age, among men the fracture incidence decreased whereas among women fracture incidence increased. Among women above 50 years, fracture incidence was higher than that among men of above 50 years.

Discussion

This study reports the fracture incidence among Thais aged between 20 and 60: fractures are common, particularly among men under 40 and women above 50 years. The increase in the incidence of fractures between the ages of 20 and 60 among women and the simultaneous decrease among men seen in this Thai study have been reported previously in studies from the UK[1, 4-5], US[2], and Norway[3]. Men in their 20s have previously been reported to have a much higher incidence of fractures than women: this gender difference gradually disappears with age[1-5, 11], as also seen in the present Thai study.

Two ways in which the pattern of fracture incidence among adult Thais presented here differs from reports from Western studies are, first, the age of onset of a steep increase in fracture rates among women: this is manifest among the 51-60 year old Thais, but in some reports from Western countries[4, 12-13] a steep increase is not apparent until after the age of 65-70 years. This steep increase among older women generally reflects osteoporosis: the present results could therefore indicate earlier onset of osteoporosis among Thai women. The second discrepancy is the observed decrease in fractures between the ages of 40 and 60 among Thai men: in some previous reports from Western countries, fracture incidence remains steady or increases slightly between the ages of 40 and 60[3, 11-12, 14]. Possibly the decrease in fracture rates after age 20-25 seen among Western men is not manifest among Thai men until much later because of continued high-risk physical labour; the decrease in fractures after the age of 40 could reflect a transitioning out of high-risk work around that age.

The absolute fracture incidence of the present study is by and large comparable to previous studies that were based on medical records and X-ray reports: some studies reported lower

incidence[1, 11-12, 14] and others reported similar rates[3-4, 13]. A recent UK study using a self-report survey reported a fracture incidence twice as high as those presented in this Thai study[5]: whether this reflects higher fracture rates or better recall in the UK remains to be investigated.

The prevalence of osteoporosis among both men and women in Thailand is reported to be comparable to that of Western countries, but despite the development osteoporosis management guidelines, most high-risk individuals and fracture patients are not identified or treated[15]. Younger Thai men and women living in rural areas have been reported to have higher bone mineral density compared to their urban counterparts[16]; ongoing urbanisation can therefore be expected to lead to an increase in the incidence of osteoporosis and related fractures. Vertebral fractures, which are commonly associated with osteoporosis, have been reported to be remarkably common among older Thai men and women, with incidence rates among Thai women 3-4 fold, and among Thai men 10 fold higher compared to white women and men, respectively[17]. This pattern might be due to trauma and micro-trauma associated with strenuous work among (older) Thai men. The results of the present Thai community-based study show high fracture rates among younger men and older women; the relative contribution of osteoporosis to fracture incidence per age-group and gender in Thailand remains to be clarified.

This study has several limitations. The study sample did not include adequate representation of all age groups to allow for population based age-standardised incidence calculations. Because fracture incidence is generally described as two-peaked, with greatest incidence in the young and the elderly[1-3, 5], the fracture incidence presented in this study is an under-estimate of that of the general Thai population, as the young (<20) are not

represented and the elderly (61+, n=431) are under-represented. The findings of this study are therefore limited to Thais between the ages of 20 and 60.

The accuracy of self-report studies is by definition limited by the accuracy of participant reporting. A comparison of self-report with X-ray reports (the gold standard) was not feasible. Instead, we have attempted to quantify self-report (in-) accuracy in two other ways: first, by showing over-reporting of fractures at rounded ages (Fig. 1). This phenomenon distorts the time distribution rather than the overall number of reported events. The second self-report inaccuracy we have attempted to quantify refers to fall-off: the more accurate recall of recent events compared to events that occurred longer ago. The results of the present study clearly indicate a decline in fracture incidence when calculated over an increasing number of years. Although this pattern appears to be general across age and gender, the magnitude of 'recall inaccuracy' depends on the severity of the event, with leg fractures being recalled more accurately than finger/toe fractures. These results, however, should be interpreted with caution as the decline in incidence with increasing recall period could in part be explained by a real increase in fracture incidence over time. Thailand is transitioning to a modern consumer economy[9] which could be leading to an increase in fractures due to traffic and workplace injury. Baseline frequencies of transport[18] and other injuries[19] from the 2005 survey of the Thai Cohort Study have been reported; the change in injury incidence and fracture incidence over time is ground for further study. Regardless of the underlying change over time, using only the last year of recall to calculate incidence is the most accurate and timely representation of fracture incidence; furthermore, it facilitates comparisons with other studies reporting 12-months recall of fractures.

Conclusions

In conclusion, the results of this study indicate that the pattern of fracture incidence among adult Thai men and women between 20 and 60 years is similar to that reported for Western countries such as the US and the UK. Self-report surveys provide a feasible alternative to hospital-records and X-ray records research for establishing fracture incidence; however, where lifetime fractures are reported, using only fractures reported to have occurred in the last year minimises bias due to poor recall. Overall, we see fracture in Thailand is a larger burden for younger men and older women but we need more background information before we can understand better the environmental and personal factors that account for this age and sex pattern of occurrence. Such analyses will be the focus of future reports from the Thai Cohort Study.

Competing Interests

The authors declare that they have no competing interests.

Authors' contributions

JG and RM analysed the data and conceptualized and drafted the manuscript. SS and AS designed and instituted the Thai Health-Risk Transition research project and helped the data analysis and interpretation for this report. All authors read and approved the final manuscript.

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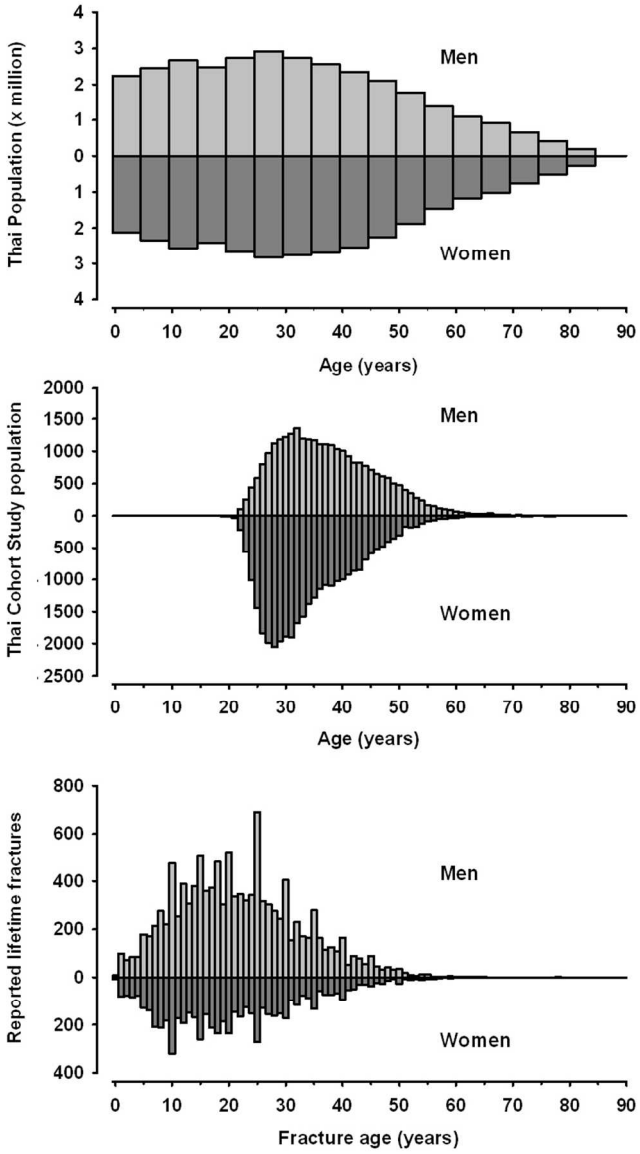
Figure Legends

Figure 1. Top: Histogram of Thai population age distribution according to the 2005 US Census Bureau International Data Base (http://www.census.gov/population/international/data/idb/country.php, accessed on July 18th 2011). Middle: Histogram of Thai Cohort Study participant age. Bottom: Histogram of the total lifetime fractures reported by Thai Cohort Study participants: over-reporting of fractures can be seen at ages such as 10, 15, 18, 25, 30, 35 and 40

Figure 2. Fracture incidence calculated using a recall period of 1 through to 10 years. Results are shown for fractures that were reported to occur between the ages 20 to 30, 30 to 40 and 40 to 50.

Figure 3. Overall fracture incidence for men and women for a recall period of one year. Error bars represent 95% confidence intervals.



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140x256mm (150 x 150 DPI)

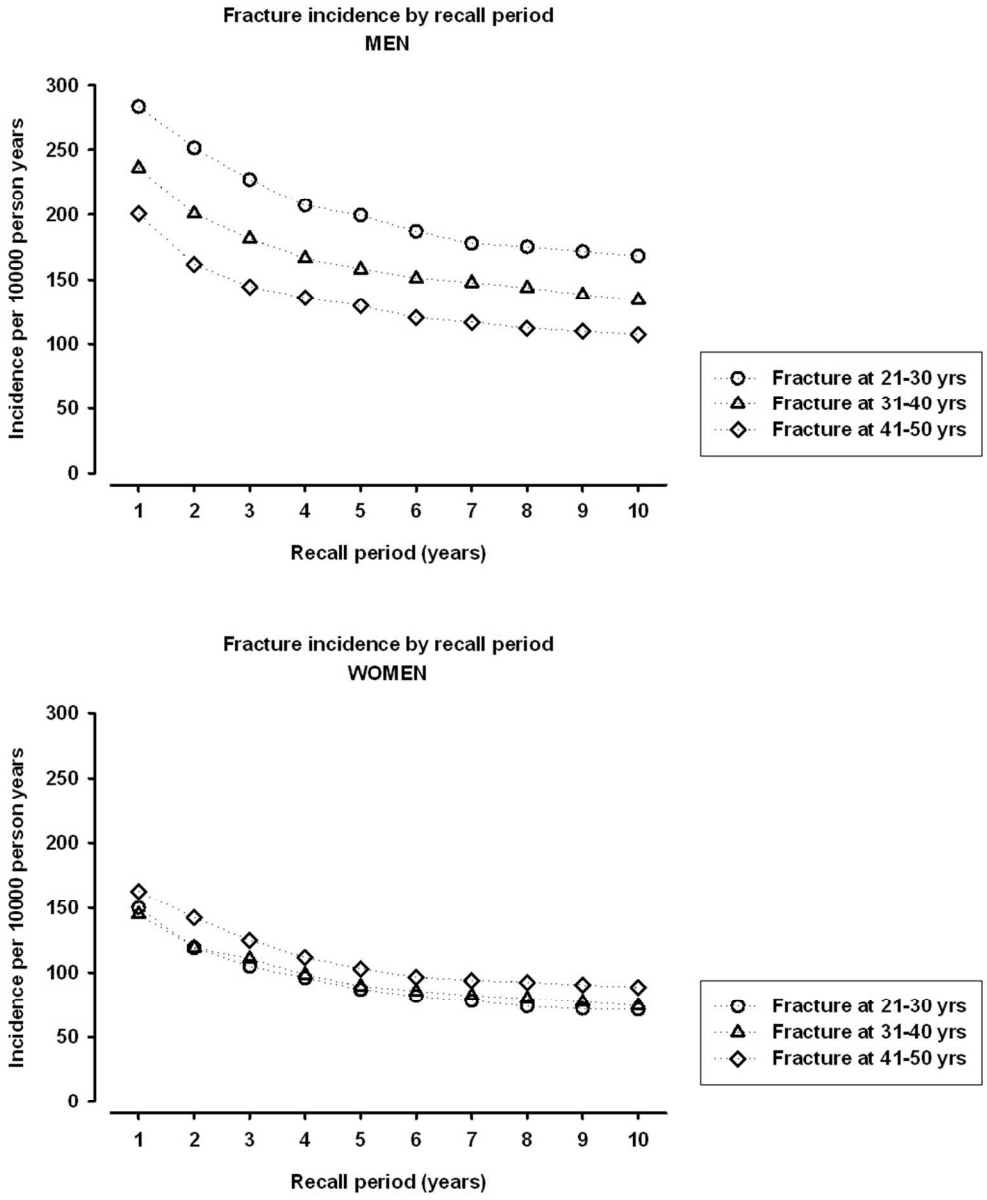

Figure 2. Fracture incidence calculated using a recall period of 1 through to 10 years. Results are shown for fractures that were reported to occur between the ages 20 to 30, 30 to 40 and 40 to 50.
173x210mm (150 x 150 DPI)

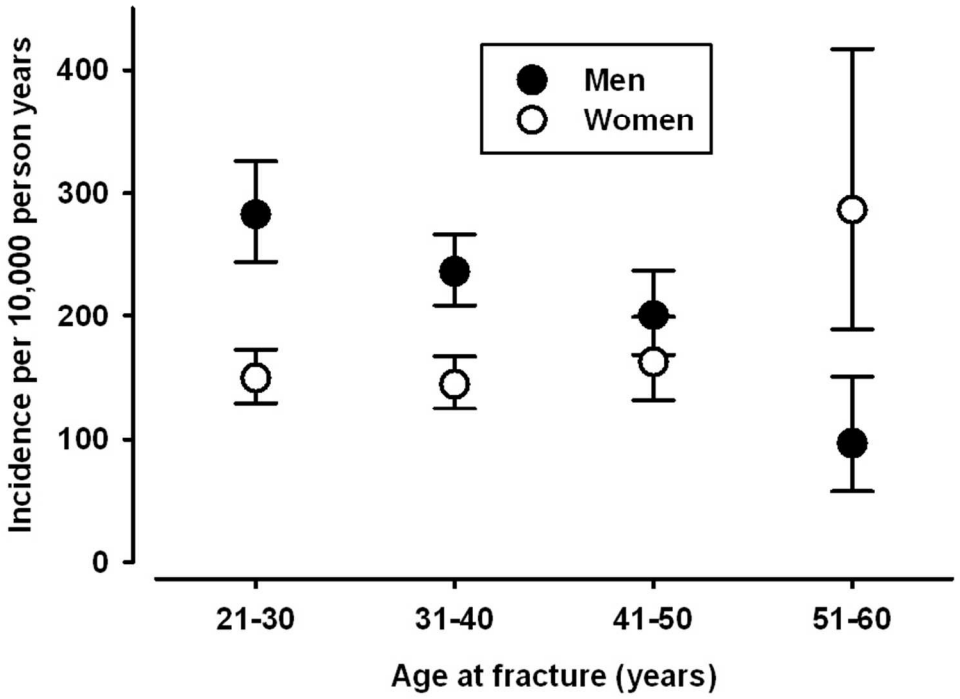

Figure 3. Overall fracture incidence for men and women for a recall period of one year. Error bars represent 95% confidence intervals.

160x124mm (150 x 150 DPI)

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

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	5
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	5
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6
Objectives	3	State specific objectives, including any pre-specified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-9
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	8-9
Bias	9	Describe any efforts to address potential sources of bias	9
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	9
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	n/a

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	9
Results			
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	9-10
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9-10
		(b) Indicate number of participants with missing data for each variable of interest	9
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	-
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	-
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	9-10
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	
		(*b*) Report category boundaries when continuous variables were categorized	9-11
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9-11
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13-14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
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	15-16

*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.

Reporting of lifetime fractures: methodological considerations and results from the Thai Cohort Study

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Primary Subject Heading:	Epidemiology
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Keywords:	fracture survey, Thailand, Thai Cohort Study, incidence

Reporting of lifetime fractures: methodological considerations and results from the Thai Cohort Study

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Key words: fracture incidence; fracture survey; Thailand; Thai Cohort Study

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There were no competing interests

Structured abstract

Objectives: To provide estimates of fracture incidence among young adults in Thailand

Design: Cross-sectional analysis of a large national cohort

Setting: Thailand

Participants: 60,569 study participants residing nationwide responded to the 2009 follow up survey; 55% were women and median age was 34 years (range 19 to 92).

Outcome measures: Participant–reported lifetime fractures, along with age at fracture. Fracture incidence rates per person-year were then compared using lifetime fracture reports, and again selecting only fractures reported for the last year. Incidence rates were compared by age and sex.

Results: 18010 lifetime fractures were reported; 11645 (65%) by men. Lifetime fracture prevalence was 30% for men and 15% for women. Lifetime incidence per 10^4 person years was 83; analysing only fractures from the last year yielded a corresponding incidence rate of 187. For ages 21 to 30, fractures per 10^4 person-years were more common among men than women (283 [95%CI 244 to 326] and 150 [130 to 173] respectively); with increasing age, rates decreased among men and increased among women (for ages 51 to 60, 97 [58 to 151] and 286 [189 to 417], respectively).

Conclusions: Large scale surveys provide a feasible method for establishing relative fracture incidence among informative subgroups in a population. Limiting analyses to fractures reported to have occurred recently minimises bias due to poor recall. The pattern of fracture incidence among Thais aged 20 to 60 was similar to that reported for Western countries: high falling rates in young men and high rising rates in older women.

Article summary

Article focus

- In developing and newly industrialised countries, epidemiological data on fractures usually cannot be derived from large administrative datasets; we have therefore developed other means to study the occurrence of fractures
- We illustrate and recommend a robust method limiting the effects of recall bias and estimating fracture incidence using direct population surveys.
- An additional aim of the study is to provide relative fracture incidence among young Thai adults using a 2009 4-year follow-up survey of a large national Thai cohort study (TCS).

Key messages

- Limiting analyses to fractures reported to have occurred recently minimises bias due to poor recall. Survey of an educated subpopulation provided a feasible alternative for establishing relative fracture incidence.
- The relative fracture incidence among adult Thai men and women between 20 and 60 years was similar to that reported for Western countries such as the US and the UK.

Strengths and limitations

- The strengths of the study are the very large sample size, the detailed questions on fractures, and the careful consideration of recall bias in the analysis.
- The accuracy of self-report is assisted by education.
- The gold standards concerning fractures (X-rays and medical records) were not available for our large study population.

Introduction

Fractures are an important public health burden. Descriptive epidemiological data on the incidence and distribution of fractures in the population are relevant for the provision of health services, identifying trends and informing preventative strategies. Population fracture distributions have been described previously using administrative data, including X-ray reports,[1-4] and using survey data[5], with widely varying results. Administrative datasets of patients attending outpatient fracture clinics have the advantage of accurate fracture ascertainment, but do not capture patients admitted to hospital, patients treated in primary care or fractures that do not result in medical intervention[5]. Furthermore, to determine actual fracture incidence based on (administrative) hospital data, an estimate of the hospital catchment population is required, which is usually not feasible particularly for large surgical centres. Survey data capture all fractures regardless of medical intervention, provided there is accurate recall of the event by the study participants. Self-report of life events, however, is prone to telescoping (inaccurately reporting distant events as having occurred more recently) and fall-off (events reported in previous surveys may, in subsequent surveys, not be reported as having ever occurred)[6].

In developing countries and newly industrialised countries, large administrative datasets of routinely collected medical information may not be readily available and estimates of fracture occurrence must rely on other means. Recognising the importance of survey data in establishing fracture incidence in developing and newly industrialised countries, we present a method for quantifying and resolving the effect of poor recall on self-reported lifetime fracture incidence. In this study we also provide estimates of relative fracture incidence

among young and middle-aged adult men and women in Thailand, using the 2009 4-year follow-up survey of a large national Thai cohort study (TCS).

Methods

Study population and data collection

The data derived from the 2009 follow-up survey of the Thai Cohort Study (TCS), which is an ongoing community-based study of adult distance learning Sukhothai Thammathirat Open University (STOU) students residing throughout the country. In 2005 the STOU student register listed about 200,000 names and addresses: a baseline 20-page questionnaire was sent to each student and 87,134 (44%) replied. The baseline characteristics of cohort participants[7] and comparisons with the adult population of Thailand[8-9] have been reported previously: the STOU cohort has a slightly higher proportion of females than the general Thai population (54.7 vs. 50.5%); more young adults (51.5 vs. 23.9% were aged between 21 and 30 years) and fewer people aged over 50 (2.0 vs. 24.7%)[8]; the age distribution of the STOU cohort is shown in Figure 1. Study participants were also less likely to be married and more likely to have completed junior high school; geographically the main regions in Thailand are well represented in the STOU cohort[8].

Overall the cohort represents well the geo-demographic, ethnic, occupational and socioeconomic status of the young-adult Thai population. This is because most Open University students are unable to leave their locations to attend an on-campus university fulltime: most already have established jobs and family responsibilities, and are of modest economic circumstances. However, they are better educated than the general Thai population and thus are able to respond to complex health questionnaires. In 2009, a follow-up survey was sent and 60,569 (>70%) participants replied: 55% were women and

the median age was 34 years (range 19 to 92). Data scanning, verifying, and correcting were conducted using Scandevet, a program developed by a research team from Khon Kaen University. Further data editing was completed using SQL and SPSS software.

Ethical considerations

Ethics approval was obtained from Sukhothai Thammathirat Open University Research and Development Institute (protocol 0522/10) and the Australian National University Human Research Ethics Committee (protocols 2004344 and 2009570). Informed written consent was obtained from all participants.

Measures

The core question asked was "In your life have you ever experienced a fracture to the areas of your body mentioned below? If so please place a cross in the Yes box and indicate the age at which the fracture occurred" followed by a list: Finger/toe; wrist; arm; collarbone; rib; skull; face/jaw/nose; neck; back; pelvis; leg; ankle; other. Skull fractures may have been over-reported (by being confused with skull trauma due to the wording used in the original Thai questionnaire) and as this is the subject of further investigation skull fractures are not included in this report. Other variables included in this analysis are age and gender. Participant age was divided into bands of 10 years (21-30, 31-40, 41-50, 51-60 and 61-70). Age-category analyses presented here excluded 7 cohort members aged less than 21 years as they were too few in number to reliably represent that age group. Generally, age groups with very small numbers of people in them were not presented in the age-specific results to prevent distorting age effects. .

Analysis

Only fractures that were reported together with an age at the time of fracture were included in the analysis. Lifetime prevalence of fractures was calculated as the percentage of participants who reported ever having had a fracture. Lifetime incidence of fractures per 100,000 person-years was calculated by dividing the number of reported fractures by the sum of the ages of all study participants, and multiplying by 100,000. Fracture incidence was also calculated using a range of recall periods: for example, for a recall period of 10 years, only fractures that were reported to have occurred within the last 10 years were included in the incidence calculation, and the denominator was the number of study participants multiplied by 10 (to account for 10 years of recall). Confidence intervals for the incidence rates were calculated by first assuming fracture occurrence to have a Poisson distribution, and finding its related confidence interval[10]. Differences in recall for leg vs. finger/toe fractures were calculated using a Z-test for two proportions: the reported number of fractures over 10 years divided by the expected number of fractures based on 1-year recall multiplied by 10. All analyses were conducted using SAS software, version 9.2.

Results

The 60569 Thai Cohort Study participants who responded to the 2009 survey reported a total of 18280 lifetime fractures; age at the time of fractures was included for 18010 (99%) of these. The overall lifetime prevalence of ever having sustained any fracture was 22%: there were 47445 (78%) participants who did not report any fracture; 9964 (16%) who reported a fracture at one site; 2146 (4%) who reported a fracture at two sites and 1014 (2%) who reported fractures at three or more sites. The distribution of the age-at-fracture as well as the overall study participant age distribution is shown in Figure 1. Among participants below the age of 40, women are in the majority; above 40 years men are in the

majority. Although there are more women than men in the study, 65% (11645/18010) of all fractures were reported by men. There was over-reporting of fractures at rounded ages such as 25, 30, 35 and 40 as well as 18 years (Figure 1, bottom); a more natural distribution can be achieved by using a 5-year interval scale.

Table 1. Lifetime prevalence of fractures in Thai cohort members by age and sex.

	Lifetime prevalence of fractures			
	Men		Women	
Age group	Ever had a fracture / number of people	Prevalence (%)	Ever had a fracture / number of people	Prevalence (%)
21-30	1833 / 6688	27	1743 / 13003	13
31-40	3527 / 11519	31	2038 / 13174	15
41-50	2128 / 6883	31	948 / 5956	16
51-60	588 / 1965	30	197 / 943	21
61-70	89 / 300	30	18 / 74	24
Total	*8165 / 27355*	*30*	*4944 / 33150*	*15*

The prevalence of fractures among men in their 20s and 30s was twice as high as that of women of the same age group (Table 1). Having sustained a fracture was more common among women in their 50s and 60s than among younger women; among men, there was no marked difference between the age groups.

Table 2. Fracture incidence calculated from lifetime fractures and from fractures reported for the last year only

	Lifetime fractures		Fractures in the last year	
Fracture site	Number of fractures	Crude incidence *	Number of fractures	Crude incidence †
Finger/toe	3519	163	268	442
Wrist	1995	92	98	162
Arm	2967	137	76	125
Collarbone	1571	73	62	102
Rib	514	24	53	88
Face/Jaw/Nose	1006	47	47	78
Neck	213	10	21	35
Back	610	28	73	121
Pelvis	270	13	19	31
Leg	2007	93	108	178
Ankle	2051	95	171	282
Other	1287	60	134	221
Total	*18010*	*834*	*1130*	*1866*

* Calculated over 2159580 person years. †Calculated over 60569 person years.

Note: Fracture incidence expressed per 100,000 person-years. The lifetime fracture crude incidence includes childhood fractures; the fractures in the last year do not (as the youngest study participant is 19 years).

The fracture incidence per 100,000 person years by fractures site is given in Table 2. Finger/toe, arm and ankle fractures were the most common; pelvis and neck fractures the least common. Counting only fractures that occurred in the year prior to the survey resulted in a much higher fracture incidence for most fracture sites. Lifetime fracture incidence includes childhood fractures and relies on accurate recall over a lifetime; fractures over the last year, on the other hand, are derived from recent events, and because the youngest participants were 19 years, childhood fractures are not included.

This is further illustrated in Figure 2: calculating fracture incidence over a longer recall period resulted in a lower fracture incidence; this effect is seen both in men and women, and across all age groups. The decline in incidence when calculated over longer recall periods is greater for less memorable fractures such as finger/toe, than for fractures associated with greater inconvenience such as leg fractures. Based on the number of fractures reported to have occurred in the last year, we can calculate the expected number for a 10-year period of recall and then compare this to the actual reported number. For finger/toe fractures, the reported number was 55% (95% CI 54 to 57) of the expected, and for leg fractures the corresponding number was 65% (95%CI 62 to 67). Assuming steady fracture rates over time, the 10-year recall was statistically significantly lower for finger/toe than for leg fractures.

Because the fracture incidence declined when calculated over increasing length of recall, for further analyses only fractures reported to have occurred in the last year were used. Fracture incidence per age group for men and women is shown in Figure 3: fractures were more common among young men than among young women; with increasing age, among men the fracture incidence decreased whereas among women fracture incidence increased. Among women above 50 years, fracture incidence was higher than that among men of above 50 years.

Discussion

This study reports the fracture incidence among Thais aged between 20 and 60 years. Fractures are common, particularly among men under 40 and women above 50 years.

The results of the present study indicate a progressive decline in recall-based fracture incidence over an increasing number of years. Although this pattern appears to be general across age and gender, the magnitude of 'recall inaccuracy' also depends on the severity of the event, with leg fractures being recalled much more accurately than finger/toe fractures. These results, however, should be interpreted with caution as the decline in incidence with increasing recall period could in part be explained by a real increase in fracture incidence over time. Thailand is transitioning to a modern consumer economy[9] which could be leading to an increase in fractures due to traffic injury. Baseline frequencies of transport[11] and other injuries[12] from the 2005 survey of the Thai Cohort Study have been reported; a change in injury incidence and fracture incidence over time is a topic for further study. Regardless of the underlying change over time, using only the last year of recall to calculate incidence is the most accurate and timely representation of fracture incidence; furthermore, it facilitates comparisons with other studies reporting 12-months recall of fractures.

The overall fracture incidence recorded in the present study is by and large comparable to previous studies that were based on medical records and X-ray reports: some studies reported lower incidence[1, 13-15] and others reported similar rates[3-4, 16]. A recent UK study using a self-report survey reported a fracture incidence twice as high as that presented in this Thai study[5]: whether this reflects higher fracture rates or better recall in the UK remains to be investigated.

The increase in the incidence of fractures between the ages of 20 and 60 among women and the simultaneous decrease among men seen in this Thai study have been reported previously in studies from the UK[1, 4-5], US[2], and Norway[3]. Men in their 20s have previously been reported to have a much higher incidence of fractures than women: this gender difference gradually disappears with age[1-5, 14], as also seen in the present Thai study.

The pattern of fracture incidence among adult Thais presented here differs from reports from Western studies in two ways. First, the age of onset of a steep increase in fracture rates among women is manifest among the 51-60 year old Thais, but in reports from Western countries[4, 13, 16] a steep increase is not apparent until after the age of 65-70 years. This steep increase among older women generally reflects osteoporosis: the present results could therefore indicate earlier onset of osteoporosis among Thai women. This is in agreement with a 2001 study of age-specific osteoporosis prevalence among Thai women which showed that prevalence increased steeply between the ages of 50 and 59 years[17]. The second discrepancy is the observed decrease in fractures between the ages of 40 and 60 among Thai men. Possibly the decrease in fracture rates after age 20-25 seen among Western men[3, 14] is not manifest among Thai men until much later because of continued high-risk physical labour; the decrease in fractures after the age of 40 in Thai men could reflect a transitioning out of high-risk work around that age.

This study has several limitations. The study sample did not include sufficient representation of all age groups to allow for population based age-standardised incidence calculations. Because fracture incidence is generally described as two-peaked, with greatest incidence in the young and the elderly[1-3, 5], the fracture incidence presented in this study is an under-

estimate of that of the general Thai population, as the young (<20) are not represented and the elderly (61+, n=431) are under-represented. The findings of this study are therefore limited to Thais between the ages of 20 and 60.

The accuracy of self-report studies is by definition limited by the accuracy of participant reporting. A comparison of self-report with X-ray reports (the gold standard) was not feasible. Instead, we have attempted to quantify self-report (in-) accuracy in two other ways: first, by showing over-reporting of fractures at rounded ages (Fig. 1). This phenomenon distorts the time distribution rather than the overall number of reported events. The second self-report inaccuracy we have quantified is fall-off over time. Recent events were recalled more accurately than events that occurred longer ago.

Conclusions

Self-report surveys provide a feasible alternative to hospital-records and X-ray records research for establishing fracture incidence; however, when lifetime fractures are reported, using only fractures reported to have occurred in the last year minimises bias due to poor recall. The results of this study indicate that the pattern of fracture incidence among adult Thai Cohort Study participants between 20 and 60 years is similar to that reported for Western countries such as the US and the UK. Overall, we see fracture in Thailand is a larger burden for younger men and older women but we need more background information before we can understand better the environmental and personal factors that account for this age and sex pattern of occurrence. Such analyses will be the focus of future reports from the Thai Cohort Study.

Competing Interests

The authors declare that they have no competing interests.

Authors' contributions

JG and RM analysed the data and conceptualized and drafted the manuscript. SS and AS designed and instituted the Thai Health-Risk Transition research project and helped the data analysis and interpretation for this report. All authors read and approved the final manuscript.

Funding

This work was supported by the International Collaborative Research Grants Scheme with joint grants from the Wellcome Trust UK (GR071587MA) and the Australian National Health and Medical Research Council (NHMRC)(268055), and as a global health grant from the NHMRC (585426). We thank the staff at Sukhothai Thammathirat Open University (STOU) who assisted with student contact and the STOU students who are participating in the cohort study. We also thank Dr Bandit Thinkamrop and his team from Khon Kaen University for guiding us successfully through the complex data processing.

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Figure Legends

Figure 1. Top: Histogram of Thai Cohort Study participant age. Bottom: Histogram of the total lifetime fractures reported by Thai Cohort Study participants: over-reporting of fractures can be seen at ages such as 10, 15, 18, 25, 30, 35 and 40

Figure 2. Fracture incidence calculated using a recall period of 1 through to 10 years. Results are shown for fractures that were reported to occur between the ages 20 to 30, 30 to 40 and 40 to 50.

Figure 3. Overall fracture incidence for men and women for a recall period of one year. Error bars represent 95% confidence intervals.

Authors' contributions

JG and RM analysed the data and conceptualized and drafted the manuscript. SS and AS designed and instituted the Thai Health-Risk Transition research project and helped the data analysis and interpretation for this report. All authors read and approved the final manuscript.

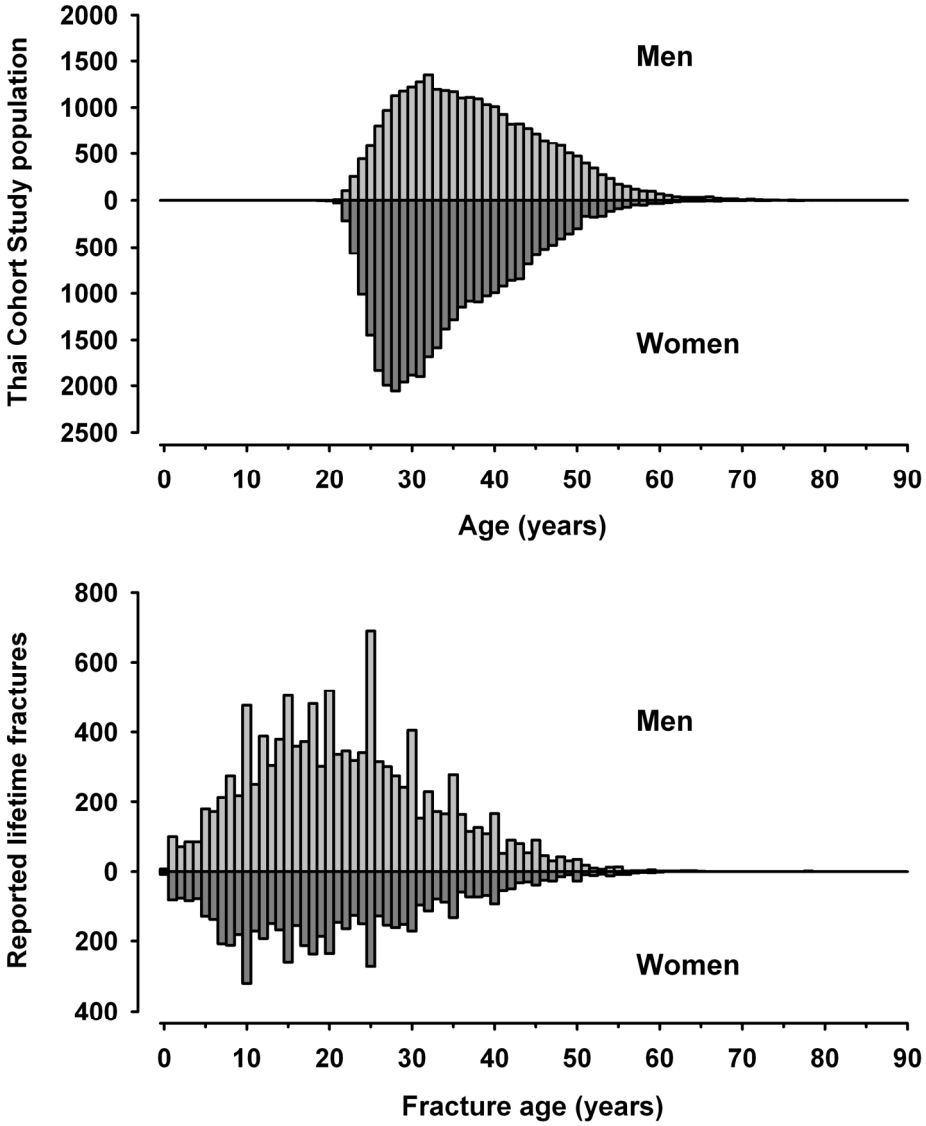

Figure 1. Top: Histogram of Thai Cohort Study participant age. Bottom: Histogram of the total lifetime fractures reported by Thai Cohort Study participants: over-reporting of fractures can be seen at ages such as 10, 15, 18, 25, 30, 35 and 40
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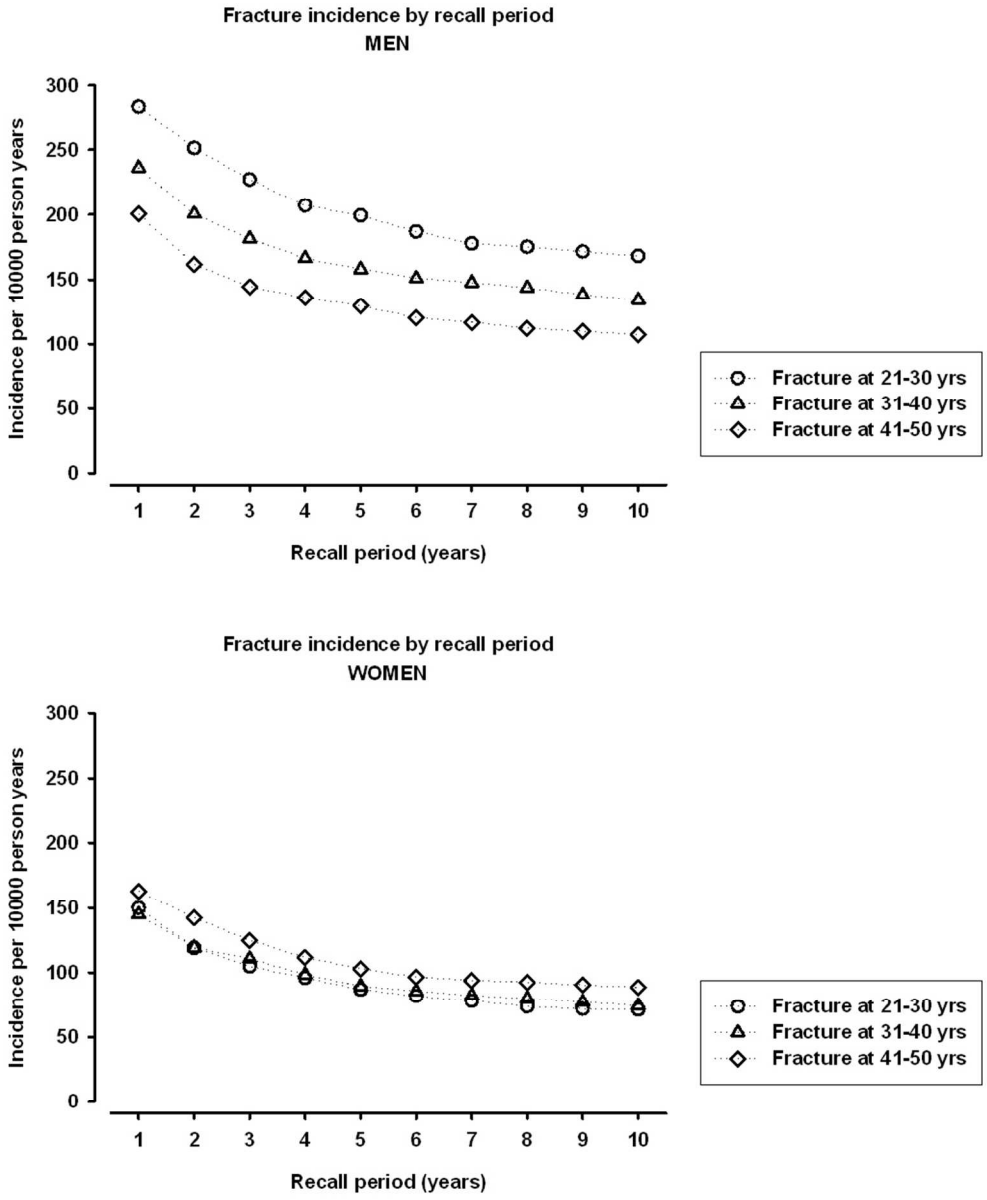

Figure 2. Fracture incidence calculated using a recall period of 1 through to 10 years. Results are shown for fractures that were reported to occur between the ages 20 to 30, 30 to 40 and 40 to 50.
173x210mm (150 x 150 DPI)

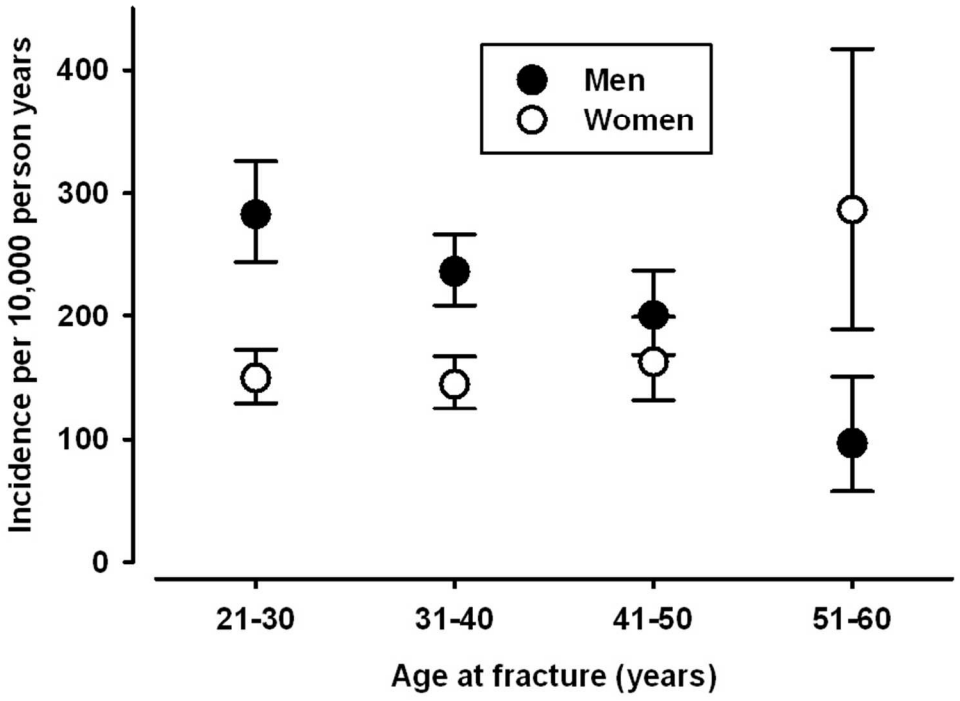

Figure 3. Overall fracture incidence for men and women for a recall period of one year. Error bars represent 95% confidence intervals.

160x124mm (150 x 150 DPI)

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

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	5
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	5
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6
Objectives	3	State specific objectives, including any pre-specified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-9
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	8-9
Bias	9	Describe any efforts to address potential sources of bias	9
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	9
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	n/a

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	9
Results			
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	9-10
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9-10
		(b) Indicate number of participants with missing data for each variable of interest	9
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	-
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	-
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	9-10
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	
		(*b*) Report category boundaries when continuous variables were categorized	9-11
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9-11
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13-14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
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	15-16

*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.

Reporting of lifetime fractures: methodological considerations and results from the Thai Cohort Study

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Primary Subject Heading:	Epidemiology
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Keywords:	fracture survey, Thailand, Thai Cohort Study, incidence

Reporting of lifetime fractures: methodological considerations and results from the Thai Cohort Study

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There were no competing interests

Structured abstract

Objectives: To provide estimates of fracture incidence among young adults in Thailand

Design: Cross-sectional analysis of a large national cohort

Setting: Thailand

Participants: 60,569 study participants residing nationwide responded to the 2009 follow up survey; 55% were women and median age was 34 years (range 19 to 92).

Outcome measures: Self–reported lifetime fractures, along with age at fracture. Fracture incidence rates per person-year were then compared using lifetime fracture reports, and again selecting only fractures reported for the last year. Incidence rates were compared by age and sex.

Results: 18010 lifetime fractures were reported; 11645 (65%) by men. Lifetime fracture prevalence was 30% for men and 15% for women. Lifetime incidence per 10^4 person years was 83; analysing only fractures from the last year yielded a corresponding incidence rate of 187. For ages 21 to 30, fractures per 10^4 person-years were more common among men than women (283 [95%CI 244 to 326] and 150 [130 to 173] respectively); with increasing age, rates decreased among men and increased among women (for ages 51 to 60, 97 [58 to 151] and 286 [189 to 417], respectively).

Conclusions: Large scale surveys provide a feasible method for establishing relative fracture incidence among informative subgroups in a population. Limiting analyses to fractures reported to have occurred recently minimises bias due to poor recall. The pattern of self-reported fracture incidence among Thais aged 20 to 60 was similar to that reported for Western countries: high falling rates in young men and high rising rates in older women.

Article summary

Article focus

- In developing and newly industrialised countries, epidemiological data on fractures usually cannot be derived from large administrative datasets; we have therefore developed other means to study the occurrence of fractures
- We illustrate and recommend a robust method limiting the effects of recall bias and estimating fracture incidence using direct population surveys.
- An additional aim of the study is to provide relative fracture incidence among young Thai adults using a 2009 4-year follow-up survey of a large national Thai cohort study (TCS).

Key messages

- Limiting analyses to fractures reported to have occurred recently minimises bias due to poor recall. Survey of an educated subpopulation provided a feasible alternative for establishing relative fracture incidence.
- The relative self-reported fracture incidence among adult Thai men and women between 20 and 60 years was similar to that reported for Western countries such as the US and the UK.

Strengths and limitations

- The strengths of the study are the very large sample size, the detailed questions on fractures, and the careful consideration of recall bias in the analysis.
- The accuracy of self-report is assisted by education.
- The gold standards concerning fractures (X-rays and medical records) were not available for our large study population.

Introduction

Fractures are an important public health burden. Descriptive epidemiological data on the incidence and distribution of fractures in the population are relevant for the provision of health services, identifying trends and informing preventative strategies. Population fracture distributions have been described previously using administrative data, including X-ray reports,[1-4] and using survey data[5], with widely varying results. Administrative datasets of patients attending outpatient fracture clinics have the advantage of accurate fracture ascertainment, but do not capture patients admitted to hospital, patients treated in primary care or fractures that do not result in medical intervention[5]. Furthermore, to determine actual fracture incidence based on (administrative) hospital data, an estimate of the hospital catchment population is required, which is usually not feasible particularly for large surgical centres. Survey data capture all fractures regardless of medical intervention, provided there is accurate recall of the event by the study participants. Self-report of life events, however, is prone to telescoping (inaccurately reporting distant events as having occurred more recently) and fall-off (events reported in previous surveys may, in subsequent surveys, not be reported as having ever occurred)[6].

In developing countries and newly industrialised countries, large administrative datasets of routinely collected medical information may not be readily available and estimates of fracture occurrence must rely on other means. Recognising the importance of survey data in establishing fracture incidence in developing and newly industrialised countries, we present a method for quantifying and resolving the effect of poor recall on self-reported lifetime fracture incidence. In this study we also provide estimates of relative fracture incidence

among young and middle-aged adult men and women in Thailand, using the 2009 4-year follow-up survey of a large national Thai cohort study (TCS).

Methods

Study population and data collection

The data derived from the 2009 follow-up survey of the Thai Cohort Study (TCS), which is an ongoing community-based study of adult distance learning Sukhothai Thammathirat Open University (STOU) students residing throughout the country. In 2005 the STOU student register listed about 200,000 names and addresses: a baseline 20-page questionnaire was sent to each student and 87,134 (44%) replied. The baseline characteristics of cohort participants[7] and comparisons with the adult population of Thailand[8-9] have been reported previously: the STOU cohort has a slightly higher proportion of females than the general Thai population (54.7 vs. 50.5%); more young adults (51.5 vs. 23.9% were aged between 21 and 30 years) and fewer people aged over 50 (2.0 vs. 24.7%)[8]; the age distribution of the STOU cohort is shown in Figure 1. Study participants were also less likely to be married and more likely to have completed junior high school; geographically the main regions in Thailand are well represented in the STOU cohort[8].

Overall the cohort represents well the geo-demographic, ethnic, occupational and socioeconomic status of the young-adult Thai population. This is because most Open University students are unable to leave their locations to attend an on-campus university fulltime: most already have established jobs and family responsibilities, and are of modest economic circumstances. However, they are better educated than the general Thai population and thus are able to respond to complex health questionnaires. In 2009, a follow-up survey was sent and 60,569 (>70%) participants replied: 55% were women and

the median age was 34 years (range 19 to 92). Data scanning, verifying, and correcting were conducted using Scandevet, a program developed by a research team from Khon Kaen University. Further data editing was completed using SQL and SPSS software.

Ethical considerations

Ethics approval was obtained from Sukhothai Thammathirat Open University Research and Development Institute (protocol 0522/10) and the Australian National University Human Research Ethics Committee (protocols 2004344 and 2009570). Informed written consent was obtained from all participants.

Measures

The core question asked was "In your life have you ever experienced a fracture to the areas of your body mentioned below? If so please place a cross in the Yes box and indicate the age at which the fracture occurred" followed by a list: Finger/toe; wrist; arm; collarbone; rib; skull; face/jaw/nose; neck; back; pelvis; leg; ankle; other. Skull fractures may have been over-reported (by being confused with skull trauma due to the wording used in the original Thai questionnaire) and as this is the subject of further investigation skull fractures are not included in this report. Other variables included in this analysis are age and gender. Participant age was divided into bands of 10 years (21-30, 31-40, 41-50, 51-60 and 61-70). Age-category analyses presented here excluded 7 cohort members aged less than 21 years as they were too few in number to reliably represent that age group. Generally, age groups with very small numbers of people in them were not presented in the age-specific results to prevent distorting age effects. .

Analysis

Only fractures that were reported together with an age at the time of fracture were included in the analysis. Lifetime prevalence of fractures was calculated as the percentage of participants who reported ever having had a fracture. Lifetime incidence of fractures per 100,000 person-years was calculated by dividing the number of reported fractures by the sum of the ages of all study participants, and multiplying by 100,000. Fracture incidence was also calculated using a range of recall periods: for example, for a recall period of 10 years, only fractures that were reported to have occurred within the last 10 years were included in the incidence calculation, and the denominator was the number of study participants multiplied by 10 (to account for 10 years of recall). Confidence intervals for the incidence rates were calculated by first assuming fracture occurrence to have a Poisson distribution, and finding its related confidence interval[10]. Differences in recall for leg vs. finger/toe fractures were calculated using a Z-test for two proportions: the reported number of fractures over 10 years divided by the expected number of fractures based on 1-year recall multiplied by 10. All analyses were conducted using SAS software, version 9.2.

Results

The 60569 Thai Cohort Study participants who responded to the 2009 survey reported a total of 18280 lifetime fractures; age at the time of fractures was included for 18010 (99%) of these. The overall lifetime prevalence of ever having sustained any fracture was 22%: there were 47445 (78%) participants who did not report any fracture; 9964 (16%) who reported a fracture at one site; 2146 (4%) who reported a fracture at two sites and 1014 (2%) who reported fractures at three or more sites. The distribution of the age-at-fracture as well as the overall study participant age distribution is shown in Figure 1. Among participants below the age of 40, women are in the majority; above 40 years men are in the

majority. Although there are more women than men in the study, 65% (11645/18010) of all fractures were reported by men. There was over-reporting of fractures at rounded ages such as 25, 30, 35 and 40 as well as 18 years (Figure 1, bottom); a more natural distribution can be achieved by using a 5-year interval scale.

Table 1. Lifetime prevalence of fractures in Thai cohort members by age and sex.

	Lifetime prevalence of fractures			
	Men		Women	
Age group	Ever had a fracture / number of people	Prevalence (%)	Ever had a fracture / number of people	Prevalence (%)
21-30	1833 / 6688	27	1743 / 13003	13
31-40	3527 / 11519	31	2038 / 13174	15
41-50	2128 / 6883	31	948 / 5956	16
51-60	588 / 1965	30	197 / 943	21
61-70	89 / 300	30	18 / 74	24
Total	*8165 / 27355*	*30*	*4944 / 33150*	*15*

The prevalence of fractures among men in their 20s and 30s was twice as high as that of women of the same age group (Table 1). Having sustained a fracture was more common among women in their 50s and 60s than among younger women; among men, there was no marked difference between the age groups.

Table 2. Fracture incidence calculated from lifetime fractures and from fractures reported for the last year only

	Lifetime fractures		Fractures in the last year	
Fracture site	Number of fractures	Crude incidence *	Number of fractures	Crude incidence †
Finger/toe	3519	163	268	442
Wrist	1995	92	98	162
Arm	2967	137	76	125
Collarbone	1571	73	62	102
Rib	514	24	53	88
Face/Jaw/Nose	1006	47	47	78
Neck	213	10	21	35
Back	610	28	73	121
Pelvis	270	13	19	31
Leg	2007	93	108	178
Ankle	2051	95	171	282
Other	1287	60	134	221
Total	*18010*	*834*	*1130*	*1866*

* Calculated over 2159580 person years. †Calculated over 60569 person years.

Note: Fracture incidence expressed per 100,000 person-years. The lifetime fracture crude incidence includes childhood fractures; the fractures in the last year do not (as the youngest study participant is 19 years).

The fracture incidence per 100,000 person years by fractures site is given in Table 2. Finger/toe, arm and ankle fractures were the most common; pelvis and neck fractures the least common. Counting only fractures that occurred in the year prior to the survey resulted in a much higher fracture incidence for most fracture sites. Lifetime fracture incidence includes childhood fractures and relies on accurate recall over a lifetime; fractures over the last year, on the other hand, are derived from recent events, and because the youngest participants were 19 years, childhood fractures are not included.

This is further illustrated in Figure 2: calculating fracture incidence over a longer recall period resulted in a lower fracture incidence; this effect is seen both in men and women, and across all age groups. The decline in incidence when calculated over longer recall periods is greater for less memorable fractures such as finger/toe, than for fractures associated with greater inconvenience such as leg fractures. Based on the number of fractures reported to have occurred in the last year, we can calculate the expected number for a 10-year period of recall and then compare this to the actual reported number. For finger/toe fractures, the reported number was 55% (95% CI 54 to 57) of the expected, and for leg fractures the corresponding number was 65% (95%CI 62 to 67). Assuming steady fracture rates over time, the 10-year recall was statistically significantly lower for finger/toe than for leg fractures.

Because the fracture incidence declined when calculated over increasing length of recall, for further analyses only fractures reported to have occurred in the last year were used. Fracture incidence per age group for men and women is shown in Figure 3: fractures were more common among young men than among young women; with increasing age, among men the fracture incidence decreased whereas among women fracture incidence increased. Among women above 50 years, fracture incidence was higher than that among men of above 50 years.

Discussion

This study reports the fracture incidence among Thais aged between 20 and 60 years. Fractures are common, particularly among men under 40 and women above 50 years.

The results of the present study indicate a progressive decline in recall-based fracture incidence over an increasing number of years. Although this pattern appears to be general across age and gender, the magnitude of 'recall inaccuracy' also depends on the severity of the event, with leg fractures being recalled much more accurately than finger/toe fractures. These results, however, should be interpreted with caution as the decline in incidence with increasing recall period could in part be explained by a real increase in fracture incidence over time. Thailand is transitioning to a modern consumer economy[9] which could be leading to an increase in fractures due to traffic injury. Baseline frequencies of transport[11] and other injuries[12] from the 2005 survey of the Thai Cohort Study have been reported; a change in injury incidence and fracture incidence over time is a topic for further study. Regardless of the underlying change over time, using only the last year of recall to calculate incidence is the most accurate and timely representation of fracture incidence; furthermore, it facilitates comparisons with other studies reporting 12-months recall of fractures.

The overall fracture incidence recorded in the present study is by and large comparable to previous studies that were based on medical records and X-ray reports: some studies reported lower incidence[1, 13-15] and others reported similar rates[3-4, 16]. A recent UK study using a self-report survey reported a fracture incidence twice as high as that presented in this Thai study[5]: whether this reflects higher fracture rates or better recall in the UK remains to be investigated.

The increase in the incidence of fractures between the ages of 20 and 60 among women and the simultaneous decrease among men seen in this Thai study have been reported previously in studies from the UK[1, 4-5], US[2], and Norway[3]. Men in their 20s have previously been reported to have a much higher incidence of fractures than women: this gender difference gradually disappears with age[1-5, 14], as also seen in the present Thai study.

The pattern of fracture incidence among adult Thais presented here differs from reports from Western studies in two ways. First, the age of onset of a steep increase in fracture rates among women is manifest among the 51-60 year old Thais, but in reports from Western countries[4, 13, 16] a steep increase is not apparent until after the age of 65-70 years. This steep increase among older women generally reflects osteoporosis: the present results could therefore indicate earlier onset of osteoporosis among Thai women. This is in agreement with a 2001 study of age-specific osteoporosis prevalence among Thai women which showed that prevalence increased steeply between the ages of 50 and 59 years[17]. The second discrepancy is the observed decrease in fractures between the ages of 40 and 60 among Thai men. Possibly the decrease in fracture rates after age 20-25 seen among Western men[3, 14] is not manifest among Thai men until much later because of continued high-risk physical labour; the decrease in fractures after the age of 40 in Thai men could reflect a transitioning out of high-risk work around that age.

This study has several limitations. First, the fracture incidence derived from the Thai Cohort Study 2009 survey is not representative of the Thai population. However the Thai Cohort Study is a large nation-wide study and the participants represent well the socioeconomic status of the young Thai population. The variations in fracture rates by age and gender observed by internal

comparisons in the Thai Cohort Study participants are therefore likely to reflect fracture rate patterns in the general young-adult Thai population. Because fracture incidence is generally described as two-peaked, with greatest incidence in the young and the elderly[1-3, 5], the fracture incidence presented in this study is an under-estimate of that of the general Thai population, as the young (<20) are not represented and the elderly (61+, n=431) are under-represented. The findings of this study are therefore limited to Thais between the ages of 20 and 60.

Second, the study relies entirely on self-report of recalled fractures. A comparison of self-report with X-ray reports (the gold standard) was not feasible. Instead, we have attempted to quantify self-report (in-) accuracy in two other ways: first, by showing over-reporting of fractures at rounded ages (Fig. 1). This phenomenon distorts the time distribution rather than the overall number of reported events. The second self-report inaccuracy we have quantified is fall-off over time. Recent events were recalled more accurately than events that occurred longer ago.

Conclusions

Self-report surveys provide a feasible alternative to hospital-records and X-ray records research for establishing fracture incidence; however, when lifetime fractures are reported, using only fractures reported to have occurred in the last year minimises bias due to poor recall. The results of this study indicate that the pattern of fracture incidence among adult Thai Cohort Study participants between 20 and 60 years is similar to that reported for Western countries such as the US and the UK. Overall, we see fracture in Thailand is a larger burden for younger men and older women but we need more background information before we can understand better the environmental and personal factors that account for

this age and sex pattern of occurrence. Such analyses will be the focus of future reports from the Thai Cohort Study.

Competing Interests

The authors declare that they have no competing interests.

Authors' contributions

JG and RM analysed the data and conceptualized and drafted the manuscript. SS and AS designed and instituted the Thai Health-Risk Transition research project and helped the data analysis and interpretation for this report. All authors read and approved the final manuscript.

Funding

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Figure Legends

Figure 1. Top: Histogram of Thai Cohort Study participant age. Bottom: Histogram of the total lifetime fractures reported by Thai Cohort Study participants: over-reporting of fractures can be seen at ages such as 10, 15, 18, 25, 30, 35 and 40

Figure 2. Fracture incidence calculated using a recall period of 1 through to 10 years. Results are shown for fractures that were reported to occur between the ages 20 to 30, 30 to 40 and 40 to 50.

Figure 3. Overall fracture incidence for men and women for a recall period of one year. Error bars represent 95% confidence intervals.

Authors' contributions

JG and RM analysed the data and conceptualized and drafted the manuscript. SS and AS designed and instituted the Thai Health-Risk Transition research project and helped the data analysis and interpretation for this report. All authors read and approved the final manuscript.

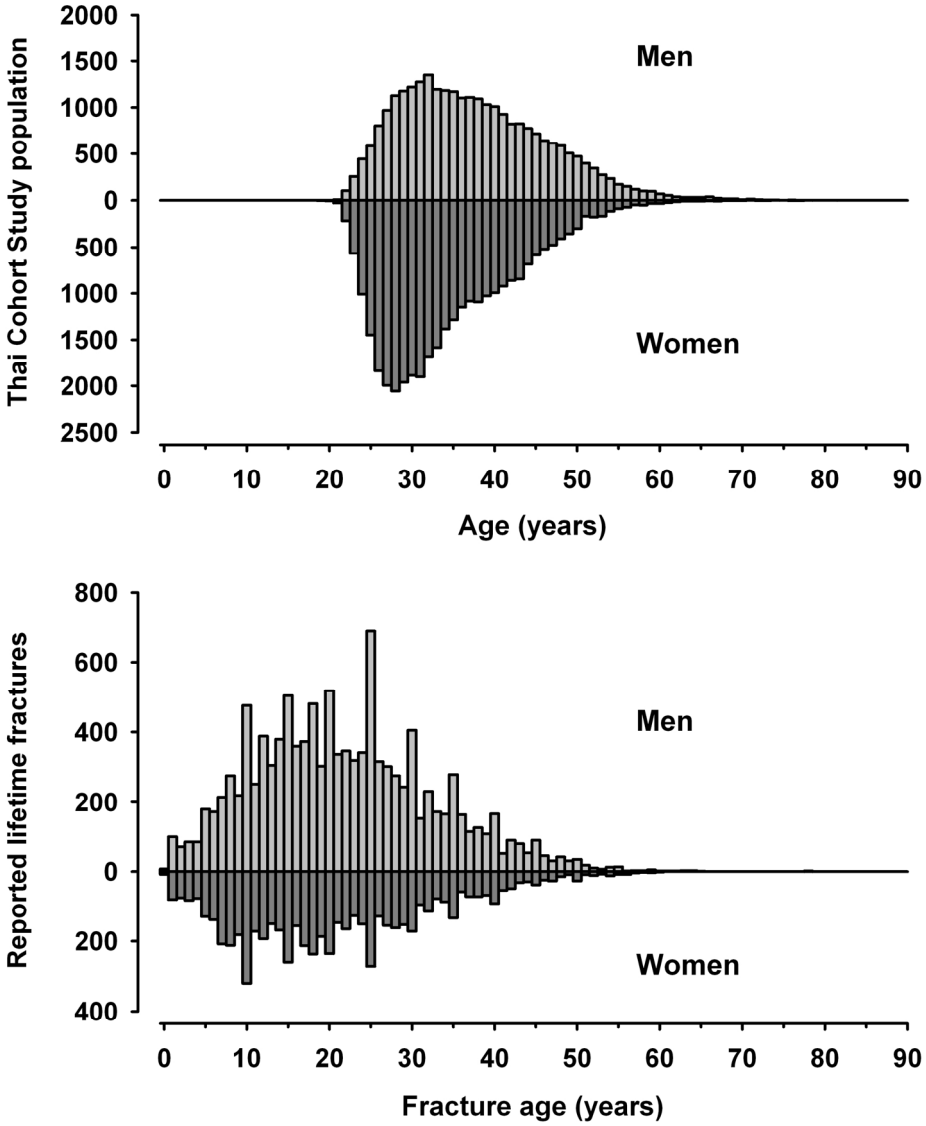

Figure 1. Top: Histogram of Thai Cohort Study participant age. Bottom: Histogram of the total lifetime fractures reported by Thai Cohort Study participants: over-reporting of fractures can be seen at ages such as 10, 15, 18, 25, 30, 35 and 40
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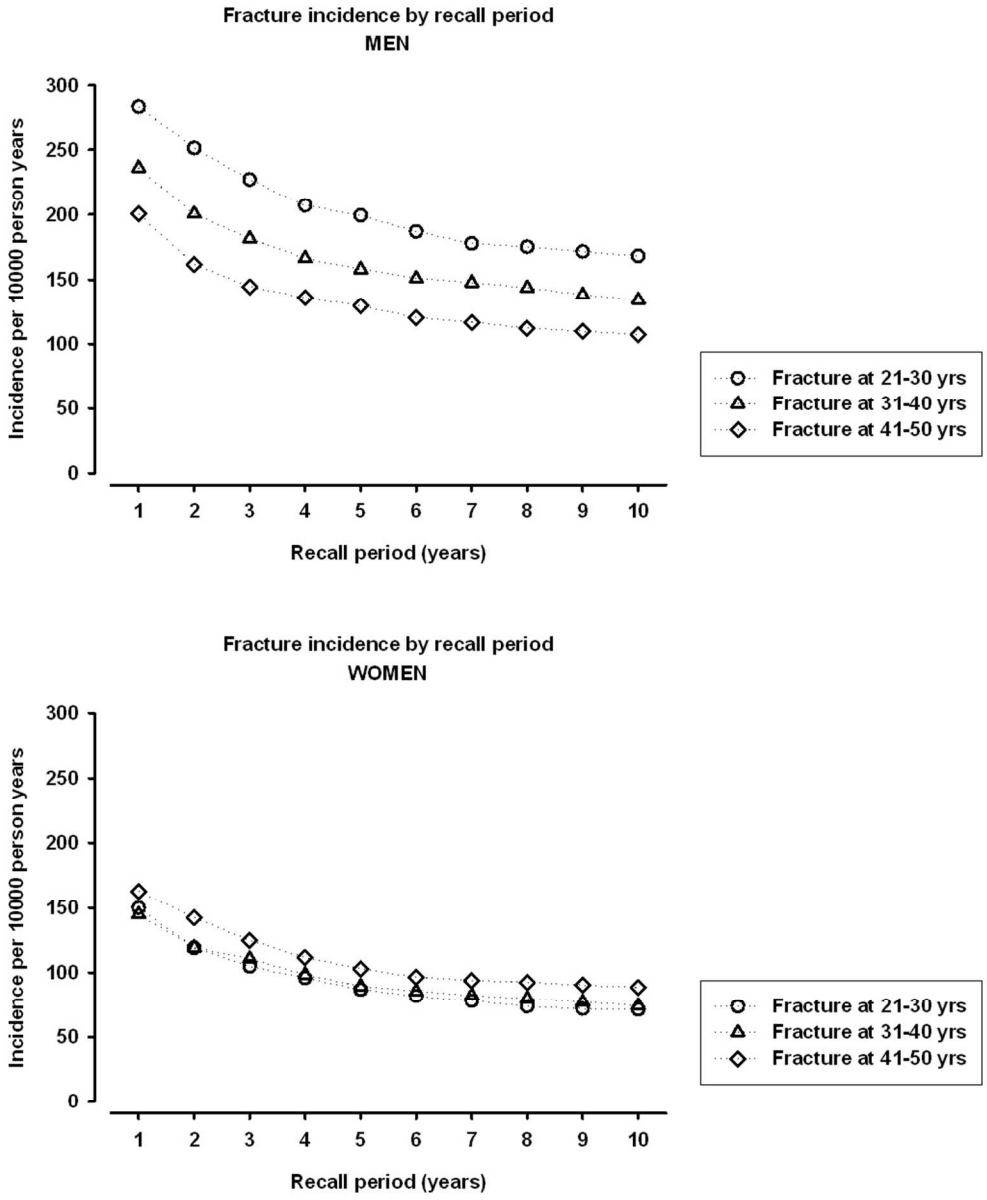

Figure 2. Fracture incidence calculated using a recall period of 1 through to 10 years. Results are shown for fractures that were reported to occur between the ages 20 to 30, 30 to 40 and 40 to 50.
173x210mm (150 x 150 DPI)

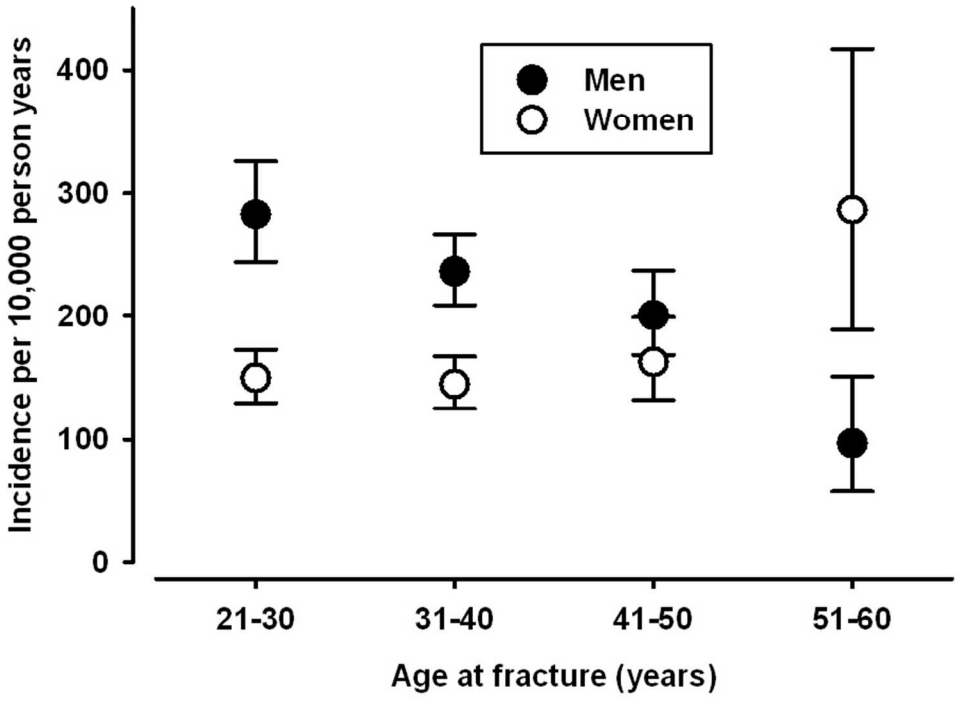

Figure 3. Overall fracture incidence for men and women for a recall period of one year. Error bars represent 95% confidence intervals.

160x124mm (150 x 150 DPI)

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

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	5
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	5
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6
Objectives	3	State specific objectives, including any pre-specified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-9
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	8-9
Bias	9	Describe any efforts to address potential sources of bias	9
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	9
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	n/a

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	9
Results			
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	9-10
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9-10
		(b) Indicate number of participants with missing data for each variable of interest	9
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	-
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	-
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	9-10
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	
		(*b*) Report category boundaries when continuous variables were categorized	9-11
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9-11
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13-14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
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	15-16

*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.