Constituent country inequalities in myocardial infarction incidence and case fatality in men and women in the United Kingdom, 1996–2005

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ABSTRACT

Background Understanding myocardial infarction (MI) incidence and case fatality trends across the four UK constituent countries is of importance following devolution of the government of health-care services.

Methods Retrospective cohort study using a primary care database (5.19 million patients) examining trends in incidence of first MI and 30-day case fatality.

Results From 1996 to 2005, the incidence of MI decreased in all countries, but reductions were greater in England (men, −3.1%; women, −2.8%) and Wales (men, −3.3%; women, −4.6%) than in Scotland (men, −1.9%; women, −0.6%) and Northern Ireland (men no change, women, −0.8%) (average annual percentage change). Greater reductions in England and Wales than Scotland and Northern Ireland meant a widening of north–south difference in MI incidence over the study period. Downward trends in 30-day case fatality were found in each country but less regional variation was evident (England men, −12.0%, women, −11.0%; Wales men, −18.4%, women, −12.6%; Scotland men, −9.5%, women, −9.0%; Northern Ireland men, −8.6%, women, −13.0%).

Conclusion From 1996 to 2005, downward trends in the incidence of first MI and 30-day case fatality were evident in each constituent country. Greater improvements in case fatality, compared with incidence, were found within each country.

Keywords case fatality, incidence, myocardial infarction, trends, United Kingdom

Introduction

Acute myocardial infarction (MI) is the major cause of coronary heart disease (CHD) morbidity and mortality. Each year in the UK, there are approximately 67 000 MIs in men and 46 000 MIs in women of all ages,[1] but there is little information available on constituent country differences in incidence and case fatality, or how these differences may have changed over time.[1–3]

Over the past two decades, marked declines in acute coronary event rates and 1-month case fatality have been reported in some UK populations. For example, annual relative declines in MI incidence between 2 and 4% per year since the early 1980s were noted among men and women in Belfast and Glasgow.[4] The British Regional Heart Study reported a 3.5% age adjusted annual relative decline in the incidence of first major CHD event (including fatal and non-fatal MI and cardiac death) among men from 1978/80 to 1998/2000, accompanied by a 1.4% annual relative decline in 28-day case fatality.[5] The Scottish Morbidity Record Database also reported evidence of marked declines in 30-day case fatality in men and women in Scotland between 1986 and 1995.[6]

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Since 1998, government of health services across the UK has been devolved to each of the four constituent countries,[7–10] and this has lead to different National Service Frameworks for CHD in England,[11] Wales[12] and Scotland.[13] Understanding of the extent of geographical variations in MI incidence and case fatality relies upon comparing results from a number of individual studies carried out in localized areas of the UK. Comparison across studies is difficult due to the variety of case definitions and populations investigated.[14,15] Furthermore, the majority of studies were completed before the introduction of respective National Service Frameworks for CHD[11–13] and may not reflect current CHD trends at a constituent country level.

Using data from a representative primary care database,[16] we examined trends in MI incidence and case fatality among men and women in the four UK constituent countries, and changes to constituent country differences over the period 1996–2005.

Methods

Data source

The Health Information Network (THIN) is a large primary care database comprising patient data from general practices (GPs) across the UK. The data extracted for this study was from the version THIN314, which comprised data from 314 general practices, giving a combined total of 5.19 million patients, representing approximately 3% of the UK population. Approximately 50% of practices in THIN also report to the General Practice Research Database (GPRD), a validated primary care database. A comparison of the strength of established associations in THIN practices, which do not report to GRPD and those which do, showed similar results.[16] The prescription rate, general practitioner consultation rate, pregnancy rate and death rate in THIN are comparable with published estimates.[17] The geographical distribution of the adult population (>34 years) in THIN was comparable to the UK population distribution in 1996, 2000 and 2006 (2000 figures: UK population 84% England, 5% Wales, 9% Scotland, 4% North Ireland; THIN population 85% England, 5% Wales, 6% Scotland, 3% N Ireland).[18] The age and sex distribution of each country's THIN population was representative of the respective country's population estimates.

Case definition

Read Clinical Classification codes indicative of an incident MI or a previous MI were selected by a clinician (L.S.) from a wider list of CHD codes identified by the following criteria.

(i) Beginning G3% or Gyu3% (excluding aneurysm of heart (G341%) and cardiac syndrome (G37%)).

(ii) Identified using the following keywords and their derivatives: coronary, angina, MI, ischaemic, heart attack, ischaemic chest pain, atherosclerotic.

(iii) Identified in the Department of Health CHD indicator set.[19]

Mi incidence

All patients who had their first MI after their index date (the patient registration date or the date the GP was computerized and contributing data) between 1 January 1996 and 31 December 2005 were selected ($N = 30,139$). To control for delayed recording of past MI events in newly registered patients, patients whose first MI was recorded within 30 days after registration were excluded ($n = 564$, 1.9%).[20] A sensitivity analysis showed MI recording rates levelled after 30 days and it was not necessary to exclude a longer period. Patients with a clinical diagnosis indicating a history of MI recorded on or before the first incident MI ($n = 137$, 0.5%) and those aged less than 35 years on their first MI date ($n = 123$, 0.4%) were also excluded.

Annual incidence was calculated as the number of patients who had their first MI recorded in each year divided by the THIN mid-year adult (>34 years) population for that year.

Given the difficulty in choosing a relevant time period to measure factors among non-MI patients, explanatory factors for constituent country differences in MI incidence were not examined.

30-day case fatality

The annual 30-day case fatality[14] was calculated as the number of patients who died within 30 days of their first MI in each year divided by the total number of patients who had their first MI in that year.

Case fatality may be under-estimated due to under-recording of death in primary care. Within THIN, each practice has been assigned a year from which death reporting is acceptable (by comparing the observed number of deaths in the general practice with that expected, according to national mortality statistics and the demographic structure of the practice).[21] To prevent survivor bias patients who had their first MI event recorded before the practice acceptable mortality reporting year were excluded from the case fatality analysis ($n = 1723$, 5.7%).

Examining determinants of geographic variations in case fatality

Explanatory variables examined were: age group; history of hyperlipidaemia, hypertension, renal disease, active liver disease, CHD (clinical CHD diagnoses or an average of more than one nitrate prescription per year), diabetes (medical diabetic event or prescriptions for diabetic medication (section 6.1

of the British National Formulary[22])); prescribed a lipid lowering medication before the first MI (section 2.12 of the British National Formulary excluding dextrothyroxine sodium); smoking and alcohol status (determined at patient index date); body mass index (BMI); socio-economic deprivation quintile (by assigning individual patient addresses (2006 data) to area indicators of socio-economic deprivation derived from 2001 census information and available at the level of output area[23]).

Each variable was recorded for all patients with the exception of smoking (33.5% missing), alcohol consumption (11.8% missing), BMI (15.0% missing) and socio-economic deprivation (17.9% missing).

Statistical analyses

Direct standardization was used to calculate the age-standardized MI incidence and case fatality by applying age group (35–39 etc. to 85+ years) specific risks stratified by sex to the Office for National Statistics 2004 population estimates for the UK[24] (incidence calculations), or the distribution of first MI cases in the UK in 2004 (THIN data) (case fatality calculations). The average annual percentage change in risk for age standardized rates (MI incidence and case fatality as calculated above) was investigated using Poisson regression using the denominator as the offset, and the number of cases or events as the outcome, and including calendar year as a continuous variable. In order to smooth random fluctuation over time, risks were calculated as 3 yearly weighted averages (e.g. 1997 represents the average age standardized risks from 1996 to 1998 calculated as $((n1996 + n1997 + n1998)/(N1996 + N1997 + N1998))$, where n is the age standardized expected number of deaths and N is the standard population denominator. Standard errors and 95% confidence intervals (CI) for the standardized risks were calculated using standard methods.[25]

For the more detailed regional analysis over two time periods (1996–2000 and 2001–2005) (i) Poisson regression was used for the MI incidence outcome and (ii) logistic regression for the case fatality outcome. All analyses were stratified by gender. We carried out tests for interaction by fitting models that contained interaction terms of time with constituent country. For both, multilevel (mixed effects analysis) modelling was used to take into account patient clustering within practices.[26]

Results

Incidence of first MI: trends and differences between constituent countries

Between 1996 and 2005, 29 315 (62.1% male) patients diagnosed with their first MI were identified. Downward trends in the age standardized incidence risk of first MI were found in men and women in each constituent country, with the exception of men in Northern Ireland. Temporal trends were significantly different in each region. The largest declines in the age standardized incidence of first MI were found in Wales and England (Table 1). There was some evidence of a downward trend in MI incidence in men and women in Scotland and among women in Northern Ireland, but the average annual relative percentage changes were smaller than observed for Wales and England (Table 1).

In each year, over the period 1996–2005, the age standardized incidence of first MI was lower in Wales and England compared with Scotland and Northern Ireland (Table 2). In 1996/2000, the age adjusted incidence risk among men in Scotland and Northern Ireland was 24.8% (95% CI: 4.9–48.6%) and 22.0% (95% CI: −2.7% to 53.0%), respectively, greater than in England. In 2001–2005, this increased to 32.9% (15.3–53.2%) and 31.1% (8.3–58.7%), respectively (Table 2). The change in risk ratio for men in Scotland compared with England was statistically significant ($P = 0.031$). A similar pattern was found among women, but these changes were not statistically significant when time-trends across periods were compared between constituent countries (Table 2).

30-day case fatality: trends and differences between constituent countries

Of the 27 592 patients included in the case fatality analysis, 4336 (15.7%) died within 30 days of their first MI. Temporal trends were significantly different in each region. Steep downward trends in the age standardized 30-day case fatality were evident in men and women in Wales, England and Scotland. In England and Scotland the average annual relative percentage decrease in case fatality was 10–12% per year in men and women, but greater declines were found in Wales (Table 1).

Results suggest a possible reduction in constituent country differences in 30-day case fatality following first MI in patients diagnosed over the period 1996–2000 compared with 2001–2005, as the odds ratios moved closer to the null (Table 3). Significant changes in the odds ratios over time among men in Wales, compared with England, were found. In 2001–2005 there was some evidence to suggest that the odds of 30-day case fatality among men in Wales was lower than in England, but some of this difference was accounted for by area level deprivation and smoking status (Table 3). Significant changes in the odds ratios over time among women in Northern Ireland, compared with England, were also found (Table 3).

Table 1 Age standardized myocardial infarction incidence and case fatality in 1996, 2000 and 2005 in the adult population (>34 years) and average annual percentage change from 1996 to 2005, by constituent country and gender

Gender	Constituent country	Incidence of first MI				30-day case fatality			
		1996 Age standardized[a] (per 1000 pop, 95% CI)	2000 Age standardized[a] (percentage, 95% CI)	2005 Age standardized[a] (per 1000 pop, 95% CI)	Average annual percentage change[b]	1996 Age standardized[c] (percentage, 95% CI)	2000 Age standardized[c] (percentage, 95% CI)	2005 Age standardized[c] (percentage, 95% CI)	Average annual percentage change[b]
Men	England	3.5 (3.4, 3.7)	3.2 (3.0, 3.3)	2.3 (2.2, 2.4)	−3.1* (−3.0, −3.2)	24.3 (22.0, 26.5)	12.3 (10.7, 13.9)	7.7 (6.2, 9.3)	−12.0* (−10.7, −13.2)
	Wales	3.6 (2.9, 4.3)	3.1 (2.5, 3.7)	2.4 (1.9, 2.8)	−3.3* (−3.2, −3.4)	24.1 (14.5, 33.7)	15.7 (9.8, 21.6)	3.9 (−0.3, 8.1)	−18.4* (−17.1, −19.7)
	Scotland	4.4 (3.6, 5.1)	4.2 (3.6, 4.9)	3.0 (2.4, 3.5)	−1.9* (−1.9, −2.0)	25.3 (18.1, 32.5)	16.3 (10.5, 22.1)	10.2 (4.4, 16.0)	−9.5* (−8.4, −10.6)
	Northern Ireland	3.5 (2.6, 4.4)	3.4 (2.6, 4.2)	3.5 (2.7, 4.3)	0** (0, 0.1)	13.6 (4.3, 22.8)	15.0 (7.3, 22.7)	15.0 (7.3, 22.6)	−8.6* (−7.4, −8.6)
Women	England	1.9 (1.7, 2.0)	1.6 (1.5, 1.7)	1.3 (1.2, 1.4)	−2.8* (−2.7, −2.9)	30.2 (27.1, 33.3)	16.4 (13.9, 18.9)	9.5 (7.7, 11.3)	−11.0* (−9.6, −12.4)
	Wales	1.9 (1.5, 2.4)	1.7 (1.3, 2.1)	1.1 (0.8, 1.4)	−4.6* (−4.5, −4.7)	30.9 (16.2, 45.5)	30.2 (19.3, 41.1)	3.8 (−1.5, 9.1)	−12.6* (−11.2, −14.0)
	Scotland	2.3 (1.7, 2.8)	2.6 (2.1, 3.1)	2.2 (1.7, 2.6)	−0.6* (−0.5, −0.7)	37.4 (25.3, 49.6)	31.9 (22.3, 41.6)	17.2 (10.1, 24.3)	−9.0* (−7.7, −10.2)
	Northern Ireland	2.9 (2.1, 3.7)	2.2 (1.5, 2.8)	2.4 (1.8, 3.1)	−0.8* (−0.7, −0.9)	42.7 (29.4, 56.0)	35.4 (23.5, 47.2)	20.5 (10.5, 30.6)	−13.0* (−11.7, −14.3)

[a]Age standardized to the ONS UK 2004 population estimates (35 to 85+ years) using 5 yearly age groups (35 to 85+ years).

[b]From Poisson regression: average annual percentage change over the period 1996–2005 relative to the rate in 1996.

[c]Age standardized to the age and sex distribution of incident cases in the UK in 2004 in THIN using 5 yearly age groups (35 to 85+ years).

*$P < 0.001$, **$P = 0.324$. Interaction between calendar year and constituent country: MI incidence men and women: $P < 0.001$, case fatality men and women: $P < 0.001$.

Table 2 Poisson risk ratio for the incidence of first MI in adult (>34 years) men and women, comparing Wales, Scotland and Northern Ireland to England, over the period 1996–2000 and 2001–2005

	Time period	1996–2000			2001–2005		
	Constituent country	Number of first incident MI events	Risk ratio[a] (95% CI)	P-value	Number of first incident MI events	Risk ratio[a] (95% CI)	P-value
Men	England	7581	1		7436	1	
	Wales	503	1.06 (0.86, 1.30)	0.610	553	1.07 (0.91, 1.25)	0.436
	Scotland[b]	644	1.25 (1.05, 1.49)	0.012	730	1.33 (1.15, 1.53)	<0.001
	Northern Ireland	345	1.22 (0.97, 1.53)	0.086	389	1.31 (1.08, 1.59)	0.005
Women	England	4580	1		4360	1	
	Wales	339	1.19 (0.93, 1.53)	0.164	336	1.09 (0.90, 1.33)	0.366
	Scotland	457	1.46 (1.18, 1.80)	<0.001	528	1.63 (1.37, 1.93)	<0.001
	Northern Ireland	231	1.37 (1.04, 1.81)	0.024	260	1.52 (1.21, 1.91)	<0.001

[a]Multilevel Poisson regression risk ratio and 95% CI for the risk ratio adjusted for calendar year and age group.
[b]Interaction of period with the effect of Scotland (relative to trends in England): $P = 0.047$.

Table 3 Odds ratio for 30-day case fatality following first MI in adult (>34 years) men and women, comparing Wales, Scotland and Northern Ireland to England, over the period 1996–2000 and 2001–2005

	Time period	1996–2000			2001–2005		
	Constituent country	Number of deaths[a]	Odds ratio[b] (95% CI), P-value	Adjusted odds ratio[c] (95% CI), P-value	Number of deaths[a]	Odds ratio[b] (95% CI), P-value	Adjusted odds ratio[c] (95% CI), P-value
Men	England	1175	1	1	738	1	1
	Wales[d]	68	1.02 (0.45, 2.32), 0.963	1.27 (0.58, 2.76), 0.548	33	0.58 (0.29, 1.19), 0.140	0.65 (0.29, 1.42), 0.280
	Scotland	123	1.74 (0.90, 3.39), 0.101	1.35 (0.67, 2.74), 0.403	91	1.59 (0.90, 2.80), 0.112	1.73 (0.90, 3.34), 0.101
	Northern Ireland	51	1.51 (0.58, 3.90), 0.401	1.49 (0.59, 3.73), 0.395	34	0.82 (0.35, 1.94), 0.639	0.76 (0.29, 1.97), 0.572
Women	England	979	1	1	648	1	1
	Wales	52	1.00 (0.46, 2.16), 0.994	1.97 (0.81, 4.76), 0.132	43	0.95 (0.48, 1.90), 0.879	0.81 (0.35, 1.86), 0.621
	Scotland	122	1.78 (0.95, 3.31), 0.071	1.90 (0.97, 3.72) 0.062	96	1.76 (1.00, 3.09), 0.050	1.52 (0.75, 3.10), 0.248
	Northern Ireland[e]	54	1.95 (0.82, 4.62), 0.127	1.97 (0.81, 4.76), 0.132	29	0.90 (0.39, 2.09), 0.819	0.91 (0.33, 2.44), 0.837

[a]30-day case fatality.
[b]Multilevel logistic regression odds ratio and 95% CI for the odds ratio adjusted for calendar year and age group at first MI diagnosis.
[c]Multilevel logistic regression odds ratio and 95% CI for the odds ratio adjusted for calendar year, age group at first MI diagnosis, smoking status and area socio-economic deprivation quintile.
[d]Interaction between the effect of period and the effect of Wales (relative to trends in England), adjusted for age group, $P = 0.067$; adjusted for age group, smoking status and area socio-economic deprivation quintile, $P = 0.048$.
[e]Interaction between the effect of period and the effect of Northern Ireland (relative to trends in England) adjusted for age group $P = 0.001$; adjusted for age group, smoking status and area socio-economic deprivation quintile, $P = 0.022$.

Discussion

Main findings of this study

Between 1996 and 2005, downward trends in the incidence of first MI and 30-day case fatality were found in men and women in all four UK constituent countries. The magnitude of the decline in MI incidence was greater in England and Wales than in Scotland and Northern Ireland, which may reflect a widening of constituent country differences in MI

incidence. Whereas constituent country differences in 30-day case fatality from 1996 to 2005 were reduced.

Over the period 1996–2005, declines in age standardized incidence of first MI in men and women were found in Scotland (men −1.9%/year, women −0.6%/year) and Northern Ireland (men no change, women −0.8%/year). These results differ from the MONICA study that reported an upward trend in age standardized incidence of major coronary events in Glasgow (men 1.4%, women 0.2%), and much greater annual relative declines in age standardized incidence of major coronary events in Belfast (men −4.6%/year, women −1.4%/year). However, the MONICA study was completed in a much younger population (aged 35–64 years) and in an earlier time period (from the mid-1980s to the 1990s). Hence, these differences along with differences in the case definition of major coronary events (MONICA study definition includes coronary death) render direct comparisons of trends rather difficult.

The crude risk of death within 30 days following a first incident MI was greater in Scotland compared with England, although the difference was not statistically significant after controlling for explanatory variables. A greater case fatality in Scotland may reflect underlying differences in the prevalence of risk factors, in particular a higher prevalence of smoking.[27] Constituent country differences in case fatality may also reflect differences in acute coronary care. For example, in the MONICA study populations over the period 1988–1993, higher case fatality in Glasgow compared with Belfast was attributed to the shorter delay between coronary event onset and access to care in Belfast, as well as other differences in coronary care pathways.[15]

In Wales, 30-day case fatality among men declined to lower than that found in England from 2001 to 2005. Caution is needed when interpreting this result. One might consider that poorer death recording by general practices in Wales might lead to an artefactual downward trend in case fatality in our data. However, in supplementary analyses we found the number of deaths recorded by GPs in Wales was consistent with the number of expected according to national mortality statistics and the demographic structure of the GP population over this period. Changes in short-term case fatality is more likely to reflect access to medical care and rapid treatment as well as changes in diagnostic thresholds, rather than changes in risk behaviours. One might consider the devolution of the National Assembly for Wales in 1999 and the respective introduction of the National Service Frameworks for CHD in England in 2000 and Wales in 2002 to have contributed to regional variations in case fatality trends, but the key aims and objectives of these frameworks were similar.[11,12] The sharp downward

trend in case fatality in Wales from 2001 warrants further investigation before conclusions can be drawn.

Limitations of this study

The representativeness and generalizability of the data from each constituent country may be questioned. General practices voluntarily electing to participate in THIN, thus excluding patients who are not registered with a general practice participating in THIN. However, 99% of the total UK population is registered with an NHS GP,[28] and the age and sex distribution of the population within each constituent country in THIN was shown to be representative of each country's population. External validation of the MI incidence estimates for Scotland showed rates in THIN were comparable to that reported by the Information Services Division for men and women aged 45–64 years in 2000 (men, 4.5 per 1000; women, 1.48 per 1000) and 2005 (men, 3.5 per 1000; women, 1.17 per 1000).[29]

MI diagnosis and death in a patient's primary care record is usually based on a hospital discharge letter or a diagnosis made directly by the general practitioner, and then recorded onto the database using READ codes. MI incidence may be under-estimated if a diagnosis is not recorded on the patients' electronic record, or over-estimated if there is retrospective recording of past MI events in newly registered patients. However, numerous studies have confirmed the validity of MI and death recording in primary care databases[16,30–32] and have used THIN to investigate risk factors for MI.[33,34] In GPRD, a primary care database comparable to THIN,[16] recording of an MI event could be confirmed by supporting evidence elsewhere in the medical records in 87% of patients,[31] and defining MI events using READ codes had a positive predictive value of 93% with the electronic event date recorded within 15 days of the actual event date in 90% of cases.[32] Validity of MI diagnosis in THIN had been reported to be over 95%.[35–37] In this study, exploratory analysis demonstrated exclusion of MI events recorded within the first month after patient registration date limited the effect of retrospective recording of past MI events in newly registered patients.

The validity of case fatality trends relies upon the accuracy of recording patient death and the date of death. In a primary care database death rates may be under-estimated due to under-recording of patient death, but the all cause mortality rate in THIN is comparable with national estimates (in 2000; THIN 10.29 per 1000 population, UK 10.33 per 1000).[17] Case fatality may be under-estimated if the death is not recorded on the patient record, or the date of death is incorrect (i.e. not within 30 days). To prevent such survivor bias in this analysis, MI events recorded

before the general practice acceptable mortality reporting year were excluded.[21] Over the study period, there have been changes to the clinical criteria used to define an MI event,[38] which may effect case fatality estimates.[39] It may be considered that downward trends in case fatality are due to increased recording of milder MI events, but if this was true then an increase in the recording of MIs would be expected. Our results indicate the opposite: marked declines in case fatality accompanied by downward trends in the incidence of first MI. Lastly, information on a patients' history of chronic disease and risk behaviour may not be recorded on the patient record. This may under-estimate the proportion of patients with a history of disease and weakens the association between explanatory variables and 30-day case fatality.

What is already known on this topic

Downward trends in acute coronary event rates and 1-month case fatality over the 1990s have been reported in some UK populations.[4–6] However an understanding of geographical variations in MI incidence and case fatality relies upon comparing results from a number of individual studies carried out in localized areas of the UK, making comparison difficult due to the variety of case definitions and populations investigated.[14,15]

What this study adds

The strength of this research is that it is the first population-based study to examine the trends in the incidence of first MI and 30-day case fatality in men and women across all four UK constituent countries using a single data set. Over the period 1996–2005, downward trends in the incidence of first MI and 30-day case fatality are evident in each constituent country of the UK. Greater improvements in 30-day case fatality compared with incidence of MI were found in each constituent country, which may reflect greater improvements in acute coronary care than changes to underlying risk behaviours and CHD prevention.

Future information on constituent-country specific trends will be of increasing interest, following devolution of the governing of health across the four constituent countries of the UK.

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