Introduction

In the UK, the steady decline in death rates from coronary heart disease (CHD) seen since the 1970s has continued in recent years. Between 1994 and 2004, death rates decreased by approximately 30% in those aged 35–55 years and by approximately 50% in those aged greater than 55 years. Yet CHD remains the leading cause of death among men and women in the UK. There is also some evidence of decline in the incidence of first, and new and recurrent major CHD events (myocardial infarction or coronary death) in the UK during the 1980s and 1990s.

If the decline in mortality outweighs the decline in the incidence of newly diagnosed CHD, then the prevalence of CHD will increase, resulting in a greater burden of disease in the population. There is some evidence to suggest that the prevalence of CHD increased in men and women in England and Wales during the 1990s. However, the joint effects and respective contributions of changes in incidence and mortality on prevalence are unclear. An understanding of such patterns is important because the strategies to reduce incidence (largely primary prevention) differ from strategies to reduce mortality among patients with existing disease (largely secondary prevention).

Using data from a representative UK primary care database, we determined the incidence of first CHD diagnosis, CHD prevalence, and all-cause mortality among men and women diagnosed with CHD from 1996 to 2005. We then examined the contribution of changes in incidence and mortality to trends in prevalence in this population.

Methods

Data source

The Health Information Network (THIN) is a large primary care database compiled of patient data from a number of voluntarily participating general practices across the UK. All participating practices contribute demographic, medical, and therapeutic data to THIN for all patients on their practice register. At the time of this study, 314 general practices were contributing data to THIN, providing data for 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, e.g. hypertension and stroke, in THIN practices which do not report to GPRD to THIN practices

* Corresponding author. Tel: +44 20 7299 4762; fax: +44 20 7299 4637. E-mail address: alisha.davies@lshtm.ac.uk

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which do report to GRPD reported similar results from both sets of general practices. The prescription rate, general practitioner consultation rate, pregnancy rate, and death rate in THIN are comparable with published estimates. In addition, CHD prevalence in THIN, as defined by the Quality and Outcomes Framework (QOF), was comparable with the QOF national level. The mean number of years a general practice contributed to THIN was 14.7 years, and the mean period of registration for a patient was 6.7 years.

Study population
All adult patients permanently registered with participating general practices from 1996 to 2005. Year of birth, but not month or exact date, was available for all patients, so age was calculated using the 1st of July of the birth year as the birthday. Patients aged less than 35 years at CHD diagnosis were excluded.

Case definition
Patients were selected from the following two categories:

(1) those who had a clinical CHD diagnosis—identified using a Read Clinical Classifications code list which included all Read codes beginning G3% or Gyu3% [excluding aneurysm of heart (G341%) and cardiac syndrome (G37%)]; all codes identified using the following keywords and their derivatives—coronary, angina, myocardial infarction, ischaemic, heart attack, ischaemic chest pain, atherosclerotic—and all codes identified in the Department of Health CHD indicator set\(^{10}\); and

(2) those having an average of more than one nitrate prescription per year.

A sensitivity analysis showed little change in the use of different CHD Read codes over the period 1996–2002. From 2002 to 2005, there was decreasing use of Read codes denoting ischaemic heart disease (G3.00) and angina pectoris (G33.00) and increasing use of Read codes for CHD monitoring (beginning G90b) and annual review (G6A2.00).

Observation period
For each patient, the start of the observation period was the later of either the date the patient registered with a participating general practice or the date the practice was computerized and starting contributing data to the database. The end date was the earliest of the date of: death; transferring care to another general practice; last data collection from the general practice; or the 31st December 2005.

Coronary heart disease onset date
The CHD onset date was the earliest of either the first CHD diagnostic Read code recorded or the first nitrate prescription or the date of death from CHD.

Coronary heart disease prevalence
Prevalence was calculated as the number of patients (aged \(>34\) years) under observation on the 1st of July of each year with CHD onset prior to the 1st of July divided by the mid-year total adult (aged \(>34\) years) population in the THIN database.

Coronary heart disease incidence
In order to exclude retrospective recording of previously diagnosed CHD in newly registered patients, the first 12 months since registration was excluded from the incidence analyses. Incident cases were defined as adults whose CHD onset date was on or after the patient start date plus 365 days. Patients whose CHD onset date was on or before the start date and patients whose first recorded CHD diagnosis was evidence of past CHD diagnosis (e.g. angina following myocardial infarction) were included in the prevalence estimates but not as incident cases. Annual incidence risk was calculated as the number of incident cases (aged \(>34\) years) divided by the mid-year total adult population in THIN.

All-cause mortality in those with coronary heart disease
All-cause mortality among the population of people with CHD was calculated as the proportion with prevalent disease at the mid-point of each year (1st of July) who died in each year.

Further life expectancy
Further life expectancy (LE) was calculated for the population of people with CHD and the UK population aged \(>34\) years over the period 1996–2002 (information on all-cause mortality and population totals for the UK were available for these years only\(^{15}\)). Sex- and age-specific all-cause mortality rates were calculated for 5 year age groups (35–39 to 85+ years) and an abridged period life table constructed. In line with established practice, the average number of person-years lived in the last open-ended interval was estimated as the proportion of the population surviving to age 85 divided by the age-specific death rate.\(^{13}\)

Statistical analyses
All rates were calculated for men and women in 10 year age bands. Direct standardization was used to calculate age-standardized rates for men and women by applying age-specific rates (single years) to the Office for National Statistics (ONS) 2004 population estimates for the UK (standard population).\(^{14}\) The 2004 population estimates rather than the 2001 population census figures were used, as the estimates are adjusted for known errors and are a more recent representation of the UK population structure. Trends over time were investigated using Poisson’s regression to determine the annual change in risk and 95% confidence interval (CI) for the change with each single increase in year.

Examining the effect of changes in incidence and mortality on prevalence
The effects on prevalence were estimated for three possibilities and results compared with the observed prevalence for the period 1996–2005:

(1) holding incidence and mortality constant at the 1996 rates, i.e. the 1996 incidence rates were applied to the whole mid-year THIN population and the 1996 mortality rates were applied to the population with existing CHD for each year over the period 1997–2005;

(2) holding incidence constant at the 1996 rate but allowing mortality to vary according to that observed each year;

(3) holding mortality constant at the 1996 rate but allowing incidence to vary according to that observed each year.

Ethical approval
Ethical approval was granted by the South East Multi-Centre Research Ethics Committees and the London School of Hygiene and Tropical Medicine Ethics Committee.

Results
From 1996 to 2005, 188 686 (55.7% male) patients aged greater than 34 years ever diagnosed with CHD were
identified. The majority had a Read diagnostic code for CHD (93.6%), the remainder being identified on the basis of nitrate prescriptions alone. The exclusion criteria and number of patients excluded from this population for the incidence and all-cause mortality analyses are illustrated in Figure 1. Over the 10 year period, 76,091 (55.2% male) patients were newly diagnosed with CHD and there were 56,720 (53.9% male) deaths (all causes) among the population with existing CHD.

Incidence
From 1996 to 2005, the age-standardized incidence decreased from 7.6 (95% CI 7.6–7.7) to 5.6 (95% CI 5.6–5.7) per 1000 in men and from 5.5 (95% CI 5.4–5.5) to 4.1 (95% CI 4.1–4.1) per 1000 in women, an average annual decline of 2% per year in men and women (Figure 2 and Tables 1 and 2). The decline in incidence was found in the 55–64, 65–74, 75–84, and 85+ year age groups in both sexes (Tables 1 and 2).

All-cause mortality among patients with coronary heart disease
From 1996 to 2005, the age-standardized all-cause mortality rates decreased from 38.3 (95% CI 38.2–32.4) to 26.2 (95% CI 26.2–26.3) per 1000 in men and from 39.8 (95% CI 39.7–39.9) to 26.8 (95% CI 26.8–26.9) per 1000 in women, an average annual decline of 4.5% (95% CI 4.5–4.6, P < 0.001) in men and 3.4% (95% CI 3.3–3.4, P < 0.001) in women. Decreases in mortality were found in the 55–64, 65–74, and 75–84 age groups in both sexes (Tables 1 and 2).

Prevalence
Over the period 1996–2005, the age-standardized prevalence increased from 81.1 (95% CI 80.1–81.3) to 91.9 (95% CI 90.9–91.2) per 1000 in men and from 54.9 (95% CI 54.8–55.1) to 63.4 (95% CI 63.3–63.6) per 1000 in women, an average annual increase of 1.3% (95% CI 1.3–1.3, P < 0.001) per year in men and 1.7% (95% CI 1.7–1.7, P < 0.001) per year in women. The greatest increases were in the older age groups (75 years and above) (Tables 1 and 2).

Further life expectancy
From 1996 to 2002, gains in further LE among the male population with CHD were greater than in the overall male UK population (for each single calendar year increase, LE increased by 1.44 (95% CI 0.75–2.14, P = 0.003) years and 0.26 (95% CI 0.19–0.33, P < 0.001) years, respectively). This suggests that the decline in all-cause mortality among those diagnosed with CHD was greater than the decline in the all-cause mortality among the general population. There was little evidence of increasing LE among the female population with CHD, despite gains in LE in the female general population (for each single calendar year increase, LE increased by 0.38 (95% CI −0.15 to 0.90, P = 0.123) years compared with 0.15 (95% CI 0.07–0.24, P = 0.005) years).
Table 1  The average annual percentage change in risk for age-specific and age-standardized coronary heart disease prevalence, incidence of first ever coronary heart disease diagnosis, and all-cause mortality among patients with coronary heart disease in men in the UK, 1996–2005

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>CHD prevalence</th>
<th>CHD incidence</th>
<th>All-cause mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>35–44</td>
<td>−0.08; −0.90 to 0.74; 0.849</td>
<td>−0.07; −1.66 to 1.55; 0.935</td>
<td>−11.46; −17.18 to −5.35; &lt;0.001</td>
</tr>
<tr>
<td>45–54</td>
<td>−0.44; −0.76 to −0.12; 0.007</td>
<td>−0.46; −1.32 to 0.41; 0.298</td>
<td>−4.16; −6.55 to −1.70; 0.001</td>
</tr>
<tr>
<td>55–64</td>
<td>−1.02; −1.22 to −0.83; &lt;0.001</td>
<td>−2.61; −3.25 to −1.98; &lt;0.001</td>
<td>−2.30; −3.61 to −0.98; 0.001</td>
</tr>
<tr>
<td>65–74</td>
<td>1.33; 1.16 to 1.49; &lt;0.001</td>
<td>−2.31; −2.91 to −1.69; &lt;0.001</td>
<td>−3.06; −3.82 to −2.28; &lt;0.001</td>
</tr>
<tr>
<td>75–84</td>
<td>3.11; 2.92 to 3.31; &lt;0.001</td>
<td>−3.35; −4.08 to −2.62; &lt;0.001</td>
<td>−1.76; −2.37 to −1.14; &lt;0.001</td>
</tr>
<tr>
<td>85+</td>
<td>4.52; 4.12 to 4.93; &lt;0.001</td>
<td>−3.78; −5.20 to −2.33; &lt;0.001</td>
<td>−0.26; −1.09 to 0.57; 0.536</td>
</tr>
<tr>
<td>Age-standardizeda</td>
<td>1.32; 1.30 to 1.33; &lt;0.001</td>
<td>−2.20; −2.26 to −2.13; &lt;0.001</td>
<td>−4.53; −4.55 to −4.50; &lt;0.001</td>
</tr>
</tbody>
</table>

The values are annual percentage change (estimates for the annual trend over the period 1996–2005 obtained using Poisson’s regression); 95% CI; P-value.

Table 2  The average annual percentage change in risk for age-specific and age-standardized coronary heart disease prevalence, incidence of first ever CHD diagnosis, and all-cause mortality among patients with coronary heart disease in women in the UK, 1996–2005

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>CHD prevalence</th>
<th>CHD incidence</th>
<th>All-cause mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>35–44</td>
<td>1.14; −0.14 to 2.42; 0.081</td>
<td>5.04; 2.53 to 7.60; &lt;0.001</td>
<td>−8.27; −16.21 to 0.43; 0.062</td>
</tr>
<tr>
<td>45–54</td>
<td>0.96; 0.45 to 1.46; &lt;0.001</td>
<td>0.61; −0.64 to 1.87; 0.342</td>
<td>0.80; −3.87 to 5.70; 0.741</td>
</tr>
<tr>
<td>55–64</td>
<td>−0.91; −1.20 to −0.63; &lt;0.001</td>
<td>−3.31; −4.14 to −2.48; &lt;0.001</td>
<td>−3.95; −6.05 to −1.79; &lt;0.001</td>
</tr>
<tr>
<td>65–74</td>
<td>0.99; 0.78 to 1.19; &lt;0.001</td>
<td>−3.12; −3.79 to −2.44; &lt;0.001</td>
<td>−2.73; −3.83 to −1.62; &lt;0.001</td>
</tr>
<tr>
<td>75–84</td>
<td>2.45; 2.25 to 2.64; &lt;0.001</td>
<td>−2.78; −3.46 to −2.09; &lt;0.001</td>
<td>−1.10; −1.80 to −0.39; 0.002</td>
</tr>
<tr>
<td>85+</td>
<td>3.90; 3.62 to 4.18; &lt;0.001</td>
<td>−2.13; −3.13 to −1.13; &lt;0.001</td>
<td>0.15; −0.49 to 0.80; 0.642</td>
</tr>
<tr>
<td>Age-standardizeda</td>
<td>1.68; 1.66 to 1.70; &lt;0.001</td>
<td>−2.31; −2.38 to −2.24; &lt;0.001</td>
<td>−3.35; −3.38 to −3.32; &lt;0.001</td>
</tr>
</tbody>
</table>

The values are annual percentage change (estimates for the annual trend over the period 1996–2005 obtained using Poisson’s regression); 95% CI; P-value.

aStandardized to the ONS UK 2004 population estimates.

Trends in incidence, mortality, and prevalence

If incidence and mortality remained constant at the 1996 rates, the expected rise in prevalence was greater than that observed. If incidence remained constant at the 1996 rate but mortality varied according to what was observed in each year, the expected prevalence in 2005 was 93.8 (95% CI 93.0–94.5) per 1000 population in men and 65.3 (95% CI 64.7–65.9) per 1000 population in women, 2.8 and 3.0% greater than that observed prevalence in men and women, respectively. If mortality remained constant at the 1996 rate but incidence varied according to what was observed in each year, the expected prevalence in 2005 was 91.7 (95% CI 91.0–92.4) per 1000 population in men and 63.7 (95% CI 63.1–64.3) per 1000 population in women, 0.6 and 0.4% greater than that observed prevalence in men and women, respectively.

Discussion

From 1996 to 2005, the prevalence of diagnosed CHD increased by 1.3% in men and 1.7% in women per year. Over this 10 year period, decreases in the incidence of newly diagnosed CHD (annual decrease of 2.2% in men and 2.3% in women) and all-cause mortality among the CHD prevalent population (annual decrease of 4.5% in men and 3.4% in women) were found. Although there has been a reduction in the incidence of newly diagnosed CHD, this has been outweighed by the decreased mortality among patients with CHD, and prevalence has risen. However, in the absence of the changes in mortality and incidence that have occurred over this period, the rise in prevalence would have been greater than that observed.

Comparability of trends with other published sources

There are no other previous studies investigating recent trends in the incidence of newly diagnosed CHD, CHD prevalence, and all-cause mortality among the CHD-prevalent population using a single data set. The magnitude of the trends in incidence and mortality found in this study are similar to the overall results for men and women from the MONICA study (1980–1990s) average relative annual decline in the UK populations: first and recurrent major coronary event −3.0% in men and −1.1% in women; CHD mortality rate −4.2% in men and −3.1% in womena and the British Regional Heart Study (BRHS) (1978–1996 average annual change in men: first major event −2.4%; CHD mortality rates −4.1%). However, direct comparison is difficult due to differences in the study populations and case definitions. Increasing prevalence in the 1990s has been reported by Key Statistics from General Practice in England and Wales (1994–1998: men 34.4 per 1000 to 37.2 per 1000; women 20.8 per 1000 to 21.9 per 1000). More recent reports of increasing trends in CHD prevalence are found in primary care in Scotland (1997–2002: men 2.9–4.5%; women 1.8–2.9%). Increasing prevalence is reflected
by rising numbers of CHD hospital admissions in England and increases in the prescription rates of lipid regulatory drugs.16

Prevalence trends

Results show that increases in prevalence reflect longer survival in those diagnosed with CHD, as supported by evidence of decreases in all-cause mortality among patients with CHD. Decreasing trends in all-cause mortality among patients with CHD may reflect improvements in the background risk of death in the general population. However, gains in LE among the population with CHD were greater than those seen in the general population, suggesting that improvements in mortality among those with CHD is over and above the improvements in the risk of death in the general population. This is comparable with the evidence from the USA which suggests that the decline in CHD mortality from the mid-1980s to the mid-1990s was accompanied by substantial improvements in survival.17–19

Improved survival in patients diagnosed with CHD could be due to the decline in major coronary events (myocardial infarction)2–4,20 or improvements in case fatality.3,4,21

Many studies in England and Wales,22 Scotland,23 and Ireland24 have consistently shown that 50–60% of the CHD mortality decline can be explained by improvements in risk factors, principally smoking, whereas only 40% can be explained by improvements in treatment. In contrast, evidence from the MONICA studies suggests that the contribution of changes in coronary care25 to changes in case fatality and coronary event rates is greater than the contribution of changes in risk factors.26

If CHD incidence and all-cause mortality in 1996 were held constant over the years 1997–2005, the incidence rate relative to the mortality rate was such that prevalence would increase, resulting in an expected prevalence in 2005 much greater than that observed in men and women. The difference between the observed and expected prevalence was largely due to the decreasing incidence of newly diagnosed CHD rather than decreasing mortality, as small decreases in incidence in the absence of any decline in all-cause mortality resulted in an expected prevalence which closely reflected that observed.

Strengths and limitations

A key strength of this analysis is the geographical and social representativeness of THIN which enables the investigation of time trends in CHD across all age groups and both sexes in the UK. Limitations include possible selection bias due to general practices voluntarily electing to participate in THIN. However, there is evidence that the reporting behaviour of general practices in THIN approximates to the national level.9 All patients within a general practice contributing to THIN are included in the database, so there is no selection bias at the individual patient level within a participating practice. Sampling bias due to excluding patients who are not registered with a general practice participating in THIN is possible. However, THIN is representative of the UK population and it is reported that 99% of the total UK population is registered with a National Health Service GP.27 As with all primary care data sources, CHD prevalence and incidence may be under-estimated if a CHD diagnosis is not recorded on the patients’ computerized medical record.

In this analysis, patients receiving treatment for angina symptoms in the absence of a clinical diagnosis recorded for CHD were identified and included, accounting for only 6% of the total number of patients with CHD. CHD diagnoses were not validated by reviewing medical records; therefore, the data may be subject to misclassification bias. However, a validation study in a comparable primary care database (GPRD) showed 87% agreement between clinical diagnoses on patient computer and paper medical files.28 The first year after patient registration date was excluded to prevent the inclusion of retrospective diagnosis of CHD in newly registered patient from the incidence calculations. Despite this, incidence remains subject to reporting bias, owing to increased recording of diagnosed CHD possibly due to the introduction of the National Service Framework for CHD.29 Mortality may be under-estimated in THIN owing to under-recording of patient death in general practice; however, the all-cause mortality rate in THIN is comparable with national estimates (in 2000; THIN 10.3 per 1000 population, UK 10.3 per 1000).8

Conclusion and implications

This study provides valuable information on the extent to which changes in CHD incidence and mortality affect the prevalence of CHD in the UK. Increases in prevalence in the UK in men and women, especially in the older age groups, are likely to be attributable to falling CHD mortality and subsequent increased survival of patients with CHD. This would suggest that further population ageing is likely to result in further increases in prevalence, even if incidence of CHD continues to fall.30,31 A greater burden of CHD in the population is an important consideration for health care provision and planning of CHD treatment and specialist care. If adverse trends in obesity, diabetes, and physical inactivity22,24 also lead to a reversal of decline in incidence rates, or an increase in incidence, the effect will be compounded further.

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Conflict of interest: none declared.

References
