BMJ open
accessible medical research

PRESS RELEASE

UK stroke incidence, mortality and cardiovascular risk management 1999–2008: time-trend analysis from the General Practice Research Database

Sally Lee,[1] Anna C E Shafe,[1] Martin R Cowie[2]

To cite: Lee S, Shafe ACE, Cowie MR. UK stroke incidence, mortality and cardiovascular risk management 1999–2008: time-trend analysis from the General Practice Research Database. *BMJ Open* 2011;**1**: e000269. doi:10.1136/bmjopen-2011-000269

► Prepublication history and additional material for this paper are available online. To view these files please visit the journal online (http://bmjopen.bmj.com).

Received 21 July 2011
Accepted 10 August 2011

[1]MAPOR, Boehringer Ingelheim Ltd, Bracknell, Berkshire, UK
[2]National Heart and Lung Institute, Imperial College London, London, UK

Correspondence to
Professor M R Cowie;
m.cowie@imperial.ac.uk

ABSTRACT

Objectives: Stroke is a major cause of morbidity and mortality. This study aimed to investigate secular trends in stroke across the UK.

Design: This study aimed to investigate recent trends in the epidemiology of stroke in the UK. The study was a time-trend analysis from 1999 to 2008 within the UK General Practice Research Database. Outcome measures were incidence and prevalence of stroke, stroke mortality, rate of secondary cardiovascular events, and prescribing of pharmacological therapy for primary and secondary prevention of cardiovascular disease.

Results: The study cohort included 32 151 patients with a first stroke. Stroke incidence fell by 30%, from 1.48/1000 person-years in 1999 to 1.04/1000 person-years in 2008 ($p<0.001$). Stroke prevalence increased by 12.5%, from 6.40/1000 in 1999 to 7.20/1000 in 2008 ($p<0.001$). 56-day mortality after first stroke reduced from 21% in 1999 to 12% in 2008 ($p<0.0001$). Prescribing of drugs to control cardiovascular risk factors increased consistently over the study period, particularly for lipid lowering agents and antihypertensive agents. In patients with atrial fibrillation, use of anticoagulants prior to first stroke did not increase with increasing stroke risk.

Conclusion: Stroke incidence in the UK has decreased and survival after stroke has improved in the past 10 years. Improved drug treatment in primary care is likely to be a major contributor to this, with better control of risk factors both before and after incident stroke. There is, however, scope for further improvement in risk factor reduction in high-risk patients with atrial fibrillation.

ARTICLE SUMMARY

Article focus

- Regional UK data have suggested a decline in stroke incidence, in association with increased use of preventive treatments and reduction in cardiovascular risk factors.
- This is the first national study to examine recent trends in stroke incidence and mortality.

Key messages

- In the UK, stroke incidence and stroke mortality fell consistently between 1999 and 2008.
- This change coincided with a marked increase in primary care prescription of primary and secondary cardiovascular prevention therapies.
- Despite these positive findings, there appears to be a need for better risk stratification as the data suggest underutilisation of anticoagulation in patients with atrial fibrillation at high risk of stroke and lower use of all preventive treatments in women than in men.

Strengths and limitations of this study

- The General Practice Research Database (GPRD) is the largest primary care database in the world, containing the longitudinal records of over 3 million patients.
- We are reliant on the quality of general practitioner coding in the GPRD dataset. There may be some coding error and misreporting of cardiovascular events and risk factors.
- The GPRD contains secondary care data but this is limited to diagnoses; data on secondary care prescribing are not available.

BACKGROUND

Stroke is a major cause of morbidity and mortality in the UK. Around 110 000 strokes occur in England each year,[1] with recent studies reporting an incidence of between 1.36/1000/year[2] and 1.62/1000/year in 2002–2004.[3] A study in the Scottish Borders reported a higher crude incidence rate of 2.8/1000/year, which was attributed to the higher proportion of elderly subjects in the population.[4] Although deaths from stroke have fallen in the UK over the past 40 years,[5–7] stroke accounted for around 46 500 deaths in England and Wales in 2008 (9% of all deaths).[8]

Current UK health policy places great emphasis on reducing strokes.[9–11] Key to this is the need for better management of vascular risk factors, including hypertension, obesity, high cholesterol, atrial fibrillation

and diabetes.[6 11] In 2008, NHS Health Check (formerly called the Vascular Check Programme) was introduced to identify and manage vascular risk.[12] More recently, NHS Improvement has identified atrial fibrillation in primary care as a priority area for the health service for 2010/11.[13] From a public health perspective, it is important to determine whether national policies and preventive strategies are having an effect on stroke epidemiology. Perhaps the best data on trends in stroke come from the Oxfordshire region where data from two studies—the Oxford Community Stroke Project (1981–1984) and the Oxford Vascular Study (2002–2004)—were compared.[3] The results suggested a decline in the incidence of stroke (p=0.0002) in association with increased use of preventive treatments and reduction in risk factors.

There has been no study looking at trends in stroke across the UK. We report an analysis of the General Practice Research Database (GPRD) used to investigate trends in the burden of stroke between 1999 and 2008.

DESIGN

Objectives

The objectives of this study were (1) to investigate recent trends in the epidemiology of stroke in the UK, including risk factors associated with first and second strokes, and pharmacological therapies prescribed before and following a first stroke, and (2) to examine the trend in stroke fatality and the occurrence of a second stroke following survival of a first stroke.

Data source

The GPRD is a database of longitudinal patient primary care records, containing anonymised data on demographics, diagnoses, referrals, prescribing and health outcomes for patients from almost 500 general practitioner (GP) practices in the UK (over 3 million patients). The database covers approximately 6% of UK patients, and the geographical distribution is representative of the UK population.[14] Validation studies have confirmed the high data quality and completeness of clinical records within the GPRD.[15–17] A recent systematic literature review of studies using the GPRD reported that the median proportion of diagnoses correctly coded was 89%.[17]

Population

We identified patients aged 18 years and older who had a first stroke between 1999 and 2008. Stroke events were identified by a diagnosis for stroke within the patient record. The Read codes used by GPs to enter a stroke into a patient record do not necessarily specify the type of stroke, so we were not able to distinguish between ischaemic and haemorrhagic strokes. The codes used are shown in the online supplementary material. Stroke codes used were those which described acute stroke events only—any codes for monitoring or stroke rehabilitation were excluded to ensure that we correctly identified the initial stroke event and did not record follow-up of the same stroke as a secondary stroke event.

We excluded patients if they had any coded cardiovascular disease event (including coronary heart disease or peripheral vascular disease) recorded prior to stroke, except patients with a record of transient ischaemic attack.

Analysis

Data were extracted using the GPRD GOLD online version and analysed using SAS V.9.02. The incidence and prevalence of stroke were calculated based on our stroke cohort and the total study population extracted from GPRD.

Co-morbidities were identified using Read codes (see online supplementary material). In addition to coded diagnosis, a blood pressure result above 160/100 mm Hg was defined as hypertension and a cholesterol level above 5 mmol/l (193 mg/dl) was defined as hypercholesterolaemia. Pharmacological therapies prescribed in the year before the first stroke were recorded. We assumed that patients were treated with a medication if they received at least two prescriptions for that medication in the year prior to first stroke.

For follow-up, patient data were available from the time of first stroke until the end of the study period or when the patient transferred out of the practice or died. Stroke events were considered fatal if patients had a death coded in their GP record within 56 days of the stroke. This timescale was used to allow for any delay between the death occurring and the GP receiving notification of the death and entering it into their coding system.

Second cardiovascular disease events were defined as a second stroke or other cardiovascular disease event (coronary heart disease or peripheral vascular disease event) occurring more than 56 days after a first stroke. A life table survival analysis was carried out, with an event defined as either a second cardiovascular event or death. Patients were censored if they transferred out of the practice or reached the end of the study period.

We examined trends in the proportion of patients treated with different classes of pharmacological agents in the year before and after first stroke between 1999 and 2008. For patients with GP-coded atrial fibrillation (AF) prior to first stroke, we calculated $CHADS_2$ scores[9] and recorded use of anticoagulants and antiplatelet drugs for patients by $CHADS_2$ score in the year prior to and after first stroke.

RESULTS

Between 1999 and 2008, first strokes were recorded in 32 151 patients with no previous recorded cardiovascular event. Over this period, stroke incidence fell by 30%, from 1.48/1000 person-years in 1999 to 1.04/1000 person-years in 2008 (p<0.001). In patients aged 80 years and over (the group at highest risk), incidence fell by 42% from 18.97 to 10.97/1000 person-years

(p<0.001). Prevalence of stroke increased by 12.5% over the same period from 6.4/1000 persons to 7.2/1000 persons (p<0.001) (figure 1).

Table 1 shows the baseline characteristics of the cohort. The average age at first stroke was 77 years in women and 71 years in men. The most commonly coded stroke risk factor was hypertension, recorded in 65% of patients. In addition, 12% of patients were coded as diabetic, and 11% had coded AF.

Fifteen per cent (4926/32 151) of first strokes were fatal (death coded within 56 days). Mortality was 18.6% (3301 of 17 792) in women and 11.3% (1625 of 14 359) in men. Age-adjusted to the 2008 UK population,[10] the mortality difference was smaller but remained higher in women (6.8%) than men (5.5%) (p<0.001 for difference between genders). Crude mortality after incident stroke decreased from 21% in 1999 to 12% in 2008 (p<0.0001). This trend was seen in both men and women (figure 2).

Five-year survival was 82% (11 774/14 359) in men and 81% (14 411/17 792) in women. Life table survival analysis showed that survival free of a second cardiovascular event (recurrent stroke or first CHD event) at 5 years was 74% (23 766/32 151) and similar in men and women. After first stroke, patients were at high risk of a recurrent event. Of patients followed up for 5 years, 24% (3316 of 13 599) had a second cardiovascular event; 75% of second events (2475) were strokes and 16% of these (385) were fatal within 56 days.

Stroke risk factors and management

Sixty-five per cent of patients (n=20 959) had hypertension. Of these, 67% were treated with antihypertensives in the year prior to stroke (69% of female and 64% of male patients).

Prescription of treatment for cardiovascular risk reduction in the year prior to a first stroke increased over time (figure 3A). A similar trend was seen in prescriptions after the first stroke (figure 3B). By 2008, 96.6% of women and 97.4% of men with coded hypertension in the year after stroke were receiving antihypertensive therapy.

Before first stroke, 38.7% of patients (n=12 440) had hypercholesterolaemia; 8.7% were treated with lipid lowering drugs in 1999, rising to 37.6% in 2008. Prescriptions for lipid lowering drugs after a first stroke also increased rapidly over the last 10 years (figure 3).

Eleven per cent of patients (n=3483) had coded AF before their first stroke: 10% of male patients and 12% of female patients (table 1). These patients were older than the general stroke cohort. The average age in the AF group at the time of first stroke was 82 years for women and 77 years for men. Stroke mortality was higher in patients with coded AF than for the overall cohort: 27% of women and 19% of men with AF died within 56 days of their first stroke. For those over the age of 70 years, 56-day mortality after first stroke was 32% in men with coded AF compared with 23% in men without coded AF (p<0.001), and 36% in women with coded AF compared with 28% in women without coded AF (p<0.001).

Women were at higher risk, with 59% having a $CHADS_2$ score of 2 or above prior to first stroke compared with 42% of men. When we excluded age from the $CHADS_2$ calculation, women still scored higher than men: 67% of women and 59% of men had a score of 1 or above, and 18% of women and 16% of men had a score of 2 or above.

Of patients with coded AF, 25% (876) were prescribed anticoagulants before their stroke (22% of women and 29% of men). Anticoagulant prescribing did not increase with increasing $CHADS_2$ score prior to stroke (figure 4). Antiplatelet therapy was prescribed to 52% of patients with coded AF (1796/3483) (54% of women and 47% of men) and prescribing increased steeply with increasing $CHADS_2$ score.

For patients with coded AF at the time of first stroke, anticoagulant prescribing increased from 22% prior to stroke to 35% after stroke for women, and from 29% to 48% for men (table 2). In patients aged 80 and older, anticoagulant prescribing increased from 18% to 23% in women and from 24% to 34% in men.

CONCLUSION

Summary of main findings

Our study shows that the incidence of stroke in the UK fell by 29% between 1999 and 2008. The 56-day mortality after a first stroke fell by 43% between 1999 and 2008.

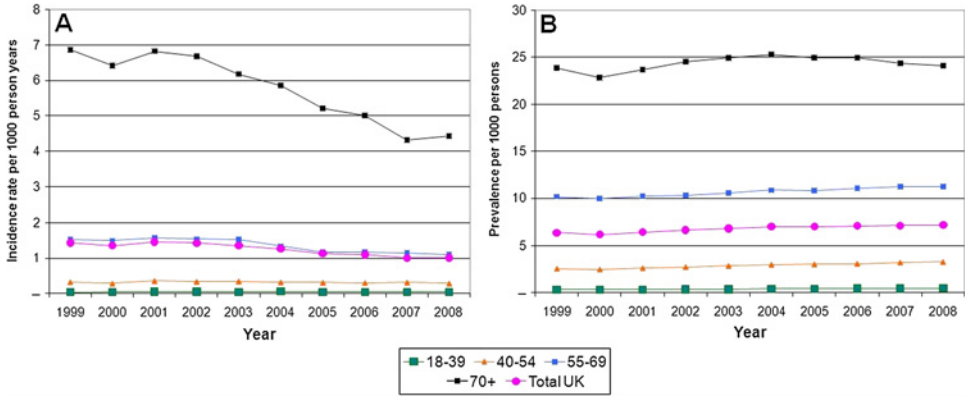

Figure 1 Incidence (A) and prevalence (B) of stroke in the UK adult population by age group.

Table 1 Baseline characteristics of the General Practice Research Database stroke cohort

	Male (n=14 359)			Female (n=17 792)			Total (n=32 151)		
	n	%	99% CI	n	%	99% CI	n	%	99% CI
Demographic characteristics									
Mean (SD) age	71.06 (12.7)		(70.8 to 71.3)	77.02 (13.0)		(76.8 to 77.3)	74.4 (13.2)		(74.2 to 74.6)
Mean (SD) BMI (n=23 856)	26.52 (4.6)		(26.4 to 26.6)	26.16 (5.6)		(26.1 to 26.3)	26.3 (5.13)		(26.2 to 26.4)
Risk factors prior to initial stroke									
Hypertension (GP diagnosed or >160/100 mm Hg)	8851	61.6	(60.6 to 62.7)	12 108	68.1	(67.2 to 69.0)	20 959	65.2	(64.5 to 65.9)
Hypercholesterolaemia (GP diagnosed or cholesterol >5 mmol/l (193 mg/dl))	5730	39.9	(38.9 to 41.0)	6710	37.7	(36.8 to 38.7)	12 440	38.7	(38.0 to 39.4)
GP-coded diabetes mellitus	1875	13.1	(12.3 to 13.8)	1909	10.7	(10.1 to 11.3)	3784	11.8	(11.3 to 12.2)
Smoking (ever)	8015	55.8	(54.7 to 56.9)	6210	34.9	(34.0 to 35.8)	14 225	44.2	(43.5 to 45.0)
GP-coded atrial fibrillation	1411	9.8	(9.2 to 10.5)	2072	11.6	(11.0 to 12.3)	3483	10.8	(10.4 to 11.3)
GP-coded transient ischaemic attack	897	6.2	(5.7 to 6.8)	1111	6.2	(5.8 to 6.7)	2008	6.2	(5.9 to 6.6)
Treatments in year prior to initial stroke (at least 2 prescriptions)									
Antihypertensives	6453	44.9	(43.9 to 46.0)	9649	54.2	(53.3 to 55.2)	16 102	50.1	(49.4 to 50.8)
ACE inhibitors and angiotensin receptor antagonists	3226	22.5	(21.6 to 23.4)	3845	21.6	(20.8 to 22.4)	7071	22	(21.4 to 22.6)
β-Blockers	2252	15.7	(14.9 to 16.5)	3581	20.1	(19.4 to 20.9)	5833	18.1	(17.6 to 18.7)
Calcium channel blockers	2349	16.4	(15.6 to 17.2)	2988	16.8	(16.1 to 17.5)	5337	16.6	(16.1 to 17.1)
Diuretics	3362	23.4	(22.5 to 24.3)	6142	34.5	(33.6 to 35.4)	9504	29.6	(28.9 to 30.2)
Anticoagulants	703	4.9	(4.4 to 5.4)	787	4.4	(4.0 to 4.8)	1490	4.6	(4.3 to 4.9)
Antiplatelet drugs	4029	28.1	(27.1 to 29.0)	5471	30.7	(29.9 to 31.6)	9500	29.5	(28.9 to 30.2)
Lipid regulating drugs	2004	14	(13.2 to 14.7)	2221	12.5	(11.8 to 13.1)	4225	13.1	(12.7 to 13.6)
Diabetes treatment									
Oral antidiabetic agents	1193	8.3	(7.7 to 8.9)	1180	6.6	(6.2 to 7.1)	2373	7.4	(7.0 to 7.8)
Insulin	340	2.4	(2.0 to 2.7)	417	2.3	(2.1 to 2.6)	757	2.4	(2.1 to 2.6)

BMI, body mass index; GP, general practitioner.

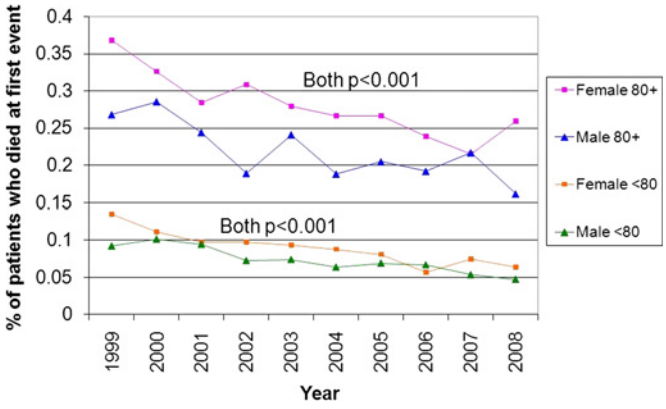

Figure 2 Stroke mortality within 56 days of first stroke by age group.

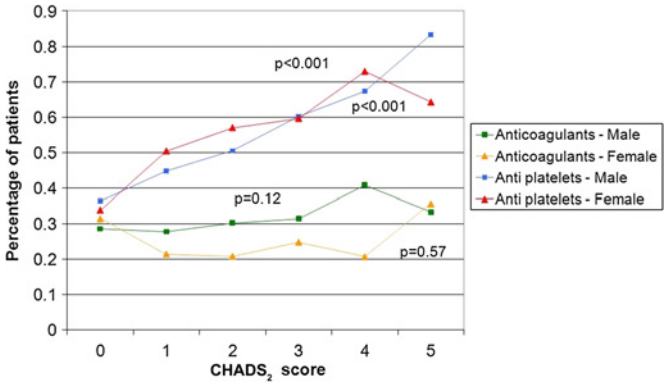

Figure 4 Percentage of GP-coded AF patients treated with anticoagulant and antiplatelet therapy prior to stroke by $CHADS_2$ score. AF, atrial fibrillation; GP, general practitioner.

Primary care management of cardiovascular risk has improved, with the majority of recorded hypertension being controlled prior to stroke, and a rapid increase in prescriptions for lipid lowering drugs to patients with diagnosed hypercholesterolaemia. However, there is a clear suggestion that risk stratification is not yet optimal, particularly in relation to patients with AF.

Comparison with existing literature

A fall in stroke incidence similar to that shown in our study has previously been reported in Oxfordshire[3] and south London.[18] Our findings are also in line with data from some other high-income countries, with Feigin *et al* reporting a 42% decrease in age-adjusted stroke incidence rates over 4 decades to 2008.[19]

The observed reduction in stroke incidence is likely to be related to better control of vascular risk factors both prior to and following a stroke. By the end of the study period, GPs were treating cardiovascular risk factors much more aggressively than in 1999. A previous study[3] reported a trend to reduced incidence of stroke in association with increased use of preventive treatments and reduction in risk factors. Our data show improvement compared with a previous analysis of GPRD data (1997–2006) in which only 75% of patients with diagnosed hypertension were receiving antihypertensive therapy 90 days after incident stroke.[20] In our study, 97% of patients with hypertension after stroke were receiving antihypertensive therapy.

Improved primary care management of risk factors presumably reflects national initiatives to reduce cardiovascular disease. These include the Quality and Outcomes Framework whereby GPs in England are incentivised to improve intervention on cardiovascular risk factors. The increased level of prescribing seen in our study is in line with a national increase in the use of statins[21] and improved treatment of hypertension.[22]

AF is an important risk factor for stroke, but recent reports have highlighted that it is both under-recognised and under-treated.[21 23] Our study confirms that such individuals have a higher mortality risk after first stroke than patients in sinus rhythm.

The $CHADS_2$ scoring system[24] is commonly used to assess stroke risk in patients with AF and help guide thromboprophylaxis. In our study, anticoagulant prescribing before stroke in patients with AF increased only slightly between 1999 and 2008. Use of anticoagulants appeared to be unrelated to the patient's $CHADS_2$ score, as has been reported previously.[25] There was a relatively high, and possibly inappropriate, level of anticoagulant prescribing in lower risk patients (those with a $CHADS_2$ score of 0) and no increase in the use of anticoagulants with increasing stroke risk. The finding of high use of anticoagulants in AF patients at low risk of stroke has been reported previously in primary care in the UK.[25]

Contrary to data from a previous study using GPRD,[25] we found that antiplatelet prescribing increased significantly with increasing $CHADS_2$ score, indicating that GPs might be responding to increasing thromboembolic risk by prescribing an antiplatelet agent rather than an anticoagulant. Use of anticoagulants was lower in women than men despite women's higher $CHADS_2$ scores.

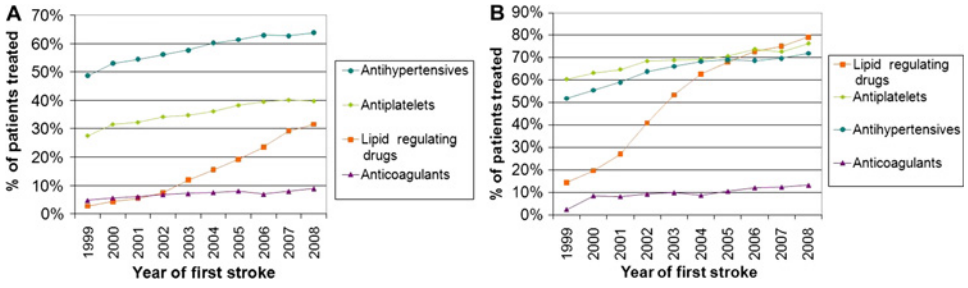

Figure 3 Pharmaceutical therapies prior to first stroke (A) and in the year following first stroke (B).

Table 2 Patients with GP-coded atrial fibrillation prior to first stroke

	Male			Female			Total		
GP-coded atrial fibrillation	**n**	**%**	**95% CI**	**n**	**%**	**95% CI**	**n**	**%**	**95% CI**
Number of patients (% of cohort)	1411	9.8		2072	11.6		3483	10.8	
Baseline characteristics									
Mean (SD) age	77.3 (9.8)		(76.8 to 77.8)	82.4 (8.7)		(82.0 to 82.8)	80.3 (9.5)		(80.0 to 80.6)
$CHADS_2$ score prior to initial stroke (% of AF patients)									
0	217	15.4	(13.5 to 17.3)	127	6.1	(5.1 to 7.2)	344	9.9	(8.9 to 10.9)
1	601	42.6	(40.0 to 45.2)	730	35.2	(33.2 to 37.3)	1331	38.2	(36.6 to 39.8)
2	430	30.5	(28.1 to 32.9)	877	42.3	(40.2 to 44.5)	1307	37.5	(35.9 to 39.1)
3	108	7.7	(6.3 to 9.0)	213	10.3	(9.0 to 11.6)	321	9.2	(8.3 to 10.2)
4	49	3.5	(2.5 to 4.4)	111	5.4	(4.4 to 6.3)	160	4.6	(3.9 to 5.3)
5	6	0.4	(0.1 to 0.8)	14	0.7	(0.3 to 1.0)	20	0.6	(0.3 to 0.8)
Treatments in year prior to initial stroke (at least 2 prescriptions) (% of AF patients)									
Anticoagulants	415	29.4	(27.0 to 31.8)	461	22.2	(20.5 to 24.0)	876	25.2	(23.7 to 26.6)
Antiplatelet drugs	668	47.3	(44.7 to 49.9)	1128	54.4	(52.3 to 56.6)	1796	51.6	(49.9 to 53.2)
Follow-up									
Died within 56 days of initial stroke (% of AF patients)	264	18.7	(16.7 to 20.7)	554	26.7	(24.8 to 28.6)	818	23.5	(22.1 to 24.9)
Survived at least 56 days following initial stroke (% of AF patients)	1147	81.3	(79.3 to 83.3)	1518	73.3	(71.4 to 75.2)	2665	76.5	(75.1 to 77.9)
Treatments in year following initial stroke (at least 2 prescriptions) (% of patients who survived at least 56 days)									
Anticoagulants	545	47.5	(44.9 to 50.1)	529	34.8	(32.8 to 36.9)	1074	40.3	(38.7 to 41.9)
Antiplatelet drugs	566	49.3	(46.7 to 52)	806	53.1	(50.9 to 55.2)	1372	51.5	(49.8 to 53.1)

AF, atrial fibrillation; GP, general practitioner.

Women were older than men in the AF patient population and lower use of anticoagulants might reflect prescriber concerns that anticoagulants are more dangerous in the elderly. However, it has been shown that there is no significant difference in bleeding risk between warfarin and aspirin in patients aged over 75 years.[26] The lower use of anticoagulants in women might also reflect findings from other areas of cardiovascular disease that women are treated less aggressively with drug therapy than men.[27 28]

Limitations of the study

We are reliant on the quality of GP coding in the GPRD dataset. There may be some coding error and misreporting of cardiovascular events and risk factors. The GPRD has quality criteria for practices involved in the data collection and we used data only from such 'up-to-standard' practices. A recent systematic review of the validity of diagnostic coding within GPRD reported high positive predictive values (>80%) for events such as myocardial infarction or stroke, but a lower value for AF (64.4%).[16]

Despite an observed difference in risk factors between men and women in our cohort, we are not able to evaluate gender difference in the risk of secondary stroke, due to the potential confounding factor of age; female patients were older than male patients. As the objectives of this study were purely descriptive, we did not make any adjustments for confounding factors. Further studies are needed to examine gender differences in stroke risk and prevention.

Implications for clinical practice

This is the first UK-wide study to investigate recent trends in stroke and it shows an encouraging reduction in the incidence of first stroke and improving survival. This is likely to be due (at least partially) to much better identification of vascular risk and the prescription of preventive therapies prior to, and after, stroke. Despite these positive findings, there are some areas where management appears to remain suboptimal. Women are less well treated than men, perhaps due to an age bias. Patients with AF, who do particularly poorly after stroke, do not appear to be appropriately risk stratified for anticoagulation therapy. Improved detection of AF and thromboprophylaxis in such patients should be a priority for healthcare systems.

Correction notice The "To cite: …" information and running footer in this article have been updated with the correct volume number (volume 1).

Funding The study was funded by Boehringer Ingelheim Ltd.

Competing interests MRC provides consultancy advice to a number of pharmaceutical companies that might have an interest in the submitted work in the previous 3 years, including a consultancy contract to advise the Boehringer Ingelheim epidemiology team on CV analyses. SL and AS are employees of Boehringer Ingelheim Ltd, who market a number of cardiovascular therapies and might have an interest in the submitted work in the previous 3 years; SL and AS received no support from any other organisation for the submitted work.

Ethics approval The protocol for the study has been approved by the Independent Scientific Advisory Committee at the Medicines and Healthcare products Regulatory Agency.

Contributors AS and SL performed the data extraction and data analyses, and helped write the manuscript. MC advised regarding the study design and data analyses, and wrote the manuscript. He is the guarantor for the study.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

REFERENCES

1. National Audit Office. *Progress in Improving Stroke Care*. 2004. http://www.nao.org.uk/publications/0910/stroke.aspx (accessed Aug 2011).
2. Hippisley-Cox J, Pringle M, Ryan R. *Stroke: Prevalence, Incidence and Care in General Practices 2002 to 2004. Final Report to the National Stroke Audit Team*. London: Royal College of Physicians, 2004.
3. Rothwell PM, Coull AJ, Giles MF, *et al*. Change in stroke incidence, mortality, case-fatality, severity, and risk factors in Oxfordshire, UK from 1981 to 2004 (Oxford Vascular Study). *Lancet* 2004;363:1925–33.
4. Syme PD, Byrne AW, Chen R, *et al*. Community-based stroke incidence in a Scottish population. The Scottish Borders Stroke Study. *Stroke* 2005;36:1837–43.
5. Lawlor DA, Davey Smith G, Leon DA, *et al*. Secular trends in mortality by stroke subtype in the 20th century: a retrospective analysis. *Lancet* 2002;370:1818–23.
6. National Audit Office. *Reducing Brain Damage: Faster Access to Better Stroke Care*. 2005. http://www.nao.org.uk/publications/0506/reducing_brain_damage.aspx (accessed Aug 2011).
7. Ashton C, Bajekal M, Raine R. Quantifying the contribution of leading causes of death to mortality decline among older people in England, 1991–2005. *Health Stat Quart* 2010;45:100–27. http://www.statistics.gov.uk/hsq/hsqissue (accessed Jul 2010).
8. Office for National Statistics. *Mortality Statistics: Deaths Registered in 2008*. http://www.statistics.gov.uk/downloads/theme_health/DR2008/DR_08.pdf (accessed Jul 2010).
9. Department of Health. *Saving Lives: Our Healthier Nation*. London: Stationery Office, 1999. http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_4118614 (accessed Jul 2010).
10. Department of Health. *National Service Framework for Older People*. London: Department of Health, 2001. http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_4003066 (accessed Jul 2010).
11. Department of Health. *National Stroke Strategy*. London: Department of Health, 2007. http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_081062 (accessed Jul 2010).
12. Department of Health. *Putting Prevention First. Vascular Checks: Risk Assessment and Management*. London: Department of Health, 2008. http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_083822 (accessed Jul 2010).
13. NHS Improvement—Heart. http://www.improvement.nhs.uk/heart/ (accessed Jul 2010).
14. Garcia Rodriguez LA, Gutthann SP. Use of the UK General Practice Research Database for pharmacoepidemiology. *Br J Clin Pharmacol* 1998;45:419–25.
15. Jick SS, Kaye JA, Vasilakis-Scaramozza C, *et al*. Validity of the general practice research database. *Pharmacotherapy* 2003;23:686–9.
16. Khan NF, Harrison SE, Rose PW. Validity of diagnostic coding within the General Practice Research Database: a systematic review. *Br J Gen Pract* 2010;60:128–36.
17. Herrett E, Thomas SL, Schoonen WM, *et al*. Validation and validity of diagnoses in the General Practice Research Database: a systematic review. *Br J Clin Pharmacol* 2010;69:4–14.
18. Heuschmann PU, Grieve AP, Toschke AM, *et al*. Ethnic group disparities in 10-year rends in stroke incidence and vascular risk factors. The South London Stroke Register (SLSR). *Stroke* 2008;39:2204–10.
19. Feigin VL, Lawes CM, Bennett DA, *et al*. Worldwide stroke incidence and early case fatality reported in 56 population-based studies: a systematic review. *Lancet Neurol* 2009;8:355–69.
20. Toschke AM, Wolfe CD, Heuschmann PU, *et al*. Antihypertensive treatment after stroke and all-cause mortality—an analysis of the General Practitioner Research Database (GPRD). *Cerebrovasc Dis* 2009;28:105–11.
21. Department of Health. *Building on Excellence, Maintaining Progress. Coronary Heart Disease National Service Framework Progress Report for 2008*. http://www.cardiomyopathy.org/assets/files/Progress%20report%202008.pdf (accessed Aug 2011).
22. Falaschetti E, Chaudhury M, Mindell J, *et al*. Continued improvement in hypertension management in England: results from the Health Survey for England 2006. *Hypertension* 2009;53:480–6.

23. National Institute for Health and Clinical Excellence. *Atrial Fibrillation: the Management of Atrial Fibrillation*. Clinical Guideline 36. Costing report. 2006. http://www.nice.org.uk/CG36 (accessed Jul 2010).
24. Gage BF, Waterman AD, Shannon W, *et al*. Validation of clinical classification schemes for predicting stroke: results from the National Registry of Atrial Fibrillation. *JAMA* 2001;285:2864–70.
25. Gallagher AM, Rietbrock S, Plumb J, *et al*. Initiation and persistence of warfarin or aspirin in patients with chronic atrial fibrillation in general practice: do the appropriate patients receive stroke prophylaxis? *J Thromb Haemost* 2008;6:1500–6.
26. Mant J, Hobbs FDR, Fletcher K, *et al*. Warfarin versus aspirin for stroke prevention in an elderly community population with atrial fibrillation (the Birmingham atrial fibrillation treatment of the aged study, BAFTA): a randomised controlled trial. *Lancet* 2007;370:493–503.
27. Hippisley-Cox J, Pringle M, Crown N, *et al*. Sex inequalities in ischaemic heart disease in general practice: cross sectional survey. *BMJ* 2001;322:832–6.
28. Nicol ED, Fittall B, Roughton M, *et al*. NHS heart failure survey: a survey of acute heart failure admissions in England, Wales and Northern Ireland. *Heart* 2008;94:172–7.

Appendix: Codes

Stroke

Pegasus Code	Read Code	Read Term
1469	G66..00	Stroke and cerebrovascular accident unspecified
1298	G66..11	CVA unspecified
3149	G64z.00	Cerebral infarction NOS
5363	G64..11	CVA - cerebral artery occlusion
6116	G66..13	CVA - Cerebrovascular accident unspecified
6960	G61..11	CVA - cerebrovascular accid due to intracerebral haemorrhage
569	G64..12	Infarction - cerebral
7780	G667.00	Left sided CVA
12833	G668.00	Right sided CVA
6155	G64..13	Stroke due to cerebral arterial occlusion
6253	G66..12	Stroke unspecified
18604	G61..12	Stroke due to intracerebral haemorrhage
17322	G664.00	Cerebellar stroke syndrome
8443	G663.00	Brain stem stroke syndrome
9985	G64z200	Left sided cerebral infarction
10504	G64z300	Right sided cerebral infarction
36717	G640000	Cerebral infarction due to thrombosis of cerebral arteries
23671	G63y000	Cerebral infarct due to thrombosis of precerebral arteries
6228	G68X.00	Sequelae of stroke,not specfd as h'morrhage or infarction
24446	G63y100	Cerebral infarction due to embolism of precerebral arteries
39344	G676000	Cereb infarct due cerebral venous thrombosis, nonpyogenic
27975	G641000	Cerebral infarction due to embolism of cerebral arteries
53745	Gyu6400	[X]Other cerebral infarction
39403	G683.00	Sequelae of cerebral infarction
47607	L440.11	CVA - cerebrovascular accident in the puerperium
65770	G677200	Occlusion and stenosis of posterior cerebral artery
51759	G677000	Occlusion and stenosis of middle cerebral artery
57527	G677100	Occlusion and stenosis of anterior cerebral artery

Other CVD

Includes Coronary Heart Disease (CHD) and Peripheral Vascular Disease (PVD).

CHD:

Pegasus Code	Read Code	Read Term
241	G30..00	Acute myocardial infarction
14658	G30z.00	Acute myocardial infarction NOS
1677	G30..15	MI - acute myocardial infarction
10562	G307100	Acute non-ST segment elevation myocardial infarction
5904	792..00	Coronary artery operations
1678	G308.00	Inferior myocardial infarction NOS
1204	G30..14	Heart attack
12229	G30X000	Acute ST segment elevation myocardial infarction
2491	G30..12	Coronary thrombosis
14897	G301z00	Anterior myocardial infarction NOS

7442	7920200	Saphenous vein graft replacement of three coronary arteries
5387	G301.00	Other specified anterior myocardial infarction
12139	G300.00	Acute anterolateral infarction
8935	G302.00	Acute inferolateral infarction
11610	7920300	Saphenous vein graft replacement of four+ coronary arteries
17872	G301100	Acute anteroseptal infarction
7634	7920100	Saphenous vein graft replacement of two coronary arteries
9507	G307000	Acute non-Q wave infarction
10603	792z.00	Coronary artery operations NOS
23892	G304.00	Posterior myocardial infarction NOS
7783	323..00	ECG: myocardial infarction
16408	G32..11	Healed myocardial infarction
14898	G305.00	Lateral myocardial infarction NOS
13571	G30..16	Thrombosis - coronary
29643	G303.00	Acute inferoposterior infarction
17689	G30..17	Silent myocardial infarction
46017	G30yz00	Other acute myocardial infarction NOS
18842	G35..00	Subsequent myocardial infarction
13566	G30..11	Attack - heart
47788	7927	Other open operations on coronary artery
32272	G38..00	Postoperative myocardial infarction
9555	G33z500	Post infarct angina
34803	G30y.00	Other acute myocardial infarction
29758	G30X.00	Acute transmural myocardial infarction of unspecif site
41221	G30y200	Acute septal infarction
10209	7921200	Autograft replacement of three coronary arteries NEC
23579	G310.00	Postmyocardial infarction syndrome
42708	7921300	Autograft replacement of four of more coronary arteries NEC
19413	7921100	Autograft replacement of two coronary arteries NEC
38609	G351.00	Subsequent myocardial infarction of inferior wall
63467	G306.00	True posterior myocardial infarction
32854	G30B.00	Acute posterolateral myocardial infarction
41835	G384.00	Postoperative subendocardial myocardial infarction
45370	7922300	Allograft replacement of four or more coronary arteries
45886	7922200	Allograft replacement of three coronary arteries
31540	7924200	Revision of bypass for three coronary arteries
26972	3234	ECG:posterior/inferior infarct
67761	7923300	Prosthetic replacement of four or more coronary arteries
46276	G381.00	Postoperative transmural myocardial infarction inferior wall
55092	792C000	Replacement of coronary arteries using multiple methods
66236	7923200	Prosthetic replacement of three coronary arteries
57241	7922100	Allograft replacement of two coronary arteries
67554	7924100	Revision of bypass for two coronary arteries
68748	G38z.00	Postoperative myocardial infarction, unspecified
31519	7925100	Double implant of mammary arteries into coronary arteries
46112	G380.00	Postoperative transmural myocardial infarction anterior wall
46166	G35X.00	Subsequent myocardial infarction of unspecified site
62608	7926000	Double anastom thoracic arteries to coronary arteries NEC
62626	G30y100	Acute papillary muscle infarction
66664	7923100	Prosthetic replacement of two coronary arteries

72562	G353.00	Subsequent myocardial infarction of other sites
96838	Gyu3400	[X]Acute transmural myocardial infarction of unspecif site
1430	G33..00	Angina pectoris
19542	662K000	Angina control - good
1431	G311.13	Unstable angina
13185	662K.00	Angina control
1344	G340.12	Coronary artery disease
7347	G311100	Unstable angina
8942	7929400	Insertion of coronary artery stent
28554	G33zz00	Angina pectoris NOS
7137	7920y00	Saphenous vein graft replacement of coronary artery OS
1414	G33z300	Angina on effort
4656	G311.11	Crescendo angina
12804	G33z700	Stable angina
25842	G33z.00	Angina pectoris NOS
15373	662K100	Angina control - poor
18118	G311400	Worsening angina
17054	7N41300	[SO]Coronary artery
18249	7920	Saphenous vein graft replacement of coronary artery
14782	662K200	Angina control - improving
15349	662Kz00	Angina control NOS
17307	G311200	Angina at rest
5096	AA1..00	Vincent's angina
18889	G34z000	Asymptomatic coronary heart disease
19655	G311.14	Angina at rest
36854	G332.00	Coronary artery spasm
12986	G331.00	Prinzmetal's angina
22020	792B000	Endarterectomy of coronary artery NEC
42304	7929500	Insertion of drug-eluting coronary artery stent
8679	7920000	Saphenous vein graft replacement of one coronary artery
17133	G30A.00	Mural thrombosis
25481	P6y4.00	Coronary artery anomaly
31413	J083300	Ludwig's angina
51515	7920z00	Saphenous vein graft replacement coronary artery NOS
9155	7N48000	[SO]Pulmonary artery
9414	7921	Other autograft replacement of coronary artery
24888	7929	Other therapeutic transluminal operations on coronary artery
18125	G330000	Nocturnal angina
3778	7A12311	Aorto biiliac graft
26863	G33z600	New onset angina
11048	G331.11	Variant angina pectoris
30421	G30..13	Cardiac rupture following myocardial infarction (MI)
34328	G311300	Refractory angina
31571	792y.00	Other specified operations on coronary artery
31195	7A0..00	Great vessels and pulmonary artery operations
45740	7A09300	Open embolectomy of pulmonary artery
37324	7A09000	Application of band to pulmonary artery
45960	8B27.00	Antianginal therapy
34965	792A.00	Diagnostic transluminal operations on coronary artery
28736	G30y000	Acute atrial infarction

40429	G301000	Acute anteroapical infarction
19164	7927100	Repair of aneurysm of coronary artery
39449	G312.00	Coronary thrombosis not resulting in myocardial infarction
44561	7921000	Autograft replacement of one coronary artery NEC
44585	792Bz00	Repair of coronary artery NOS
28104	7A06211	Blalock anastomosis of subclavian artery to pulmonary artery
38328	7A0A.00	Transluminal operations on pulmonary artery
53546	P6y4z00	Coronary artery anomaly NOS
31556	7922	Allograft replacement of coronary artery
32508	P738.00	Atresia of pulmonary artery with septal defect
45809	G350.00	Subsequent myocardial infarction of anterior wall
55137	G311011	MI - myocardial infarction aborted
33620	792B.00	Repair of coronary artery NEC
48206	7927300	Transposition of coronary artery NEC
61072	G311000	Myocardial infarction aborted
35472	7A09400	Open embolisation of pulmonary artery
36307	P737.11	Dilatation of pulmonary artery
51043	ZRBN.00	Duke's coronary artery disease score
72176	AA1z.00	Vincent's angina NOS
6182	7929y00	Other therapeutic transluminal op on coronary artery OS
29902	G330z00	Angina decubitus NOS
32509	7A08.00	Repair of pulmonary artery
43446	792A100	Intravascular ultrasound of coronary artery
52483	7A08100	Repair of pulmonary artery using patch
19402	7923	Prosthetic replacement of coronary artery
51702	7927400	Exploration of coronary artery
55569	7A0A200	Arteriography of pulmonary artery
62163	P6y4100	Single coronary artery
18903	7927000	Repair of arteriovenous fistula of coronary artery
37037	7A07000	Creation of anastomosis from vena cava to pulmonary artery
51112	7A0z.00	Great vessel and pulmonary artery operations NOS
42127	P73z.00	Pulmonary artery anomaly NOS
51507	7925300	Single anastomosis of mammary artery to coronary artery NEC
54487	P734.00	Hypoplasia of the pulmonary artery
33718	7925000	Double anastomosis of mammary arteries to coronary arteries
55598	792C.00	Other replacement of coronary artery
65029	P737.00	Pulmonary artery aneurysm
40017	7A06212	Taussig anastomosis of subclavian artery to pulmonary artery
41757	7927z00	Other open operation on coronary artery NOS
42524	7A08200	Repair of anomalous pulmonary artery NEC
59428	7A06200	Creation anastomosis subclavian artery to pulmonary art NEC
65359	7A0A000	Percutaneous transluminal embolisation of pulmonary artery
7609	7921z00	Other autograft replacement of coronary artery NOS
18982	P733.00	Coarctation of the pulmonary artery
31373	P6y4400	Anomalous coronary artery communication
37719	7925y00	Connection of mammary artery to coronary artery OS
48767	7922z00	Allograft replacement of coronary artery NOS
24176	A340000	Streptococcal angina
61248	792Az00	Diagnostic transluminal operation on coronary artery NOS
63187	P730.00	Pulmonary artery anomaly, unspecified

66583	7929200	Percut translum inject therap subst to coronary artery NEC
72797	7A09200	Removal of band from pulmonary artery
93433	7A0A700	Percut transluminal insertion of stent into pulmonary artery
93618	7929600	Percutaneous transluminal atherectomy of coronary artery
52411	P73y.00	Other specified anomaly of pulmonary artery
56905	792Ay00	Diagnostic transluminal operation on coronary artery OS
68139	7925400	Single implantation of mammary artery into coronary artery
48697	7A65000	Transposition of valve of vein
61310	7921y00	Other autograft replacement of coronary artery OS
69247	792By00	Other specified repair of coronary artery
70755	792Cz00	Replacement of coronary artery NOS
52615	P6y7.00	Myocardial bridge of coronary artery
59659	7A0Ay00	Other specified transluminal operation on pulmonary artery
62258	7A08z00	Repair of pulmonary artery NOS
65459	7A0A100	Percutaneous transluminal embolectomy of pulmonary artery
34262	7A0Az00	Transluminal operation on pulmonary artery NOS
56529	7A06.00	Other connection from subclavian artery to pulmonary artery
59423	7922y00	Other specified allograft replacement of coronary artery
60753	7926300	Single implantation thoracic artery into coronary artery NEC
66801	7A0y.00	Great vessel or pulmonary artery operations OS
67591	7926200	Single anastomosis of thoracic artery to coronary artery NEC
68138	7A04.00	Other connection from aorta to pulmonary artery
70111	7922000	Allograft replacement of one coronary artery
72604	P500.00	Absent septum between aorta and pulmonary artery
73489	7A06300	Revision anastomosis subclavian artery to pulmonary artery
90119	7A07.00	Other connection to pulmonary artery
95391	7A09z00	Other open operation on pulmonary artery NOS
19193	7923z00	Prosthetic replacement of coronary artery NOS
39546	Gyu3000	[X]Other forms of angina pectoris
61592	7927200	Transection of muscle bridge of coronary artery
62255	7A07z00	Other connection to pulmonary artery NOS
67928	P731.00	Pulmonary artery agenesis
68551	7A08y00	Other specified repair of pulmonary artery
72780	7926z00	Connection of other thoracic artery to coronary artery NOS
90852	7A06600	Perc translu occlusion anast pulmonary artery subclavian art
91479	7A09500	Pulmonary artery ligation
92419	7923000	Prosthetic replacement of one coronary artery
93432	792B200	Repair of arteriovenous malformation of coronary artery
93828	792Cy00	Other specified replacement of coronary artery
94503	7A00400	Repair anomalous pulmonary artery origin ascending aorta
94783	792B100	Repair of rupture of coronary artery
95382	7927y00	Other specified other open operation on coronary artery
96047	7A07y00	Other specified other connection to pulmonary artery
96661	7A09.00	Other open operations on pulmonary artery
96804	7926	Connection of other thoracic artery to coronary artery

Peripheral vascular disease:

Pegasus Code	Read Code	Read Term
2760	G73zz00	Peripheral vascular disease NOS
3530	G73z.00	Peripheral vascular disease NOS
5943	G73..00	Other peripheral vascular disease
4325	G73yz00	Other specified peripheral vascular disease NOS
6356	7A4B000	Percutaneous transluminal angioplasty of femoral artery
2066	7A48z00	Other bypass of femoral artery or popliteal artery NOS
10827	7A44000	Percutaneous transluminal angioplasty of iliac artery
18060	7A48.14	Other bypass of femoral artery
2761	7A12100	Bypass bifurc aorta by anastom aorta to femoral artery NEC
24692	7A48.00	Other bypass of femoral artery or popliteal artery
29112	7A4B100	Percutaneous transluminal angioplasty of popliteal artery
12331	7A48.15	Other bypass of popliteal artery
8610	G76z000	Iliac artery occlusion
27580	7A48000	Bypass femoral artery by fem/pop art anast c prosthesis NEC
28030	7A48200	Bypass femoral artery by fem/pop art anast c vein graft NEC
27494	G74y300	Embolism and thrombosis of the iliac artery unspecified
15532	7A12300	Bypass bifurcation aorta by anastom aorta to iliac artery
21927	7A41.00	Other bypass of iliac artery
11766	7A47.16	Other emergency bypass of femoral artery
42640	7A48y00	Other bypass of femoral artery or popliteal artery OS
31723	7A28000	Percutaneous transluminal angioplasty of subclavian artery
28616	7A41100	Bypass iliac artery by iliac/femoral artery anastomosis NEC
38907	G73y.00	Other specified peripheral vascular disease
39776	7A47.14	Other emergency bypass of popliteal artery
41823	7A48600	Bypass femoral artery by fem/tib art anast c vein graft NEC
9099	7A47.00	Other emergency bypass of femoral artery or popliteal artery
45428	7A48C00	Bypass femoral artery by femoral/femoral art anastomosis NEC
29183	7A26000	Bypass of subclavian artery NEC
42115	7A48D00	Bypass popliteal artery by pop/fem artery anastomosis NEC
24097	7A48300	Bypass popliteal artery by pop/pop a anast c vein graft NEC
37465	7A28100	Percutaneous transluminal angioplasty of brachial artery
36443	7A41300	Bypass iliac artery by femoral/femoral art anastomosis NEC
39877	7A48400	Bypass femoral artery by fem/tib art anast c prosthesis NEC
37546	7A26700	Bypass of brachial artery NEC
48700	7A48700	Bypass popliteal artery by pop/tib a anast c vein graft NEC
52357	7A41y00	Other specified other bypass of iliac artery
58191	7A26100	Bypass of axillary artery NEC
37787	7A48.12	Other bypass of common femoral artery
38921	7A41z00	Other bypass of iliac artery NOS
40732	7A48.16	Other bypass of superficial femoral artery
60370	7A28C00	Percutaneous transluminal angioplasty of axillary artery
61974	7A48.11	Other bypass of femoral or popliteal artery by anastomosis
60465	7A48500	Bypass popliteal artery by pop/tib a anast c prosthesis NEC
32492	7A41900	Bypass common iliac artery by aorta/com iliac art anast NEC
55554	7A41B00	Bypass leg artery by aorta/com femoral art anastomosis NEC
65692	7A47y00	Other emergency bypass of femoral or popliteal artery OS
68320	7A47z00	Other emergency bypass of femoral or popliteal artery NOS

48939	7A47C00	Emerg bypass femoral artery by fem/fem art anastomosis NEC
66804	7A41C00	Bypass leg artery by aorta/deep femoral art anastomosis NEC
70922	7A47D00	Emerg bypass popliteal artery by pop/fem art anastomosis NEC
72448	7A41200	Emerg bypass iliac artery by femoral/femoral art anast NEC
48755	7A12000	Emerg bypass bifurc aorta by anast aorta to femoral artery
63238	7A47.13	Other emergency bypass of deep femoral artery
64555	7A48100	Bypass popliteal artery by pop/pop a anast c prosthesis NEC
66917	7A41600	Emerg bypass leg artery by aorta/com fem art anastomosis NEC
67982	7A48800	Bypass femoral artery by fem/peron a anast c prosthesis NEC
97606	7A47.15	Other emergency bypass of superficial femoral artery
733	7A54000	Percutaneous transluminal angioplasty of artery NEC
5640	G70..00	Atherosclerosis
1318	G700.00	Aortic atherosclerosis
30296	7A1A000	Percutaneous transluminal balloon angioplasty of aorta
53675	7A48A00	Bypass femoral artery by fem/peron a anast c vein graft NEC
56429	P76z.00	Peripheral vascular system anomaly NOS
44528	SP12z00	Peripheral vascular complications of care NOS
66921	7A6H400	Percutaneous transluminal angioplasty of vascular graft
95430	7A56200	Percutaneous transluminal occlusion of artery
73961	Gyu7400	[X]Other specified peripheral vascular diseases
1517	G73z000	Intermittent claudication
6853	G73z011	Claudication
7975	16I..00	Claudication distance
1826	G73..12	Ischaemia of legs

Atrial Fibrillation

Pegasus Code	Read Code	Read Term
18357	3274	ECG: paroxysmal atrial tachy.
9023	G576300	Atrial premature depolarization
43860	7936900	Implantation of intravenous atrial overdrive pacemaker
1757	G573100	Atrial flutter
93460	14AR.00	History of atrial flutter
84152	793M100	Perc transluminal ablation of atrial wall for atrial flutter
6771	3273	ECG: atrial flutter
1664	G573000	Atrial fibrillation
2212	G573.00	Atrial fibrillation and flutter
1268	G573200	Paroxysmal atrial fibrillation
18746	662S.00	Atrial fibrillation monitoring
6345	14AN.00	H/O: atrial fibrillation
3757	3272	ECG: atrial fibrillation
1297	G570000	Paroxysmal atrial tachycardia
57832	9Os..00	Atrial fibrillation monitoring administration
45773	6A9..00	Atrial fibrillation annual review
39114	9hF1.00	Excepted from atrial fibrillation qual indic: Inform dissent
23437	G573z00	Atrial fibrillation and flutter NOS

90187	9Os0.00	Atrial fibrillation monitoring first letter
63350	9hF..00	Exception reporting: atrial fibrillation quality indicators
96076	G573500	Persistent atrial fibrillation
9479	7936A00	Implant intravenous pacemaker for atrial fibrillation
90188	9Os1.00	Atrial fibrillation monitoring second letter
35127	G573300	Non-rheumatic atrial fibrillation
90189	9Os2.00	Atrial fibrillation monitoring third letter
96277	G573400	Permanent atrial fibrillation
90190	9Os3.00	Atrial fibrillation monitoring verbal invite
90191	9Os4.00	Atrial fibrillation monitoring telephone invite

Hypertension

Pegasus Code	Read Code	Read Term
799	G20..00	Essential hypertension
4444	662..12	Hypertension monitoring
204	G2...00	Hypertensive disease
13186	662P.00	Hypertension monitoring
351	G20..11	High blood pressure
10818	G20z.00	Essential hypertension NOS
19070	662d.00	Hypertension annual review
4344	9N03.00	Seen in hypertension clinic
3712	G20z.11	Hypertension NOS
5215	9OI..00	Hypertension monitoring admin.
18482	662c.00	Hypertension six month review
11056	8BL0.00	Patient on maximal tolerated antihypertensive therapy
3425	662O.00	On treatment for hypertension
16565	6627	Good hypertension control
1611	F450400	Ocular hypertension
45149	9OI1.00	Attends hypertension monitor.
36305	9OIA.00	Hypertension monitor.chck done
7057	G2z..00	Hypertensive disease NOS
27511	6628	Poor hypertension control
13188	662G.00	Hypertensive treatm.changed
1894	G201.00	Benign essential hypertension
8732	G2...11	BP - hypertensive disease
4372	G202.00	Systolic hypertension
27634	9N1y200	Seen in hypertension clinic
27525	9OI..11	Hypertension clinic admin.
18057	8B26.00	Antihypertensive therapy

245	G410.00	Primary pulmonary hypertension
21826	662F.00	Hypertension treatm. started
24127	9OIA.11	Hypertension monitored
6702	F421300	Hypertensive retinopathy
5433	F282.00	Benign intracranial hypertension
16292	G21..00	Hypertensive heart disease
15377	G200.00	Malignant essential hypertension
18590	662b.00	Moderate hypertension control
5129	J623.00	Portal hypertension
22356	1JD..00	Suspected hypertension
5513	8HT5.00	Referral to hypertension clinic
7329	G24..00	Secondary hypertension
12680	8CR4.00	Hypertension clinical management plan
4668	G22..00	Hypertensive renal disease
8857	G21z011	Cardiomegaly - hypertensive
30776	6629	Hypertension:follow-up default
34065	G41y000	Secondary pulmonary hypertension
29310	G22z.11	Renal hypertension
16059	G24z.00	Secondary hypertension NOS
18765	G2y..00	Other specified hypertensive disease
16173	G21zz00	Hypertensive heart disease NOS
3979	G672.00	Hypertensive encephalopathy
21660	TJC7.00	Adverse reaction to other antihypertensives
31341	G24z100	Hypertension secondary to drug
20497	TJC7z00	Adverse reaction to antihypertensives NOS
22333	8I3N.00	Hypertension treatment refused
26347	G8y3.00	Chronic peripheral venous hypertension
32976	6146200	Hypertension induced by oral contraceptive pill
15106	G22z.00	Hypertensive renal disease NOS
43220	9OI2.00	Refuses hypertension monitor.
83473	G203.00	Diastolic hypertension
31387	G24z000	Secondary renovascular hypertension NOS
55603	7Q01000	Primary pulmonary hypertension drugs band 1
42229	G24zz00	Secondary hypertension NOS
39649	G220.00	Malignant hypertensive renal disease
31816	G672.11	Hypertensive crisis
34744	G244.00	Hypertension secondary to endocrine disorders
25371	G241000	Secondary benign renovascular hypertension
31464	G21z.00	Hypertensive heart disease NOS
32423	G222.00	Hypertensive renal disease with renal failure
57288	G241.00	Secondary benign hypertension

28684	G233.00	Hypertensive heart and renal disease with renal failure
51635	G241z00	Secondary benign hypertension NOS
31755	G240.00	Secondary malignant hypertension
37086	F404200	Blind hypertensive eye
30770	U60C511	[X] Adverse reaction to other antihypertensives
21837	G232.00	Hypertensive heart&renal dis wth (congestive) heart failure
43935	G221.00	Benign hypertensive renal disease
69753	Gyu2.00	[X]Hypertensive diseases
52427	G211.00	Benign hypertensive heart disease
61166	G21z000	Hypertensive heart disease NOS without CCF
63466	G23..00	Hypertensive heart and renal disease
62718	G21z100	Hypertensive heart disease NOS with CCF
50157	G210.00	Malignant hypertensive heart disease
44350	U60C51A	[X] Adverse reaction to antihypertensives NOS
63946	7Q01100	Primary pulmonary hypertension drugs band 2
52127	G211100	Benign hypertensive heart disease with CCF
59383	G240000	Secondary malignant renovascular hypertension
68659	G23z.00	Hypertensive heart and renal disease NOS
90875	7Q01300	Primary pulmonary hypertension drugs band 4
61660	G211000	Benign hypertensive heart disease without CCF
73293	G240z00	Secondary malignant hypertension NOS
65081	7Q01200	Primary pulmonary hypertension drugs band 3
67232	G230.00	Malignant hypertensive heart and renal disease
85944	7Q01.00	High cost hypertension drugs
63000	G231.00	Benign hypertensive heart and renal disease
63260	SLC6z00	Hypertensive agent poisoning NOS
95334	G210000	Malignant hypertensive heart disease without CCF
72226	SLC6.00	Other hypertensive agent poisoning
72668	G210100	Malignant hypertensive heart disease with CCF
97533	Gyu2100	[X]Hypertension secondary to other renal disorders

Hypercholesterolaemia

Pegasus Code	Read Code	Read Term
339	C320.00	Pure hypercholesterolaemia
637	C324.00	Hyperlipidaemia NOS
2493	44P3.00	Serum cholesterol raised
5791	C322.00	Mixed hyperlipidaemia
856	44O6.00	Lipids abnormal
7447	C320z00	Pure hypercholesterolaemia NOS
3386	C320000	Familial hypercholesterolaemia

12569	ZV65317	[V]Dietary surveillance in hypercholesterolaemia
34224	C320300	Low-density-lipoprotein-type (LDL) hyperlipoproteinaemia
26941	44Q3.00	Serum triglycerides raised
26019	C320200	Hyperlipidaemia, group A
14781	44O4.00	Serum lipids high
37273	C320400	Fredrickson's hyperlipoproteinaemia, type IIa
43484	687B.00	Hyperlipidaemia risk assessment with New Zealand table
35720	44P4.00	Serum cholesterol very high
3484	C320.11	Familial hypercholesterolaemia
59095	C320.13	Low density lipoproteinaemia
33694	ZC2CJ00	Dietary advice for hyperlipidaemia
16290	C325300	A-beta-lipoproteinaemia
53091	C320y00	Other specified pure hypercholesterolaemia
23125	44O3.00	Serum lipids borderline raised
66240	Cyu8D00	[X]Other hyperlipidaemia
34825	C320100	Hyperbetalipoproteinaemia
71747	8CR3.00	Hyperlipidaemia clinical management plan
70793	C325200	Hypo-beta-lipoproteinaemia
34146	C325100	Hypo-alpha-lipoproteinaemia

Diabetes Mellitus

Pegasus Code	Read Code	Read Term
1549	C10E.00	Type 1 diabetes mellitus
8842	66A5.00	Diabetic on insulin
1038	C100011	Insulin dependent diabetes mellitus
1647	C108.00	Insulin dependent diabetes mellitus
17858	C108.12	Type 1 diabetes mellitus
10692	C10EM00	Type 1 diabetes mellitus with ketoacidosis
24423	C108.13	Type I diabetes mellitus
24490	C100000	Diabetes mellitus, juvenile type, no mention of complication
10418	C10ED00	Type 1 diabetes mellitus with nephropathy
16946	13L4.11	Diabetic child
30323	C10EK00	Type 1 diabetes mellitus with persistent proteinuria
30294	C10EL00	Type 1 diabetes mellitus with persistent microalbuminuria
50960	L180500	Pre-existing diabetes mellitus, insulin-dependent
18387	C10E700	Type 1 diabetes mellitus with retinopathy
6509	C108700	Insulin dependent diabetes mellitus with retinopathy
44443	C108500	Insulin dependent diabetes mellitus with ulcer
6791	C108800	Insulin dependant diabetes mellitus - poor control
51261	C10E.12	Insulin dependent diabetes mellitus

32359	ZRbH.00	Perceived control of insulin-dependent diabetes
35288	C10E800	Type 1 diabetes mellitus - poor control
40837	C10EN00	Type 1 diabetes mellitus with ketoacidotic coma
46624	C10C.11	Maturity onset diabetes in youth
26855	C108400	Unstable insulin dependant diabetes mellitus
53200	C101000	Diabetes mellitus, juvenile type, with ketoacidosis
39070	C10EE00	Type 1 diabetes mellitus with hypoglycaemic coma
12455	C10E.11	Type I diabetes mellitus
55239	C10EQ00	Type 1 diabetes mellitus with gastroparesis
44440	C108E00	Insulin dependent diabetes mellitus with hypoglycaemic coma
22871	C10EP00	Type 1 diabetes mellitus with exudative maculopathy
18683	C10E500	Type 1 diabetes mellitus with ulcer
54008	C10EJ00	Type 1 diabetes mellitus with neuropathic arthropathy
46963	C108000	Insulin-dependent diabetes mellitus with renal complications
43921	C10E400	Unstable type 1 diabetes mellitus
47582	C10E000	Type 1 diabetes mellitus with renal complications
93380	C10N100	Cystic fibrosis related diabetes mellitus
40682	C10E900	Type 1 diabetes mellitus maturity onset
42729	C108E11	Type I diabetes mellitus with hypoglycaemic coma
42831	C10E200	Type 1 diabetes mellitus with neurological complications
46301	C10EC00	Type 1 diabetes mellitus with polyneuropathy
47650	C10E300	Type 1 diabetes mellitus with multiple complications
57621	C108D00	Insulin dependent diabetes mellitus with nephropathy
38161	C108711	Type I diabetes mellitus with retinopathy
41716	C108C00	Insulin dependent diabetes mellitus with polyneuropathy
49276	C108100	Insulin-dependent diabetes mellitus with ophthalmic comps
49554	C10EF00	Type 1 diabetes mellitus with diabetic cataract
51957	C108511	Type I diabetes mellitus with ulcer
41049	C108712	Type 1 diabetes mellitus with retinopathy
67853	C106000	Diabetes mellitus, juvenile, + neurological manifestation
44260	C108F00	Insulin dependent diabetes mellitus with diabetic cataract
47649	C10E100	Type 1 diabetes mellitus with ophthalmic complications
52283	C108200	Insulin-dependent diabetes mellitus with neurological comps
56448	C108A00	Insulin-dependent diabetes without complication
60499	C108600	Insulin dependent diabetes mellitus with gangrene
62209	C10EM11	Type I diabetes mellitus with ketoacidosis
69676	C10EA00	Type 1 diabetes mellitus without complication

18642	C10EH00	Type 1 diabetes mellitus with arthropathy
45276	C10E312	Insulin dependent diabetes mellitus with multiple complicat
21983	C108012	Type 1 diabetes mellitus with renal complications
40023	C102000	Diabetes mellitus, juvenile type, with hyperosmolar coma
42567	C103000	Diabetes mellitus, juvenile type, with ketoacidotic coma
69993	C10E600	Type 1 diabetes mellitus with gangrene
49949	C10E411	Unstable type I diabetes mellitus
68792	C10z000	Diabetes mellitus, juvenile type, + unspecified complication
72345	C102z00	Diabetes mellitus NOS with hyperosmolar coma
96235	C10E911	Type I diabetes mellitus maturity onset
17545	C108F11	Type I diabetes mellitus with diabetic cataract
18230	C108J12	Type 1 diabetes mellitus with neuropathic arthropathy
52104	C108300	Insulin dependent diabetes mellitus with multiple complicatn
54600	C10E412	Unstable insulin dependent diabetes mellitus
60208	C108J11	Type I diabetes mellitus with neuropathic arthropathy
61344	C108011	Type I diabetes mellitus with renal complications
66872	C108D11	Type I diabetes mellitus with nephropathy
69748	C105000	Diabetes mellitus, juvenile type, + ophthalmic manifestation
45914	C108812	Type 1 diabetes mellitus - poor control
49146	C108211	Type I diabetes mellitus with neurological complications
60107	C108411	Unstable type I diabetes mellitus
61829	C108212	Type 1 diabetes mellitus with neurological complications
65616	C108H00	Insulin dependent diabetes mellitus with arthropathy
68105	C10EB00	Type 1 diabetes mellitus with mononeuropathy
68390	C108512	Type 1 diabetes mellitus with ulcer
70448	C107000	Diabetes mellitus, juvenile +peripheral circulatory disorder
70766	C108E12	Type 1 diabetes mellitus with hypoglycaemic coma
93875	C10E712	Insulin dependent diabetes mellitus with retinopathy
93878	C10E511	Type I diabetes mellitus with ulcer
95343	C10E711	Type I diabetes mellitus with retinopathy
24694	C108B00	Insulin dependent diabetes mellitus with mononeuropathy
62352	C108H11	Type I diabetes mellitus with arthropathy
62613	C10EA11	Type I diabetes mellitus without complication
63017	C108911	Type I diabetes mellitus maturity onset
66145	C10EN11	Type I diabetes mellitus with ketoacidotic coma
72702	C10E812	Insulin dependent diabetes mellitus - poor control
91942	C10E311	Type I diabetes mellitus with multiple complications

91943	C10EC11	Type I diabetes mellitus with polyneuropathy
93468	C10EG00	Type 1 diabetes mellitus with peripheral angiopathy
93922	C104000	Diabetes mellitus, juvenile type, with renal manifestation
95992	C108A11	Type I diabetes mellitus without complication

Death

Pegasus Code	Read Code	Read Term
7847	22J..12	Death
13549	94...00	Death administration
1127	22J..13	Died
1448	22J..14	Patient died
1868	8HG..00	Died in hospital
9059	8HG..11	Death in hospital
8706	94B..00	Cause of death
18447	9234	FP22-death
6897	9495	Patient died in hospital
6855	9491	Patient died at home
6811	R21..00	[D]Sudden death, cause unknown
6576	22J..00	O/E - dead
6991	9493	Patient died in nursing home
13551	941..00	Death certificate form Med A
28801	9451	Death notif. from hospital
13555	949..12	Deceased - place patient died
13553	94Z..00	Death administration NOS
18169	ZV68011	[V]Issue of death certificate
23075	22J4.00	O/E - dead - sudden death
28378	949A.00	Patient died in hospice
27505	949Z.00	Patient died in place NOS
23073	9412	Death cert. Med A signed
15337	R213.00	[D]Unattended death
20540	949..00	Patient died - to record place
17680	94A..00	Unexpected death-Coroner told
15858	949..13	Died - place patient died
33249	94D..00	Hospital notified of death
7962	R213100	[D]Found dead
26812	9494	Patient died in resid.inst.NOS
51482	9452	Await hosp death disch letter
46304	9134.12	Registration ghost - died
31121	R212000	[D]Death, not instantaneous cause unknown
28645	9453	Receiv hosp death disch letter

39580	946..00	Death notif.- non.hosp source
43009	94E..00	Date of death
15986	R211.00	[D]Instantaneous death
23077	22J2.00	O/E - dead - expected
19628	949..11	Dead - place patient died
21195	G575100	Sudden cardiac death, so described
39311	9492	Patient died in part 3 accom.
28879	945..00	Hospital death discharge notif
30357	949B.00	Patient died in community hospital
23074	94...11	Administration after pat. died
35520	22J1.00	O/E - dead - unexpected
30327	9498	Dead on arrival at hospital
58563	94F..00	Unexpected death
30333	9496	Patient died in street
28687	9497	Patient died in publ.place NOS
23830	R21z.00	[D]Sudden death, cause unknown NOS
13550	947Z.00	SD17/18 cause of death NOS
46108	22JZ.00	O/E - dead NOS
30400	9499	Found dead at accident site
28927	945Z.00	Hospital death disch. NOS
48438	941Z.00	Death cert. Med A NOS
48491	236..12	O/E - respiratory death
46606	9134.11	Registration ghost - dead
46349	22J6.00	O/E - dead - suspicious death
32129	R213000	[D]Found after death, unknown cause of death
66033	941..11	Certificate - death
61220	R212.00	[D]Death less than 24 hours from onset of illness
40882	94B..11	Condition fatal-cause of death
30500	22J3.00	O/E - dead - unattended death
94234	R212100	[D]Died, with no sign of disease
50388	9411	Death cert. Med A due
56106	R213z00	[D]Unattended death NOS
66176	22J..11	O/E - dead - condition fatal
46616	T0y0.00	Found dead on railway right-of-way unspecified
48986	947..00	Cause of death clarif. SD17/18
49947	7L1M000	Preoperative anaesthetic death
67519	949C.00	Patient died in GP surgery
66966	T0y0200	Found dead on railway unspecified - pedestrian
68167	T0y0z00	Found dead on railway unspecified - unspecified person
71596	9471	SD17/18 received-death clarif.

73130	RyuC100	[X]Other sudden death, cause unknown
73170	947..11	SD17 - cause of death clarif
93203	R212z00	[D]Death less than 24 hours from onset of illness NOS

STROBE checklist for EARTH study

Cohort Study
Checklist

	Item No	Recommendation	Page Number	Section	Additional Information
Title and abstract					
	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2	Abstract	
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2	Abstract	
Introduction					
Background/ rationale	2	Explain the scientific background and rationale for the investigation being reported	3	Introduction	
Objectives	3	State specific objectives, including any prespecified hypotheses	3	Objectives	
Methods					
Study design	4	Present key elements of study design early in the paper	3	Methods- Study Design	
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	3	Methods- Data Source	
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	4	Methods- Population & Follow Up	
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA		
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4	Methods- Population & Analysis	
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	3	Methods- Data Source	
Bias	9	Describe any efforts to address potential sources of bias	9	Limitations	
Study size	10	Explain how the study size was arrived at	NA		This is a descriptive study, and no comparative analysis is being carried out, and therefore a sample size calculation is not appropriate. Our cohort of over 32,000 patients is very large, and allows precise

					estimates of population variables, as shown in the paper by the narrow 99% confidence intervals.
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4	Methods-Analysis	
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	4	Methods-Analysis	
		(*b*) Describe any methods used to examine subgroups and interactions	4 & 5	Methods-Follow Up	
		(*c*) Explain how missing data were addressed	4	Methods-Analysis	
		(*d*) If applicable, explain how loss to follow-up was addressed	4	Methods-Analysis	This is a GPRD study so the only type of missing data is values which are not recorded for every patients, such as body mass index. This is addressed in the Methods section. Further missing data is unlikely due to the nature of a GP database, All patients are followed up until death or until they transferred out of practice.
		(*e*) Describe any sensitivity analyses	NA		
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	5	Baseline characteristics	
		(*b*) Give reasons for non-participation at each stage	5	Baseline characteristics	
		(*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	5	Results- Table 1	
		(*b*) Indicate number of participants with missing data for each variable of interest	5	Results- Table 1	

		(*c*) Summarise follow-up time (eg average and total amount)	5	Results- Baseline characteristics
Outcome data	15*	Report numbers of outcome events or summary measures over time	6	Results- Stroke mortality and Recurrent cardiovascular events
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	5 & 6	Results
		(*b*) Report category boundaries when continuous variables were categorized	NA	NA
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA	NA
Other analyses	17	Report other analyses done? eg analyses of subgroups and interactions, and sensitivity analyses	6 & 7	Results- Atrial fibrillation
Discussion				
Key results	18	Summarise key results with reference to study objectives	7	Discussion
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	8	Discussion- limitations
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	7 & 8 & 9	Discussion & Implications
Generalisability	21	Discuss the generalisability (external validity) of the study results	7	Discussion
Other information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	10	Funding