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Evolution of the Hip Fracture Population: Time to Consider the Future?

A retrospective observational analysis

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Abstract

Objective: To describe the epidemiological changes in the hip fracture population within a defined geographical area of the United Kingdom over a consecutive 13-year period.

Design: Retrospective cohort study of prospectively collected Standardised Audit of Hip Fractures of Europe data entered on to an institutional hip fracture registry.

Participants: 10044 consecutive hip fractures admissions (2000-2012)

Setting: A Major Trauma Centre in the United Kingdom

Results: There was a generalised increase in the number of admissions between 2000 (n=740) and 2012 (n=810). This increase was non-linear and best described by a quadratic curve. Assuming no change in the prevalence of hip fracture over the next 20 years, our hospital is projected to treat 871 cases in 2020 and 925 in 2030. This represents an approximate year on year increase of just over 1%. There was an increase in the proportion of male admissions over the study period (2000:174 of 740 admissions (23.5%); 2012:249 of 810 admissions (30.7%)). This mirrored national census changes within the geographical area during the same period. While the median age 82 years (IQR 76 to 88) was similar during the period of observations there were significant increases in the numbers of patients admitted from their own home, patients mobilising independently outdoors at the time of admission, and the proportion of patients requiring help with basic activities of daily living (all $p<0.001$). There was also a two to fourfold increase in the proportion of patients admitted with a diagnosis of cardiovascular disease, renal disease, diabetes and polypharmacy (use of >4 prescribed medications) (all $p<0.001$).

Conclusions: The expanding hip fracture population has increasingly complex medical, social and rehabilitation care needs. This needs to be recognised so that appropriate health care strategies and service planning can be implemented. This epidemiological analysis allows projections of future service need, both in terms of patient numbers and dependency.

Strengths and limitations of this study

- This analysis is based on 10044 consecutive hip fracture admissions over a 13 year period from a defined geographical area using standardised data collection.
- Trends in the hip fracture population including information on patient demographics, medical co-morbidities, physical functioning, social circumstances and cognitive capacity during this period are presented.
- Based on these data we have been able to produce a simplified equation that allows individual centres to calculate their own expected increases in hip fracture admissions over the next 20 years.
- This is a retrospective analysis and there may be issues relating to coding inaccuracies and recorder bias.
- Any projections to a national population of hip fractures from a single centre, single population study may be liable to regional discrepancies and may not be applicable to other hospital populations where incidence of, for example, other co-morbidities may be significantly different

Introduction

The United Kingdom (UK) currently treats approximately 80,000 hip fractures every year at an estimated annual cost of two billion pounds in direct health-care costs alone [1,2,3]. One in every 12 patients who sustains a hip fracture will die in the first month following injury and three in every 10 will die within the first year [3]. The World Health Organisation has estimated that the number of people aged 65 and over will increase by 88% over the next 25 years due to an aging world population, better public health and an increased use of medical interventions that prolong the average life expectancy [4]. Linked to this is the spectre of the increasing incidence of patients with poor bone health, the so called 'osteoporosis epidemic' [5]. The annual number of hip fractures in the UK is projected to rise to 91,500 by 2015 and 101,000 by 2020 [6].

The projected rise in hip fracture incidence has implications for health strategy and resource allocation. These must be addressed if we are to continue to manage the specific needs of these patients and improve the standard of care. Previous studies have evaluated the increase in the incidence of this injury and projected future health-care requirements [4,7,8]. Few, if any, studies have evaluated other changes in the same population, including changes in social care, physical dependency and medical co-morbidities. These could also have an important impact on the requirement of future medical, nursing, rehabilitation and social services. This study aims to describe the epidemiological changes in the hip fracture population within a defined geographical area of the United Kingdom including data from two national censuses (2001 and 2011). The population is from a mixed urban and rural environment and likely to be representative of the UK population.

Patients and Methods

The Nottingham University Hospital admits approximately 800 hip fractures each year. For the entire study period, it has been the only hospital providing a trauma service for the local population and its surrounding areas and covers a catchment population of approximately 785,000. Since 1999, information on all hip fracture patients has been prospectively collected for the purpose of ongoing audit and service evaluation. Data for all hip fracture patients are recorded using a modified version of the standardised audit of hip fractures of Europe (SAHFE) audit form [4]. All data is collected prospectively by a team of independent audit staff who administer the local hip fracture database. SAHFE data completion is mandatory for all hip fractures in our hospital. In 2012 the trust recorded over 93% in the domain of data completeness within the national hip fracture database (NHFD) [9]. Audit data is strictly confidential and is managed in accordance with national data protection (Caldicott) guidelines.

Data recorded as part of this ongoing audit includes information on patient demographics, medical co-morbidities, physical functioning, social circumstances and cognitive capacity. Specific co-morbidities assessed include the presence of cardiovascular disease (CVD), chronic obstructive pulmonary disease (COPD), cerebrovascular disease (CVA), malignancy, diabetes mellitus (DM), renal disease, rheumatoid arthritis, Parkinson's disease, Paget's disease and polypharmacy (the use of >4 regular medications). During the study period there was no change in the definitions used by the audit for each of these conditions. This was a pragmatic, clinical audit with diagnosis based upon clinical history, examination and review of medical records. Physical functioning is assessed using specific questions related to mobility status, independence both within and outside the house and ability to perform activities of daily living such as washing, dressing, cleaning, feeding and toileting. Social circumstances are assessed by questions relating to the type of residence, co-habitation and the requirement for additional carers. The abbreviated mental test score is used to assess cognitive capacity[10].

The present study was conducted as a retrospective cohort study using the information held within the hip fracture database on all hip fractures entered between the 1st of January 2000 and 31st December 2012. These dates were chosen as they represented 13 consecutive years for which complete data was available for the entire year. Graphical and tabular summaries were performed to demonstrate how the hip fracture population has

evolved over this 13-year period. An additional comparison to Nottingham Census data (2001 and 2011) was conducted to see if the changes in the hip fracture population mirror those seen for the general population.

Statistical comparisons were performed to determine if each of the analysed variables changed over the period of observation. For continuous parametric data comparisons were made using independent t-tests and one-way Analysis of Variance (ANOVA). For continuous non-parametric data comparisons were made using Mann Whitney and Kruskal-Wallis tests. For categorical data Fishers exact and Chi-squared test were used. A p value of $p<0.05$ was used to indicate statistical significance.

Time series analysis was used to produce a mathematical model for the year on year changes in the observed number of hip fracture admissions. This model was then used to predict the expected admissions in 2020, 2025 and 2030. The 'best fit' time series model was selected to minimise the mean absolute percentage error (MAPE), mean absolute deviation (MAD) and the mean squared deviation (MSD). Statistical analysis was performed using SPSS version 19 and Minitab version 16.

Results

During the period 2000 to 2012 a total of 10044 patients were admitted with a hip fracture. The mean number of admissions per year was 773 (S.D 44.9, Range 704 to 854) with a generalised increasing incidence in hip fractures year on year. This increase was non-linear and best described by a quadratic curve (Figure 1). Assuming no change in the prevalence of hip fracture over the next 20 years, our hospital is projected to treat 871 cases in 2020, 899 in 2025 and 925 in 2030. A simple equation to allow hip fracture units to estimate their future hip fracture numbers (assuming similar demographics to Nottingham) is shown in figure 1.

Patient demographics

Overall, 2626 of the 10044 (26.1%) admissions were male. There was a steady increase in the proportion of male admissions between 2000 (174 of 740 (23.5%)) and 2012 (249 of 810 (30.7%)) ($p<0.001$) (Figure 2).

Median age at admission for all hip fractures over the 13-year period was 82 years (IQR 76 to 88, Range 17 to 105 years). Age at admission did not significantly change during the period of study (Median age in 2000 = 82 years (IQR 76 to 88); Median age in 2012 = 83 years (IQR 76 to 88 years), comparison across all years $p= 0.67$). However the median age of females (83 years (IQR 77 to 88, Range 19 to 105 years) was significantly higher than that for males (80 years (IQR 70 to 86, Range 17 to 105 years) ($p<0.001$). While they differed, the age distributions of both male and female patients did not significantly change with time (comparison across all years: female $p=0.70$, male $p=0.11$).

Social demographics

Between 2000 and 2012 (n=10044) 6742 (67.1%) patients were admitted from their own home, 1952 (19.4%) from warden aided / residential care and 1101 (11.0%) from nursing care and 249 from 'other' accommodation types. During this period there was a gradual increase in the number of admissions from patient living in their own home (2000 = 463 of 740 admissions (62.6%); 2012 = 587 of 810 admissions (72.5%)) ($p<0.001$). Over the same time period there was a reciprocal decrease in admissions from warden aided /

residential care (2000 = 171 of 740 admissions (23.1%); 2012 = 149 of 710 admissions (18.4%)) and nursing care (2000 = 98 of 740 admissions (13.2%); 2012 = 66 of 810 admissions (8.2%)) (p<0.001) (Figure 3). Of the 6742 patients living in their own home 3278 (48.6%) lived alone. The proportion of patients living alone in their own home remained similar over the period of observations (Figure 4).

At the time of admission 5027 of the 10044 (50.1%) admissions mobilised independently outdoors, 2443 (24.3%) mobilised independently indoors, 1302 (13.0%) were accompanied outdoors, 561 (5.6%) were accompanied indoors, 261 (2.6%) were immobile or could only transfer and for 450 (4.5%) mobility status was not known (Figure 5). Of the 5027 patients who were independent outdoors, 3119 (62.0%) did not use any mobility aids, 1520 (30.2%) used one aid and 388 (7.7%) used two aids / frame / walker. The reliance on walking aids increased as the level of mobility decreased (p<0.001).

The proportions of patients mobilising independently outdoors at the time of admission increased between 2000 (343 of 740 admissions (46.4%)) and 2012 (429 of 810 admissions (53.0%)) (p<0.001). However, there was a more dramatic change in the proportions of patients mobilising independently indoors (2000 = 301 of 740 admissions (40.7%); 2012 = 129 of 810 admissions (15.9%)) and mobilising accompanied outdoors (2000 = 33 of 740 admissions (4.5%); 2012 = 120 of 810 admissions (14.8%)) during the same period (p<0.001) (Figure 5).

The proportions of patients who were completely independent for all activities of daily living (ADLs) were similar across the study period (Figure 6). Overall 4011 of 10044 (39.9%) patients were completely independent for all ADLs. For the 6033 patients that were not independent for their ADLs, 2586 (42.9%) required assistance with some form of basic care (Washing, dressing, feeding, toileting) (Figure 7). The proportion of patients requiring this level of care increased from 161 of 455 patients requiring assistance with ADLs (35.4%) in 2000 to 220 of 460 patients requiring assistance with ADLs (47.8%) in 2012 (p<0.001).

Co-morbidities

Of the co-morbidities recorded there was a significant increase in the proportion of patients presenting with cardiovascular disease (CVD), diabetes mellitus (DM), renal disease

and polypharmacy (patients on greater than 4 prescribed medications) (Figure 8). Of the total 10044 patients, 4851 (48.3%) had a diagnosis of CVD, 1242 (12.4%) had a diagnosis of DM, 614 (6.1%) had a diagnosis of renal disease and 3906 (38.9%) were prescribed greater than four medications.

In 2000, the percentage of patients with CVD was 19.6% (145 of 740 admissions), which increased by a factor of 3.1 to 61.4% in 2012 (497 of 810 admissions) ($p<0.001$). Similarly the percentage of patients with DM increased by a factor of 1.8 from 8.7% (64 of 740 admissions) in 2000 to 15.4% (125 of 810 admissions) in 2012 ($p<0.001$). The presence of renal disease increased from 2% (15 of 740 admissions) in 2000 to 8.5% (69 of 840 admissions) in 2012, a greater than fourfold increase ($p<0.001$). The proportion of patients with polypharmacy also increased by a factor of two between 2000 (20.2%, 142 of 740 admissions) and 2012 (39.8%, 322 of 810 admissions), n=142 (20.2%) increased to 2012 n=322 (39.8%) ($p<0.001$).

For all other recorded co-morbidities the proportions of admissions with a positive diagnosis remained similar throughout the period of observation (respiratory disease: n=1726 (17.2%), previous stroke n=1442 (14.4%), malignancy n=1183 (11.8%), rheumatoid arthritis n=350 (3.5%), Parkinson's disease n=325 (3.2%), Paget's disease n=34 (0.3%)).

The median abbreviated mental test score for patients was 9 (IQR 3 to 10, Range 0 to 10) and did not change significantly year to year ($p=0.51$). The number of patients prescribed either Clopidogrel or Warfarin demonstrated significant variation from year to year and followed a steadily increasing trend between 2000 and 2012 (both $p<0.001$) (Figure 9).

Fracture demographics

The distributions of the type of fractures presenting to the unit by year are shown in figure 10. Of the total 10044 patients, 6012 (59.9%) presented with an intracapsular fracture of which 815 (8.1%) were undisplaced subcapital fractures, 4783 (47.6%) were displaced subcapital fractures and 414 (4.1%) were basicervical neck fractures. The remaining 4032 (40.1%) were extracapsular fractures of which 3202 (31.9%) were trochanteric (2 to 4 part), 711 (7.1%) were subtrochanteric or reverse oblique fractures, and 119 (1.1%) were other types / fracture pattern not recorded.

Discussion

This analysis of 13 consecutive years of hip fracture admissions demonstrates an increasing trend in the number of admissions between 2000 and 2012, which was largely due to an increase in the number of male admissions. Based on the observed data for this period we have produced a simplified equation that allows individual centres to calculate their own expected increases in hip fracture admissions over the next 20 years. We also observed significant increases in the number of patients admitted from their own home, the proportion of patients requiring assistance with basic activities of daily living (washing, dressing, feeding, toileting) and the incidence of cardiovascular disease, diabetes, renal disease, polypharmacy and rates of anticoagulation in our hip fracture population. Patient age, cognitive capacity and the type of hip fractures being treated were similar throughout the study period.

The 2011 National Census reported that approximately 1 in 5 (22.6%) of the population of England and Wales was aged over 60 and the total number of residents aged over 90 was 430,000, up from 340,000 in 2001 [11]. Between 2001 and 2011 the population of Nottinghamshire increased by 37,500 (5%) from 748,300 (2001) to 785,800 (2011) with an associated 3% increase in the proportion of the population aged over 60 (21.1% in 2001, 24.1% in 2011) [12,13]. This may well explain the observed 10% increase in the number of hip fracture admissions to our unit over the same time period (2001: 704 admissions, 2011: 774 admissions). The Nottingham Census also found that between 2001 and 2011 there was a large increase in population numbers in residents aged 75-89 years, and that this increase was greater for males than for females [12,13]. This suggests a greater relative improvement in survival rates for elderly male patients and helps to explain the increasing number of male admissions observed during the study period.

The observed increases in hip fracture admissions were best modelled using a quadratic time series curve which suggested that, while the number of admissions is increasing, the size of the annual increase is reducing year on year. This model forecasts our unit will admit 871 hip fracture patients in 2020 and 925 in 2030 representing an 8% and 14% increase from the observed number of admissions in 2012 (810) respectively. Based on this model we have produced a simplified equation for calculating the expected number of hip fracture admissions in any unit in England and Wales using the observed number of

admissions in that unit in 2012. Using our own data this simplified model is +/- 1% accurate when compared to the forecasted results from the time series curve for predictions up to 2030. This supports its use as a simplified method of calculating the expected number of admissions in the short to medium term.

Between 2000 and 2012 there was an increase in the number of patients admitted from their own home (62.6% versus 72.5%), although the proportion of patients living alone in their own home remained similar. The national figure for proportion of patients admitted from their home in 2012 was 74.7%, suggesting that Nottingham may be fairly representative of the English population [9].

This analysis also found that the proportion of patients with dependency increased with more requiring assistance to mobilise and with basic activities of daily living. In addition, the number of patients with identified, concurrent co-morbidities significantly increased between 2000 and 2012. Hence, we are supporting a population of patients who are increasingly frail and have significant social care needs within their own homes. This has implications for nursing care within hospital, rehabilitation and eventual discharge from hospital following fracture treatment. Patients may be less likely to achieve the requisite level of physical functioning to permit discharge home if they have poor functional reserve to begin with.

Between 2000 and 2012 there was a two- to four- fold increase in the proportions of patients presenting with cardiovascular disease, diabetes, renal disease and polypharmacy. There was a similar increase in the number of patients prescribed either Clopidogrel or Warfarin. Over the last 10 years, Quality and Outcome Frameworks (QOF) [14] have been introduced to incentivise the treatment of a range of conditions in primary care. These frameworks function as voluntary annual reward systems to primary care practices if they deliver high quality on a range of services [15]. Areas of clinical care linked to rewards include the implementation of evidence-based clinical interventions known to benefit patients with chronic conditions such as diabetes, asthma, chronic renal disease, and cardiovascular disease treatment [16,17]. The initiation of such strategies in 2003/04 may, in part, account for the sudden jump in proportion of patients we observed with diagnosed cardiovascular disease, diabetes and renal disease and the associated increase in polypharmacy.

An increase in the volume of clinical evidence and national guidance may also have contributed to the increase in diagnosis of these co-morbidities. Since 2000 NICE has published a range of guidance including specific guidelines relating to the management of Chronic heart failure (2003) [18], Type 1 diabetes (2004) [19], Hypertension (2004) [20], Vascular disease (2005) [21], Cardiovascular disease (Statins) (2006) [22] and Atrial Fibrillation (2006) [23]. National Service Framework guidance on the management of cardiovascular disease (2000) [24] may also have influenced the observed increase in this diagnosis.

The use of warfarin and clopidogrel varied from year to year but overall demonstrated a progressive increased trend over the study period. Warfarin use was not observed in the elderly population who suffer hip fractures until 2007 but has steadily risen since. Reasons for this may include the publication of NICE guidance for atrial fibrillation [23] and the results of the BAFTA trial, which supported the use of warfarin for stroke prevention in patients aged over 75 [25,26]. Similarly the trends in Clopidogrel use may reflect the publication of results from the CAPRIE and MATCH trials [27,28] and subsequent NICE guidance on the use of clopidogrel and dipyridamole in vascular disease [21].

In 2011 NICE released specific guidance on the management of hip fractures (2011)[1]. Within this was a cost analysis detailing the projected financial impact of managing the hip fracture population. It identified a number of resources that were likely to incur significant costs to the NHS in the future as the number of hip fractures increases. These included the provision of dedicated trauma lists to ensure surgery is performed within 36 hours, implant costs, adequate physiotherapy and occupational therapy to allow early mobilization and rehabilitation, and ongoing orthogeriatric assessment and support. Our study confirms that the numbers of hip fracture admissions is increasing but the population is also changing with more men, more patients admitted from their own homes, and more patients requiring assistance with mobility and activities of daily living. In addition, more patients have complex medical co-morbidities and so it is likely that the cost of treating these patients will climb at a faster rate than projections based upon changes in the age demographics alone. These changes will put pressure on orthopaedic trauma services and drive an increased requirement for nursing, physiotherapy, occupational therapy and orthogeriatric input to address the increasingly complex rehabilitation, social, and medical needs of this patient population.

This study benefits from the size of the cohort available for analysis, the consecutive period of follow up, consistent data collection and the range of data collected. The hospital serves a well defined urban / rural population with no alternative hip fracture service within this geographical area. While the unit's current data completeness rate of 93% is good and much better than Hospital Episode Statistics, it could be better. The introduction of the NICE guidance and best practice tariff may have raised awareness in reporting of facets of patient care giving more accurate and complete data in the later years. Inaccuracies in coding and recorder intervariability are potential sources of error which may account for some of the year on year differences observed. Any projections to a national population of hip fractures from a single centre, single population study may be liable to regional discrepancies and may not be applicable to other hospital populations where incidence of, for example, other co-morbidities may be significantly different. However, despite these concerns we feel that the overall trends reported here are likely to be generalisable to national practice. While the National Hip Fracture Database (NHFD) publishes yearly reports on management of the hip fracture population it has only been reporting national results since 2009; NHFD only has limited data on dependency and does not collect data on co-morbidities [3,9]. This report therefore adds significantly to the results available from this database.

Conclusion

The management of hip fractures represents a major financial, clinical and logistical burden for the NHS and social services. The increasing numbers of patients admitted with hip fractures mirrors the changes in population demographics reported by national census data. Over the last decade this group of patients have demonstrated increasing medical, social and rehabilitation care needs. This problem needs to be recognised so that appropriate health care strategies and service planning can be implemented. This paper provides data to allow projections of future service need, both in terms of patient numbers and dependency.

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Declaration of Competing Interests

We have read and understood the BMJ Group policy on declaration of interests and declare the following interests: NONE

All authors have completed the ICMJE uniform disclosure form at http://www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years [or describe if any], no other relationships or activities that could appear to have influenced the submitted work

Ethical Approval of Research

This study was performed on anonymised data held within an on-going institutional hip fracture audit programme. As there was no further patient contact the project was performed as a service evaluation without need for formal ethical approval. Utilised Nottinghamshire Census data is available publicly via the Nottinghamshire city council. Nottingham University Hospitals Hip Fracture Data is also available publicly on request.

Authorship

In accordance with the ICMJE criteria for authorship we can confirm that each of the stated authors (Paul N Baker, Omer Salar, Benjamin J Ollivere, Daren P Forward, Namal Weerasuriya, Chris G Moran) have made significant contributions to:

- The conception and design, or analysis and interpretation of these data
- Drafting the article or revising it critically for important intellectual content
- And final approval of the version to be published

The lead author affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained

Data Sharing Statement

This study was conducted on data collected as part of the on-going audit of hip fracture patients admitted to the Nottingham University Hospitals NHS Trust. All data collected as part of this audit program is held by the hip fracture audit co-ordinators in the department of trauma and orthopaedics, Queens Medical Centre, Nottingham. This database is

administered by the senior author (Prof Christopher Moran). The data used for this study was extracted from this database for the sole purpose of the stated analyses. The corresponding author therefore possesses no additional unpublished data in respect of this study.

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Legend page

Figures:

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Figure 2: Proportion of Male and Female patients admitted with a hip fracture by year (2000 to 2012).

Figure 3: Place of residence prior to admission by year (2000 to 2012).

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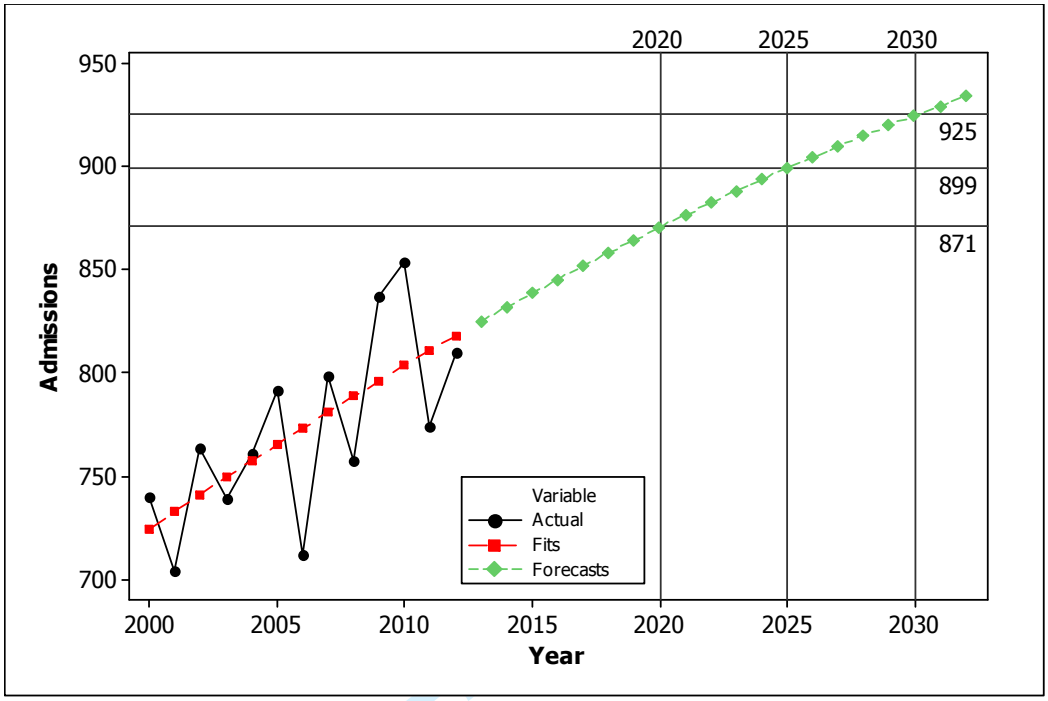
Figure 10: Distribution in the pattern of presenting fracture by year (2000 to 2012).

Tables and Figures



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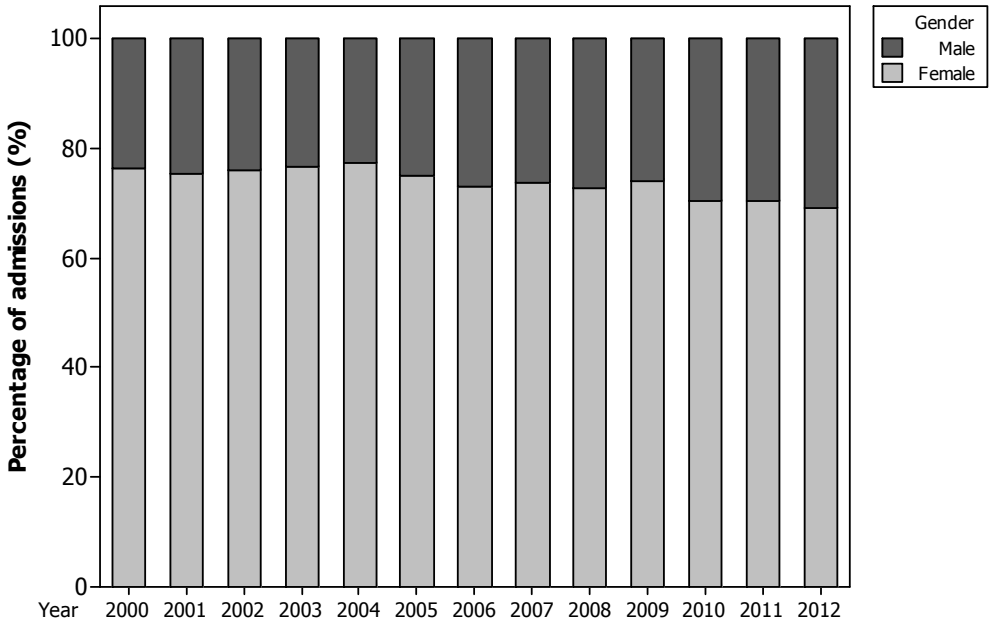

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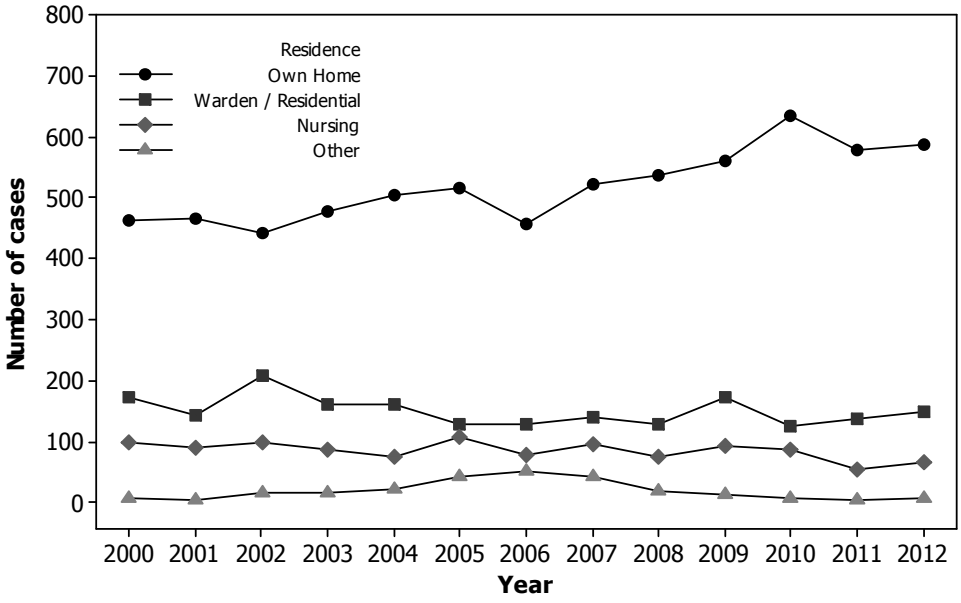

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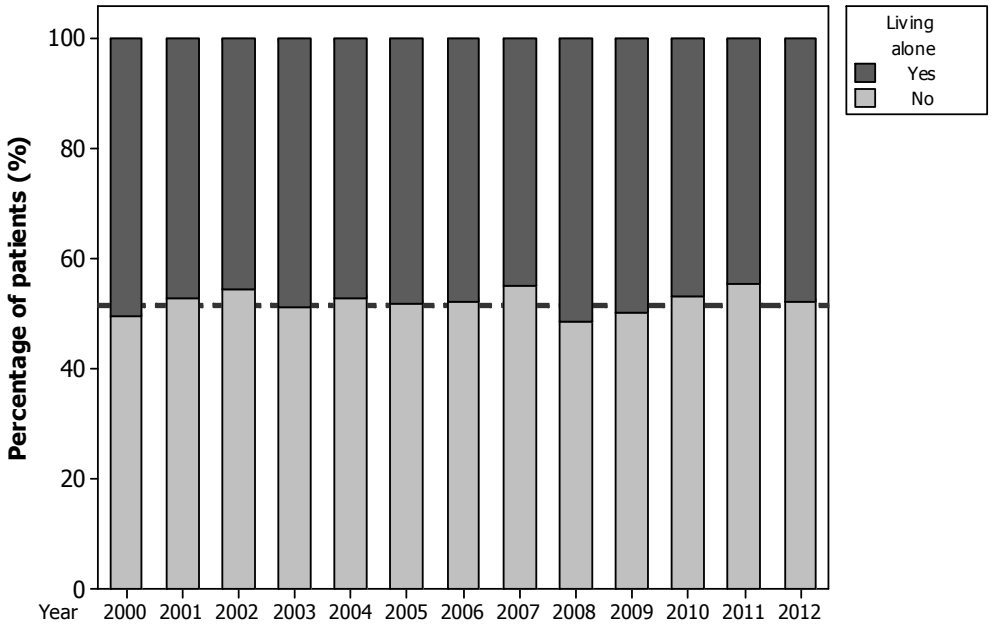

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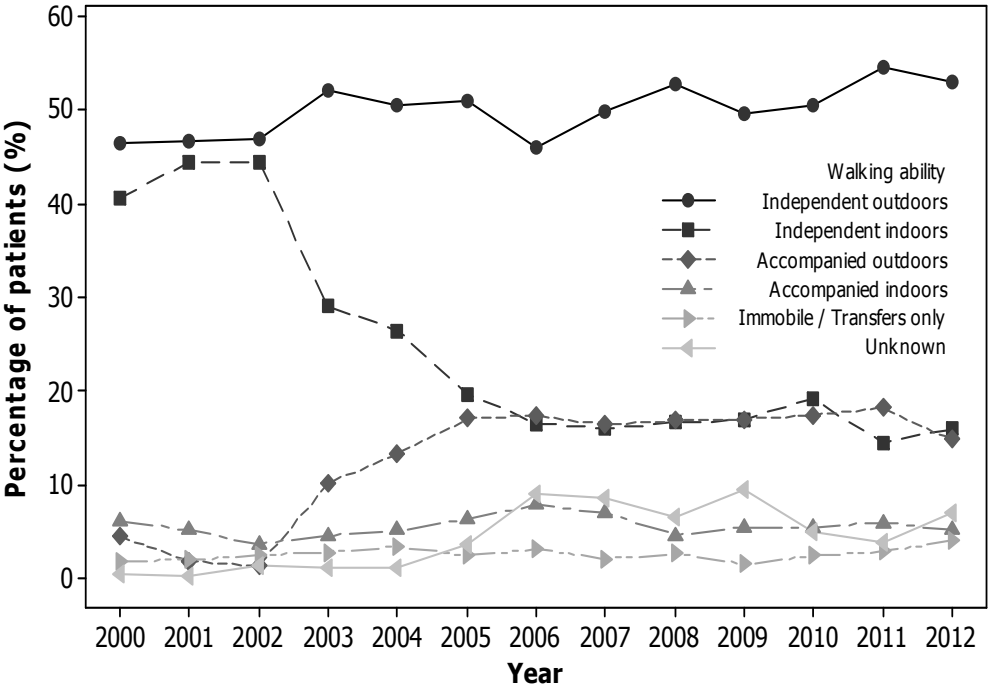

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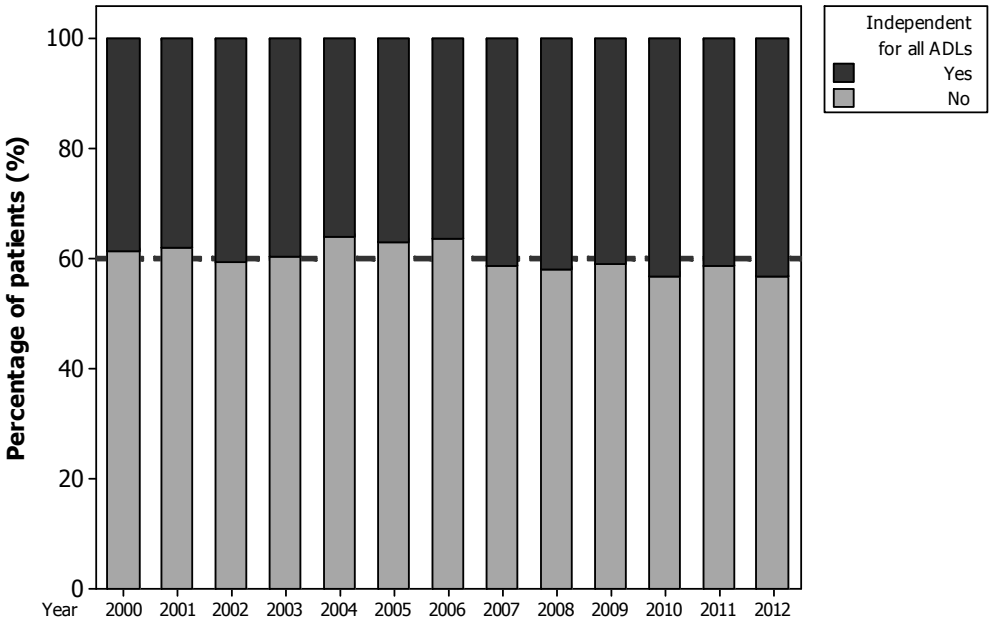

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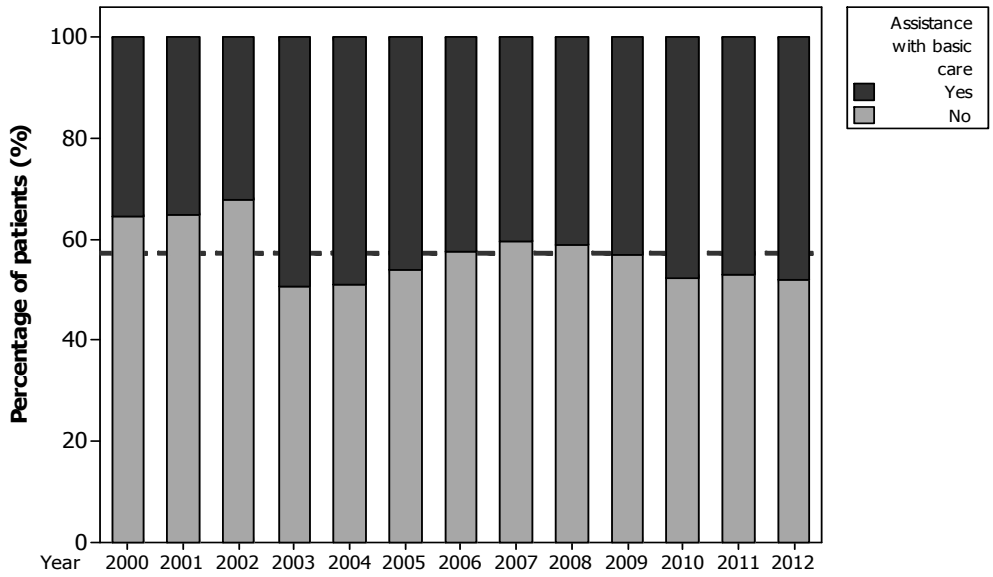

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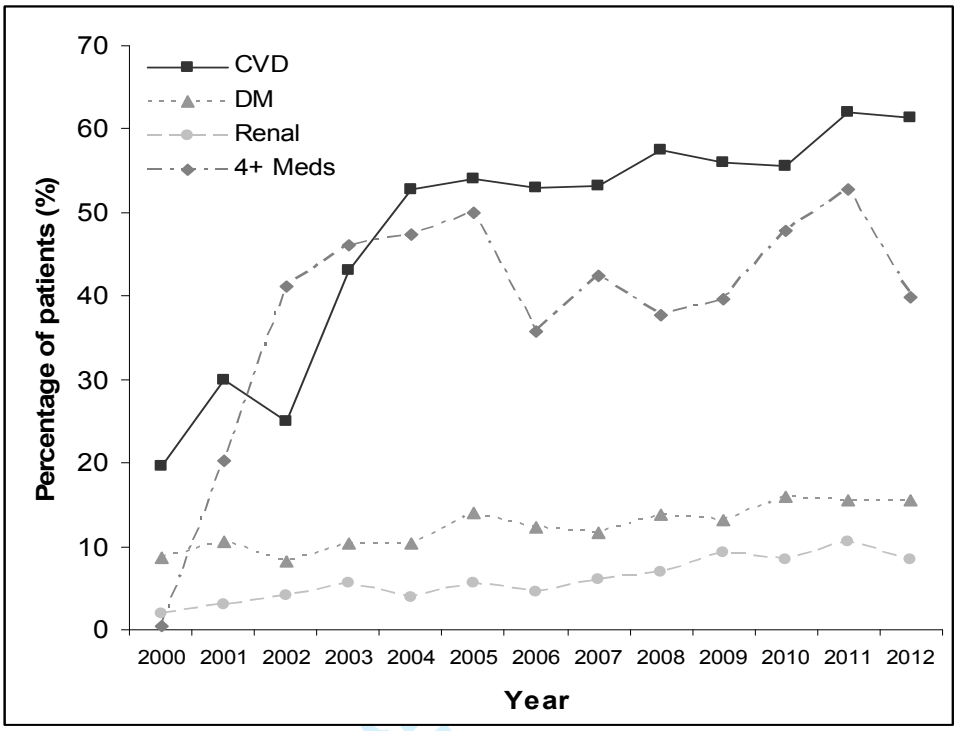

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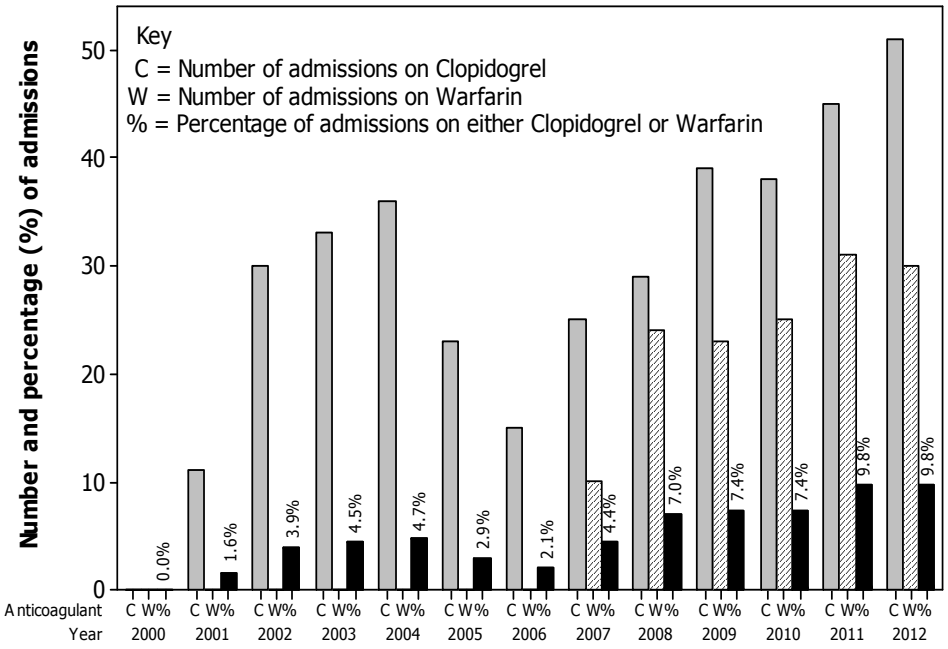

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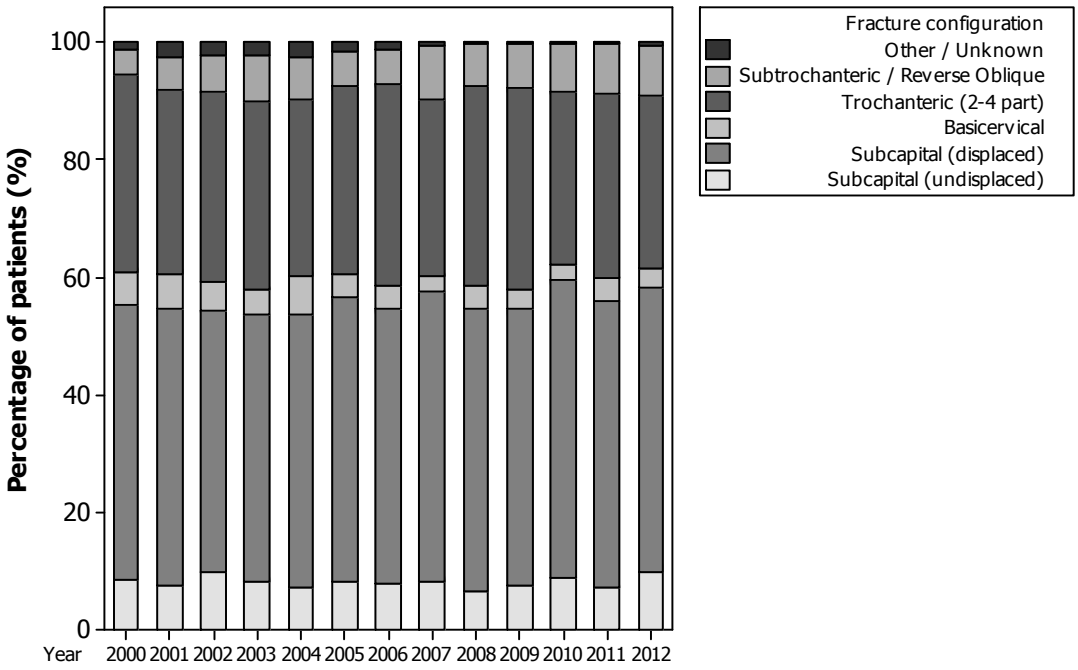

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract **Title: Page 1**
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found **Abstract: Page 4**
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported **Intro paragraph 1&2 (Page 5)**
Objectives	3	State specific objectives, including any prespecified hypotheses **Intro paragraph 2 (Page 5), Patients and Methods paragraphs 3 to 5 (Page 6&7)**
Methods		
Study design	4	Present key elements of study design early in the paper **Methods paragraph 1 to 3 (Page 6&7)**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection **Methods (Page 6&7)**
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up **Methods paragraph 1 to 3 (Page 6&7)** *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls **NA** *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants **NA**
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed **NA** *Case-control study*—For matched studies, give matching criteria and the number of controls per case **NA**
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable **Methods paragraph 2 to 5 (Page 6&7)**
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 **Methods paragraphs 1 to 4 (Page 6&7)**
Bias	9	Describe any efforts to address potential sources of bias **Not described**
Study size	10	Explain how the study size was arrived at **Methods paragraph 1&3 (Page 6&7), Figure 2**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why **Methods (Page 6&7)**

Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding **Methods paragraph 4&5 (Pages 6&7), Plus relevant figures**
		(*b*) Describe any methods used to examine subgroups and interactions **Methods paragraph 3 to 5 (Pages 6&7), Plus relevant figures**
		(*c*) Explain how missing data were addressed **Methods paragraph 1 (Page 6), Discussion paragraph 10 (Page 13)**
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed **NA** *Case-control study*—If applicable, explain how matching of cases and controls was addressed **NA** *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy **NA**
		(*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 **Methods paragraph 1 (page 6)**
		(b) Give reasons for non-participation at each stage **NA**
		(c) Consider use of a flow diagram **NA**
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders **Results (pages 8 to 10)**
		(b) Indicate number of participants with missing data for each variable of interest **NA**
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount) **NA**
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time **Results paragraph 1 (Page 8) and figure 1**
		Case-control study—Report numbers in each exposure category, or summary measures of exposure **NA**
		Cross-sectional study—Report numbers of outcome events or summary measures **NA**
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 **Results (Pages 8 to 10)**
		(*b*) Report category boundaries when continuous variables were categorized **NA**
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period **NA**
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses **Results (Pages 8 to 10)**
Discussion		
Key results	18	Summarise key results with reference to study objectives **Discussion paragraph 1 (Page 11)**

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 **Discussion paragraph 10 (Page 14)**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **Discussion (Page 11-14) paragraph 10 (page 14)**
Generalisability	21	Discuss the generalisability (external validity) of the study results **Conclusions (Page 14) Discussion paragraph 1 (Page 11) , Figure 1**
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 **NA**

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

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

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Evolution of the Hip Fracture Population: Time to Consider the Future? A retrospective observational analysis

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Evolution of the Hip Fracture Population: Time to Consider the Future?

A retrospective observational analysis

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Key words

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Abstract

Objective: To examine how the fractured neck of femur population has changed over the last decade and determine whether they have evolved to become a more physically and socially dependent cohort

Design: Retrospective cohort study of prospectively collected Standardised Audit of Hip Fractures of Europe data entered on to an institutional hip fracture registry.

Participants: 10044 consecutive hip fractures admissions (2000-2012)

Setting: A Major Trauma Centre in the United Kingdom

Results: There was a generalised increase in the number of admissions between 2000 (n=740) and 2012 (n=810). This increase was non-linear and best described by a quadratic curve. Assuming no change in the prevalence of hip fracture over the next 20 years, our hospital is projected to treat 871 cases in 2020 and 925 in 2030. This represents an approximate year on year increase of just over 1%. There was an increase in the proportion of male admissions over the study period (2000:174 of 740 admissions (23.5%); 2012:249 of 810 admissions (30.7%)). This mirrored national census changes within the geographical area during the same period. During the study period there were significant increases in the numbers of patients admitted from their own home, the proportion of patients requiring assistance to mobilise, and the proportion of patients requiring help with basic activities of daily living (all $p<0.001$). There was also a two to fourfold increase in the proportion of patients admitted with a diagnosis of cardiovascular disease, renal disease, diabetes and polypharmacy (use of >4 prescribed medications) (all $p<0.001$).

Conclusions: The expanding hip fracture population has increasingly complex medical, social and rehabilitation care needs. This needs to be recognised so that appropriate health care strategies and service planning can be implemented. This epidemiological analysis allows projections of future service need, both in terms of patient numbers and dependency.

Strengths and limitations of this study

- This analysis is based on 10044 consecutive hip fracture admissions over a 13 year period from a defined geographical area using standardised data collection.
- Trends in the hip fracture population including information on patient demographics, medical co-morbidities, physical functioning, social circumstances and cognitive capacity during this period are presented.
- Based on these data we have been able to produce a simplified equation that allows individual centres to calculate their own expected increases in hip fracture admissions over the next 20 years.
- This is a retrospective analysis and there may be issues relating to coding inaccuracies and recorder bias.
- Any projections to a national population of hip fractures from a single centre, single population study may be liable to regional discrepancies and may not be applicable to other hospital populations where incidence of, for example, other co-morbidities may be significantly different

Introduction

The United Kingdom (UK) currently treats approximately 80,000 hip fractures every year at an estimated annual cost of two billion pounds in direct health-care costs alone [1,2,3]. One in every 12 patients who sustains a hip fracture will die in the first month following injury and three in every 10 will die within the first year [3]. The World Health Organisation has estimated that the number of people aged 65 and over will increase by 88% over the next 25 years due to an aging world population, better public health and an increased use of medical interventions that prolong the average life expectancy [4]. Despite a decline in the age specific incidence of hip fractures over the last decade [5,6,7], these population changes mean the overall number of hip fractures will continue to increase [5,6] The annual number of hip fractures in the UK is projected to rise to 91,500 by 2015 and 101,000 by 2020 [6].

The projected rise in hip fracture incidence has implications for health strategy and resource allocation. These must be addressed if we are to continue to manage the specific needs of these patients and improve the standard of care. Previous studies have evaluated how hip fracture incidence has changed with time [5,6,7], the relationships to changing population demographics [5], and the impact upon projected future health-care requirements [8,9,10]. Few, if any, studies have evaluated how physical dependency, medical co-morbidities, social needs and care requirements have changed within this population with time. This is important to appreciate as these factors will also have a significant impact on the requirements for future medical, nursing, rehabilitation and social services.

To address these concerns we interrogated an institutional hip fracture database with the aim of answering the following research question: “How has the population of patients admitted to hospital with a fractured neck of femur changed over the last decade and have they evolved to become a more physically and socially dependent cohort?”. Our null hypothesis was that the fractured neck of femur population would not have changed with time for any of the markers of physical and social dependency examined during this analysis.

Patients and Methods

The Nottingham Hip Fracture Database

Nottingham University Hospitals cover a catchment population of approximately 785,000 and admit approximately 800 hip fractures each year. For the entire study period, it has been the only hospital providing a trauma service for the local population and its surrounding areas. In May1999, the Nottingham Hip Fracture Database was initiated to prospectively collect information on all hip fracture patients for the purpose of ongoing audit and service evaluation. Data for all hip fracture patients are recorded using a modified version of the standardised audit of hip fractures of Europe (SAHFE) data collection form [4]. All data is collected prospectively by a team of independent audit staff who administer the local hip fracture database. SAHFE data completion is mandatory for all hip fractures in our hospital and in 2012 the trust recorded over 93% in the domain of data completeness within the national hip fracture database (NHFD) [11]. Audit data is strictly confidential and is managed in accordance with national data protection (Caldicott) guidelines.

Study Design and Dataset

To address our research question a retrospective cohort study was conducted using all of the information held within the hip fracture database from its inception (May 1999) to the date of the current project data request (March 2013). In total 10,739 consecutive hip fracture admissions were identified. Form this cohort we excluded the cases from 1999 (n=446) and 2013 (n=249) as a complete years' worth of admission data was not available. Analysis was therefore based on a consecutive series of 10,044 hip fractures admitted during a 13 year period between the 1st of January 2000 and 31st December 2012. The baseline demographics for study cohort are given in table 1.

Outcome Variables

The Nottingham Hip Fracture Database records information on patient demographics, medical co-morbidities, physical functioning, social circumstances and cognitive capacity for each hip fracture patient. The database records information pertaining to specific co-morbidities, including questions about the presence of a diagnosis of cardiovascular disease (CVD), cerebrovascular disease (CVA), chronic obstructive pulmonary disease (COPD), renal disease, diabetes mellitus (DM), , Rheumatoid arthritis, Parkinson's disease and malignancy. During the study period there was no change in the definitions used by the database for each of these conditions. Information about medication use is

also recorded, with specific questions about the use of steroids, anticoagulants (e.g. clopidogrel, warfarin) and polypharmacy (the use of >4 regular medications) (Table 1).

Physical functioning is assessed using specific questions related to mobility status, independence both within and outside the house and ability to perform activities of daily living such as washing, dressing, cleaning, feeding and toileting. Social circumstances are assessed by questions relating to the type of residence, co-habitation and the requirement for additional carers. The abbreviated mental test score is used to assess cognitive capacity[12].

To ascertain how the hip fracture population had changed with time the distribution of each of these outcome variables was calculated for each year of the analysis (2000 to 2012). This allowed observed changes and trends in the distributional characteristics of these variables with time to be appreciated.

Statistical analysis

Initial graphical and tabular summaries were performed to demonstrate how the hip fracture population changed over the period of analysis. Comparison to publically available Nottingham Census data (2001 and 2011) was conducted to see if the observed changes in the hip fracture population mirrored those seen for the general population.

Statistical comparisons were performed to determine if each of the analysed variables changed over the period of observation. For continuous parametric data comparisons were made using independent t-tests and one-way Analysis of Variance (ANOVA). For continuous non-parametric data comparisons were made using Mann Whitney and Kruskal-Wallis tests. For categorical data Fishers exact and Chi-squared test were used. A p value of $p<0.05$ was used to indicate statistical significance.

Time series analysis was used to produce a mathematical model for the year on year changes in the observed number of hip fracture admissions. Linear, quadratic, exponential and S-Curve models were sequentially fitted to the data and for each model its adequacy was assessed using the mean absolute percentage error (MAPE), mean absolute deviation (MAD) and the mean squared deviation (MSD). The 'best fit' quadratic time series model was selected as it was the model type that minimised each of these variables. This model was then used to generate forecasts of the expected

number of admissions in 2020, 2025 and 2030. Statistical analysis was performed using SPSS version 19 (IBM Corporation, Armonk, USA) and the time series analysis was undertaken using Minitab version 16 (Minitab Ltd, Coventry, UK).

Results

Hip fracture admissions

During the period 2000 to 2012 a total of 10,044 patients were admitted with a hip fracture. The mean number of admissions per year was 773 (S.D 44.9, Range 704 to 854) with a generalised increase in the number of hip fractures admissions with each year. This increase was non-linear and best described by the quadratic curve: Admissions = 715.59 + (8.72 × number of years after 1999) - (0.06 × (number of years after 1999)2), [i.e. year 2000 = 1] (Figure 1). Assuming no change in the prevalence of hip fracture over the next 20 years, our hospital is projected to treat 871 cases in 2020, 899 in 2025 and 925 in 2030. A simple equation to allow hip fracture units to estimate their future hip fracture numbers (assuming similar demographics to Nottingham) is shown in figure 1.

Patient demographics

Baseline demographics for the entire study cohort are presented in table 1.

Age at admission did not significantly change during the period of (p= 0.67). However the median age of females (83 years (IQR 77 to 88, Range 19 to 105 years) was significantly higher than that for males (80 years (IQR 70 to 86, Range 17 to 105 years) (p<0.001). While they differed, the age distributions of both male and female patients did not significantly change with time (comparison across all years: female p=0.70, male p=0.11). During the period of study there was a steady and significant increase in the proportion of male admissions from 174 of 740 (24%) in 2000 to 249 of 810 (31%) in 2012 (p<0.001) (Table 2).

Co-morbidities

Of the co-morbidities recorded there was a significant increase in the proportion of patients presenting with cardiovascular disease (CVD), diabetes mellitus (DM), renal disease and polypharmacy (patients on greater than 4 prescribed medications) with time (Figure 2). In 2000, the percentage of patients with CVD was 20% (145 of 740 admissions), which increased by a factor of 3.1 to 61% in 2012 (497 of 810 admissions) (p<0.001). Similarly the percentage of patients with DM increased by a factor of 1.8 from 9% (64 of 740 admissions) in 2000 to 15% (125 of 810 admissions) in 2012 (p<0.001). The presence of renal disease increased from 2% (15 of 740 admissions) in 2000 to 9% (69 of 840 admissions) in 2012, a greater than fourfold increase (p<0.001). The proportion of

patients with polypharmacy also increased by a factor of two between 2000 (20%, 142 of 740 admissions) and 2012 (40%, 322 of 810 admissions)(p<0.001). For all other recorded co-morbidities the proportions of admissions with a positive diagnosis remained similar throughout the period of observation.

The median abbreviated mental test score for patients was 9 (IQR 3 to 10, Range 0 to 10) and did not change significantly year to year (p=0.51). The number of patients prescribed either Clopidogrel or Warfarin demonstrated significant variation from year to year and followed a steadily increasing trend between 2000 and 2012 (both p<0.001) (Figure 3).

Social demographics

Baseline social demographic data is presented in table 1.Between 2000 and 2012 there was a gradual increase in the number of admissions from patient living in their own home (p<0.001). Over the same time period there was a reciprocal decrease in admissions from warden aided / residential care and nursing care (p<0.001) (Figure 3). Of the 6742 patients living in their own home 3278 (49%) lived alone. The proportion of patients living alone in their own home remained similar over the period of observation (Table 2).

At the time of admission 5027 of the 10,044 (50%) admissions mobilised independently outdoors (Table 1)., Of these 5027 patients 3119 (62%) did not use any mobility aids, 1520 (30%) used one aid and 388 (8%) used two aids / frame / walker. The reliance on walking aids increased as the level of mobility decreased (p<0.001). The proportions of patients mobilising independently outdoors at the time of admission increased significantly between 2000 and 2012. During the same period there was a reciprocal decrease in the proportion of patients mobilising independently indoors (p<0.001) (Table 2).

The proportions of patients who were completely independent for all activities of daily living (ADLs) were similar across the study period (Table 2). Overall 4011 of 10,044 (40%) patients were completely independent for all ADLs. For the 6033 patients that were not independent for their ADLs, 2586 (43%) required assistance with some form of basic care (Washing, dressing, feeding, toileting) (Figure 4). The proportion of patients requiring this level of care increased from 161 of 455

patients requiring assistance with ADLs (36%) in 2000 to 220 of 460 patients requiring assistance with ADLs (48%) in 2012 ($p<0.001$).

Fracture demographics

The distributions of the type of fractures presenting to the unit by year are shown in figure 5 and given in table 1. The distribution of intracapsular and extracapsular (intertrochanteric / subtrochanteric / Other proximal femoral fractures) remained consistent over the period of study with approximately 60% of hip fractures / year being intracapsular.

Discussion

Principle findings and comparison with other studies

The last decade has seen an increase in the number of hip fractures admitted to our institution. The number of admissions is expected to increase further over the next 20 years with a forecasted 15% rise in admissions by 2030. However, while the number of admissions is increasing, the quadratic time series curve produced suggested that, while the number of admissions is increasing, the size of the annual increase is reducing year on year. Using our data we have produced a simplified forecasting model which was +/- 1% accurate when compared to the predicted results from the time series curve. This equation can be used by centres wanting to calculate their expected short to mid-term hip fracture service requirements.

The predicted rise in the number of hip fractures mirrors the trends predicted for England [5] and Scotland [6]. However, the size of the increase is smaller than the 45 to 75% rise in numbers predicted by the Scottish group 6 and significantly lower than the 'pessimistic' estimate of a doubling in the number of hip fractures by 2033 reported for England by White et al [5]. Hip fracture admissions are expected to continue to rise despite a global decrease in the age related incidence of these fractures during the last decade [5,7]. This is because the population continues to age due to the success of public health strategies and the advent of medical interventions that prolong the average life expectancy during the second half of the 20th century[4,13]. In 2011 approximately 1 in 5 (22.6%) of the population of England and Wales was aged over 60 and the total number of residents aged over 90 was 430,000, up from 340,000 in 2001 [14]. Between 2001 and 2011 the population of Nottinghamshire increased by 37,500 (5%) from 748,300 (2001) to 785,800 (2011) with an associated 3% increase in the proportion of the population aged over 60 (21.1% in 2001, 24.1% in 2011) [15,16]. This may explain the observed 10% increase in the number of hip fracture admissions to our unit over the same time period and the relatively conservative estimate for the number of future admissions. Geographical areas with greater increases in the proportion of their population over 60 are likely to experience greater increases in hip fracture admissions in future years. Our equation for predicting future clinical need must therefore be interpreted in the context of each individual centres geographic population and will be most accurate for centres that service patient populations similar to our own.

The median age of our cohort did not change with time, however, the proportion of male admissions increased. This contrasts with the review by Haleem et al [13] which found a trend towards an increasing mean age and a static female: male ratio in the 36 publications they reviewed pertaining to hip fractures between 1959 and 1998. Similarly the 2013 National Hip Fracture Database report demonstrates an increase in the proportion of hip fractures in the very elderly (>90 years) with a static female: male ratio between 2009 and 2013 11. Census data for Nottingham suggests that between 2001 and 2011 there was a large increase in the number of male patients aged 75-89 years living within the hospitals catchment area [15,16], helping to explain these differing findings and the increasing number of male admissions observed within our cohort.

Between 2000 and 2012 we observed a number of significant changes in the hip fracture population. At the end of the period a greater number of patients were living alone in their own homes, requiring assistance with basic activities of daily living, and presenting with significant medical co-morbidities. This increase in the levels of physical and social dependence has implications for the delivery of the hip fracture service. As a result of these changes we can expect to see increases in the rates of post-operative mortality, morbidity and length of hospital stay [5,6]. White et al predicted that, as the population ages, 30 day mortality rates will rise from 8.3% in 2008 to 9.3% by 2033, resulting in 7000 additional deaths each year [5]. This effect is likely to be compounded by the increasing frailty observed in this study, and if these trends continue this estimate may need to be revised upward. These changes also suggest that we are supporting a population of patients who are increasingly frail and have significant social care needs within their own homes. This has implications for acute nursing care, post-operative rehabilitation and eventual discharge planning. Patients are less likely to achieve the requisite level of physical functioning to permit discharge home if they have poor functional reserve to begin with. They are also less likely to get home if they are socially isolated and require increased levels of social care. There are also implications for benchmarking and audit systems, such as the National Hip fracture Database and the Nottingham Hip Fracture Score that use living at home versus living in an institution as a surrogate for frailty [17,18]. Our data suggest that this distinction may be becoming less clear cut. Such scores may therefore need re-calibration in future years.

Changes in the prevalence of specific co-morbidities may be a direct manifestation of an increasingly frail elderly population within declining health. Some of this effect may be attributable

to greater data accuracy as the hip fracture database matured and administrators became more familiar with the datasets. However, this is unlikely to account for the magnitude of the observed changes in each of the co-morbidities. The changing prevalence may also have been influenced by the introduction of national guidelines and health policies that aim to promote evidence based practice and incentivise the treatment of a range of chronic conditions in primary care during the period of study. Initiatives such as the Quality and Outcome Frameworks (QOF) [19] have been introduced to reward primary care practices if they deliver high quality on a range of services [20]. Areas of clinical care linked to rewards include the implementation of clinical interventions known to benefit patients with chronic conditions such as cardiovascular disease, diabetes, and chronic renal disease [21,22]. The initiation of such strategies in 2003/04 may, in part, account for the sudden jump in proportion of patients we observed with these co-morbidities. In addition, during the study period, the National Institute for Clinical Excellence [23,24,25,26,27,28] and the National Service Framework[29] have published a range of guidance which may have increased diagnostic awareness for these conditions.

Strengths and limitations

This study benefits from the size of the cohort available for analysis, the consecutive period of follow up, consistent data collection and the range of data collected. The hospital serves a well defined urban / rural population with no alternative hip fracture service within this geographical area. During the study period the trauma service at Nottingham was awarded major trauma centre status. This is, however, unlikely to have had a significant impact upon the number of hip fracture admissions and our future hip fracture projections as referral to a major trauma centre is triggered primarily based upon mechanism of injury. As the majority of hip fractures occur after low energy injuries such as fall from standing height they should not trigger the major trauma pathway and should be taken to their nearest orthopaedic unit as previously. While the unit's current data completeness rate of 93% is good and much better than Hospital Episode Statistics, it could be better. The introduction of the NICE guidance and best practice tariff may have raised awareness in reporting of facets of patient care giving more accurate and complete data in the later years. Inaccuracies in coding and recorder intervariability are potential sources of error which may account for some of the year on year differences observed. Any projections to a national population of hip fractures from a single centre, single population study may be liable to regional discrepancies and may not be applicable to other hospital populations where incidence of, for example, other co-morbidities may be significantly different. In addition our projections for future admissions are

based upon static hip fracture incidence whereas current hip fracture incidence is declining at approximately 0.6%/year [5]. While we accept this may result in the number of hip fracture admissions being over estimated it was done to simplify the analysis, and the ability of other centres to use the proposed equations. In addition it is unclear whether this decrease in prevalence will continue at the same rate over the next 20 years, will decrease further or increase at some undefined point so that the prevalence starts to rise. However, despite these concerns we feel that the overall trends reported here are likely to be generalisable to national practice. While the National Hip Fracture Database (NHFD) publishes yearly reports on management of the hip fracture population it has only been reporting national results since 2009 [11]. Despite comprising over 250,000 records its report containslimited information on dependency and does notpresent data on co-morbidities [3,11]. The information presented here therefore adds significantly to the results available from this database. Further useful information is likely to come from the recently undertaken hip fracture Anaesthesia Sprint Audit Project (ASAP) [30]. This audit of 11,000 hip fracture cases will complement the information presented here by allowing us to better understand the absolute numbers and the variation in prevalence of a range of co-morbidities, and the differing ways in which these co-morbidities are treated.

Conclusion

The cost of treating hip fractures is rising [1,5]. Currently the annual cost of treating these injuries is approximately £2 billion/year which helps to deliver a high quality service based on NICE's recommendations of surgery performed on dedicated trauma lists within 36 hours of admission, adequate physiotherapy and occupational therapy provision allowing early mobilisation and rehabilitation, and ongoing orthogeriatric assessment and support. However, the projected increase in the number of hip fractures, combined with a more frail, elderly and socially dependent patients who are likely to experience greater rates of mortality, post-operative morbidity and longer inpatient stays will drive this figure up over the next 20 years. Cost estimates for hip fracture treatment predict a 243% increase in costs to £5.6 billion by 2033 [5]. Worryingly we have shown that more and more patients have complex medical co-morbidities and social needs and so it is likely that the cost of treating these patients is likely to climb at a faster rate than these projections based upon changes in the age demographics alone. This must be appreciated to so that appropriate health care strategies and service planning can be implemented to prevent the hip fracture service

enduring a financial shortfall, particularly at a time when there is an ever increasing drive to meet best practice targets.

Authorship

In accordance with the ICMJE criteria for authorship we can confirm that each of the stated authors (Paul N Baker, Omer Salar, Benjamin J Ollivere, Daren P Forward, Namal Weerasuriya, Iain K Moppett, Chris G Moran) have made significant contributions to:

- The conception and design, or analysis and interpretation of these data
- Drafting the article or revising it critically for important intellectual content
- And final approval of the version to be published

The lead author affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained

Declaration of Competing Interests

We have read and understood the BMJ Group policy on declaration of interests and declare the following interests: NONE

All authors have completed the ICMJE uniform disclosure form at http://www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years [or describe if any], no other relationships or activities that could appear to have influenced the submitted work

Data Sharing Statement

This study was conducted on data collected as part of the on-going audit of hip fracture patients admitted to the Nottingham University Hospitals NHS Trust. All data collected as part of this audit program is held by the hip fracture audit co-ordinators in the department of trauma and orthopaedics, Queens Medical Centre, Nottingham. This database is administered by the senior author (Prof Christopher Moran). The data used for this study was extracted from this database for the sole purpose of the stated analyses. The corresponding author therefore possesses no additional unpublished data in respect of this study. Data held within the Nottingham Hip Fracture Database and the data used for these analyses was stored and used in accordance with local Caldicott guidelines.

Ethical Approval of Research

This study was performed on anonymised data held within an on-going institutional hip fracture audit programme. As there was no further patient contact the project was performed as a service evaluation without need for formal ethical approval. Utilised Nottinghamshire Census data is available publicly via the Nottinghamshire city council. Nottingham University Hospitals Hip Fracture Data is also available publicly on request.

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Figure 2: Trends in the proportion of patients admitted with cardiovascular disease (CVD), diabetes mellitus (DM), renal disease (Renal) and polypharmacy (4+ meds) between 2000 and 2012.

Figure 3: Number of admissions that were prescribed either Clopidogrel (C) or Warfarin (W). Percentages represent the proportion of admissions that were taking either of these agents in each year.

Figure 4: Patients requiring assistance with basic care (washing, dressing, feeding, toileting) as a proportion of all patients requiring assistance with their activities of daily living (ADLs) (n=6033).

Figure 5: Distribution in the pattern of presenting fracture by year (2000 to 2012).

Tables and Figures

Patient Demographics	Study Cohort (n=10,044)
Median Age (years) (IQR) (Range)	82 years (IQR 76 to 88) (Range 17 to 105)
Gender (%) Male : Female	 2626 (26%) : 7418 (74%)
Comorbidities (Yes (%)) Cardiovascular disease Cerebrovascular disease Chronic Obstructive Airways Disease Renal disease Diabetes Mellitus Rheumatoid arthritis Parkinson's disease Malignancy	 4851 (48%) 1442 (14%) 1426 (17%) 614 (6%) 1242 (12%) 350 (3%) 325 (3%) 1183 (12%)
Median Abbreviated Mental Test Score (IQR)	9 (IQR 2 to 10)
Residence (Yes (%)) Own Home Warden aided / Residential home Nursing home Hospital inpatient Rehabilitation facility Other Unknown	 6742 (67%) 1952 (19%) 1101 (11%) 127 (1%) 26 (0%) 77 (1%) 19 (0%)
Walking ability (Yes (%)) Independent outdoors Independent indoors Accompanied outdoors Accompanied indoors Unable to mobilise / transfers only Unknown	 5027 (50%) 2443 (24%) 1302 (13%) 561 (6%) 261 (3%) 450 (5%)
Walking aids (Yes (%)) No aids One or more aids Frame / Walker Wheelchair / Bedbound Unknown	 4434 (44%) 3086 (31%) 2009 (20%) 293 (3%) 222 (2%)
Fracture type (Yes (%)) Intracapsular Intertrochanteric Subtrochanteric Other (e.g. Reverse Oblique) Unknown	 6012 (60%) 3202 (32%) 522 (5%) 305 (3%) 3 (0%)

Table 1: Baseline data for the study cohort

Patient Demographics	Year				p value*
	2000	2004	2008	2012	
n	740	761	758	810	
Median Age (years) (IQR)	81 (75 to 87)	81 (74 to 87)	82 (75 to 87)	82 (75 to 87)	0.06
Gender (%) Male : Female	174(24%):566(76%)	173(23%):588(77%)	206(27%):552(73%)	249(31%):261(69%)	<0.001
Median Abbreviated Mental Test Score (IQR)	8 (2 to 10)	8 (2 to 10)	8 (2 to 10)	7 (2 to 10)	0.51
Residence (Yes (%)) Own Home Warden aided / Residential home Nursing home Other / Unknown	 463 (63%) 171 (23%) 98 (13%) 8 (1%)	 505 (66%) 161 (21%) 74 (10%) 13 (2%)	 537 (71%) 127 (17%) 75 (10%) 19 (3%)	 587 (73%) 149 (18%) 66 (8%) 8 (1%)	<0.001
Living alone in own home	234 of 463 (51%)	263 of 505 (52%)	261 of 537 (49%)	301 of 587 (51%)	0.49
Walking ability (Yes (%)) Independent outdoors Independent indoors Accompanied outdoors Accompanied indoors Unable to mobilise / transfers only Unknown	 343 (46%) 301 (41%) 33 (4%) 46 (6%) 14 (2%) 3 (0%)	 385 (51%) 201 (26%) 101 (13%) 39 (5%) 26 (3%) 9 (1%)	 400 (53%) 126 (17%) 128 (17%) 35 (5%) 20 (3%) 49 (6%)	 429 (53%) 129 (16%) 120 (15%) 42 (5%) 33 (4%) 57 (7%)	<0.001
Independent for all ADLs (%)	455 (61%)	488 (64%)	441 (58%)	460 (57%)	=0.02
Requires assistance with basic care (%) (washing, dressing, feeding, toileting)	162 (22%)	240 (32%)	181 (24%)	220 (27%)	<0.001

Table 2: Changes in patient and social demographics between 2000 and 2012 (results for 2000, 2004, 2008 and 2012 shown for clarity), *comparison of variationin factors for all years with the analysis.

Figure Legends

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Evolution of the Hip Fracture Population: Time to Consider the Future?

A retrospective observational analysis

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Key words

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Medical audit program

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Abstract

Objective: To examine how the fractured neck of femur population has changed over the last decade and determine whether they have evolved to become a more physically and socially dependent cohort ~~To describe the epidemiological changes in the hip fracture population within a defined geographical area of the United Kingdom over a consecutive 13-year period.~~

Design: Retrospective cohort study of prospectively collected Standardised Audit of Hip Fractures of Europe data entered on to an institutional hip fracture registry.

Participants: 10044 consecutive hip fractures admissions (2000-2012)

Setting: A Major Trauma Centre in the United Kingdom

Results: There was a generalised increase in the number of admissions between 2000 (n=740) and 2012 (n=810). This increase was non-linear and best described by a quadratic curve. Assuming no change in the prevalence of hip fracture over the next 20 years, our hospital is projected to treat 871 cases in 2020 and 925 in 2030. This represents an approximate year on year increase of just over 1%. There was an increase in the proportion of male admissions over the study period (2000:174 of 740 admissions (23.5%); 2012:249 of 810 admissions (30.7%)). This mirrored national census changes within the geographical area during the same period. During the study period ~~While the median age 82 years (IQR 76 to 88) was similar during the period of observations~~ there were significant increases in the numbers of patients admitted from their own home, the proportion of patients requiring assistance to mobilise ~~patients mobilising independently outdoors at the time of admission~~, and the proportion of patients requiring help with basic activities of daily living (all p<0.001). There was also a two to fourfold increase in the proportion of patients admitted with a diagnosis of cardiovascular disease, renal disease, diabetes and polypharmacy (use of >4 prescribed medications) (all p<0.001).

Conclusions: The expanding hip fracture population has increasingly complex medical, social and rehabilitation care needs. This needs to be recognised so that appropriate health care strategies and service planning can be implemented. This epidemiological analysis allows projections of future service need, both in terms of patient numbers and dependency.

Strengths and limitations of this study

- This analysis is based on 10044 consecutive hip fracture admissions over a 13 year period from a defined geographical area using standardised data collection.
- Trends in the hip fracture population including information on patient demographics, medical co-morbidities, physical functioning, social circumstances and cognitive capacity during this period are presented.
- Based on these data we have been able to produce a simplified equation that allows individual centres to calculate their own expected increases in hip fracture admissions over the next 20 years.
- This is a retrospective analysis and there may be issues relating to coding inaccuracies and recorder bias.

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- Any projections to a national population of hip fractures from a single centre, single population study may be liable to regional discrepancies and may not be applicable to other hospital populations where incidence of, for example, other co-morbidities may be significantly different

Introduction

The United Kingdom (UK) currently treats approximately 80,000 hip fractures every year at an estimated annual cost of two billion pounds in direct health-care costs alone [1,2,3]. One in every 12 patients who sustains a hip fracture will die in the first month following injury and three in every 10 will die within the first year [3]. The World Health Organisation has estimated that the number of people aged 65 and over will increase by 88% over the next 25 years due to an aging world population, better public health and an increased use of medical interventions that prolong the average life expectancy [4]. Despite a decline in the age specific incidence of hip fractures over the last decade [5,6,7], these population changes mean the overall number of hip fractures will continue to increase [5,6] ~~Linked to this is the spectre of the increasing incidence of patients with poor bone health, the so called 'osteoporosis epidemic' [5].~~ The annual number of hip fractures in the UK is projected to rise to 91,500 by 2015 and 101,000 by 2020 [6].

The projected rise in hip fracture incidence has implications for health strategy and resource allocation. These must be addressed if we are to continue to manage the specific needs of these patients and improve the standard of care. Previous studies have evaluated how hip fracture incidence has changed with time [5,6,7], the relationships to changing population demographics [5], and the impact upon ~~Previous studies have evaluated the increase in the incidence of this injury and~~ projected future health-care requirements [4,9,10~~7,8~~]. Few, if any, studies have evaluated how physical dependency, medical co-morbidities, social needs and care requirements have changed within this population with time. This is important to appreciate as these factors will also have a significant impact on the requirements for future medical, nursing, rehabilitation and social services.

~~Few, if any, studies have evaluated other changes in the same population, including changes in social care, physical dependency and medical co-morbidities. These could also have an important impact on the requirement of future medical, nursing, rehabilitation and social services. This study aims to describe the epidemiological changes in the hip fracture population within a defined geographical area of the United Kingdom including data from two national censuses (2001 and 2011). The population is from a mixed urban and rural environment and likely to be representative of the UK population.~~

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To address these concerns we interrogated an institutional hip fracture database with the aim of answering the following research question: "How has the population of patients admitted to hospital with a fractured neck of femur changed over the last decade and have they evolved to become a more physically and socially dependent cohort?". Our null hypothesis was that the fractured neck of femur population would not have changed with time for any of the markers of physical and social dependency examined during this analysis.

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Patients and Methods

The Nottingham Hip Fracture Database

Nottingham University Hospitals cover a catchment population of approximately 785,000 ~~The Nottingham University Hospital~~and admit~~s~~ approximately 800 hip fractures each year. For the entire study period, it has been the only hospital providing a trauma service for the local population and its surrounding areas. In May~~and covers a catchment population of approximately 785,000. Since~~ 1999, the Nottingham Hip Fracture Database was initiated to prospectively collect information on all hip fracture patients for the purpose of ongoing audit and service evaluation.~~information on all hip fracture patients has been prospectively collected for the purpose of ongoing audit and service evaluation.~~ Data for all hip fracture patients are recorded using a modified version of the standardised audit of hip fractures of Europe (SAHFE) ~~audit~~ data collection form [4]. All data is collected prospectively by a team of independent audit staff who administer the local hip fracture database. SAHFE data completion is mandatory for all hip fractures in our hospital and ~~.I~~in 2012 the trust recorded over 93% in the domain of data completeness within the national hip fracture database (NHFD) [9,11]. Audit data is strictly confidential and is managed in accordance with national data protection (Caldicott) guidelines.

Study Design and Dataset

To address our research question a retrospective cohort study was conducted using all of the information held within the hip fracture database from its inception (May 1999) to the date of the current project data request (March 2013). In total 10,739 consecutive hip fracture admissions were identified. Form this cohort we excluded the cases from 1999 (n=446) and 2013 (n=249) as a complete years' worth of admission data was not available. Analysis was therefore based on a consecutive series of 10,044 hip fractures admitted during a 13 year period between the 1st of January 2000 and 31st December 2012. The baseline demographics for study cohort are given in table 1.

Outcome Variables

The Nottingham Hip Fracture Database records ~~Data recorded as part of this ongoing audit includes~~ information on patient demographics, medical co-morbidities, physical functioning, social circumstances and cognitive capacity for each hip fracture patient. The database records information pertaining to specific co-morbidities, including questions about the presence of a

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diagnosis of ~~Specific co-morbidities assessed include the presence of~~ cardiovascular disease (CVD), cerebrovascular disease (CVA), chronic obstructive pulmonary disease (COPD), ~~cerebrovascular disease (CVA),~~ renal disease, ~~malignancy,~~ diabetes mellitus (DM), ~~renal disease~~, Rrheumatoid arthritis, Parkinson's disease and malignancy.~~, Paget's disease and polypharmacy (the use of >4 regular medications).~~ During the study period there was no change in the definitions used by the ~~audit~~ database for each of these conditions. Information about medication use is also recorded, with specific questions about the use of steroids, anticoagulants (e.g. clopidogrel, warfarin) and polypharmacy (the use of >4 regular medications) (Table 1).

~~This was a pragmatic, clinical audit with diagnosis based upon clinical history, examination and review of medical records.~~ Physical functioning is assessed using specific questions related to mobility status, independence both within and outside the house and ability to perform activities of daily living such as washing, dressing, cleaning, feeding and toileting. Social circumstances are assessed by questions relating to the type of residence, co-habitation and the requirement for additional carers. The abbreviated mental test score is used to assess cognitive capacity[10~~2~~].

To ascertain how the hip fracture population had changed with time the distribution of each of these outcome variables was calculated for each year of the analysis (2000 to 2012). This allowed observed changes and trends in the distributional characteristics of these variables with time to be appreciated.

Statistical analysis

~~The present study was conducted as a retrospective cohort study using the information held within the hip fracture database on all hip fractures entered between the 1st of January 2000 and 31st December 2012. These dates were chosen as they represented 13 consecutive years for which complete data was available for the entire year.~~ Initial ~~G~~graphical and tabular summaries were performed to demonstrate how the hip fracture population changed over the period of analysis. ~~has evolved over this 13-year period.~~ ~~An additional c~~Comparison to publically available Nottingham Census data (2001 and 2011) was conducted to see if the observed changes in the hip fracture population mirrored those seen for the general population.

~~———~~Statistical comparisons were performed to determine if each of the analysed variables changed over the period of observation. For continuous parametric data comparisons were made

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using independent t-tests and one-way Analysis of Variance (ANOVA). For continuous non-parametric data comparisons were made using Mann Whitney and Kruskal-Wallis tests. For categorical data Fishers exact and Chi-squared test were used. A p value of $p<0.05$ was used to indicate statistical significance.

Time series analysis was used to produce a mathematical model for the year on year changes in the observed number of hip fracture admissions. ~~This model was then used to predict the expected admissions in 2020, 2025 and 2030. The 'best fit' time series model was selected to minimise the mean absolute percentage error (MAPE), mean absolute deviation (MAD) and the mean squared deviation (MSD). Statistical analysis was performed using SPSS version 19 and Minitab version 16.~~ Linear, quadratic, exponential and S-Curve models were sequentially fitted to the data and for each model its adequacy was assessed using the mean absolute percentage error (MAPE), mean absolute deviation (MAD) and the mean squared deviation (MSD). The 'best fit' quadratic time series model was selected as it was the model type that minimised each of these variables. This model was then used to generate forecasts of the expected number of admissions in 2020, 2025 and 2030. Statistical analysis was performed using SPSS version 19 (IBM Corporation, Armonk, USA) and the time series analysis was undertaken using Minitab version 16 (Minitab Ltd, Coventry, UK).

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Results

Hip fracture admissions

During the period 2000 to 2012 a total of 10,044 patients were admitted with a hip fracture. The mean number of admissions per year was 773 (S.D 44.9, Range 704 to 854) with a generalised increase in the number of hip fractures admissions with each year. This increase was non-linear and best described by the quadratic curve: Admissions = 715.59 + (8.72 × number of years after 1999) - (0.06 × (number of years after 1999)2), [i.e. year 2000 = 1] (Figure 1). ~~increasing incidence in hip fractures year on year. This increase was non-linear and best described by a quadratic curve (Figure 1).~~ Assuming no change in the prevalence of hip fracture over the next 20 years, our hospital is projected to treat 871 cases in 2020, 899 in 2025 and 925 in 2030. A simple equation to allow hip fracture units to estimate their future hip fracture numbers (assuming similar demographics to Nottingham) is shown in figure 1.

Patient demographics

Baseline demographics for the entire study cohort are presented in table 1. ~~Overall, 2626 of the 10044 (26.1%) admissions were male. There was a steady increase in the proportion of male admissions between 2000 (174 of 740 (23.5%)) and 2012 (249 of 810 (30.7%)) (p<0.001) (Figure 2).~~

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~~Median age at admission for all hip fractures over the 13-year period was 82 years (IQR 76 to 88, Range 17 to 105 years).~~ Age at admission did not significantly change during the period of ~~study (Median age in 2000 = 82 years (IQR 76 to 88); Median age in 2012 = 83 years (IQR 76 to 88 years), comparison across all years~~ (p= 0.67). However the median age of females (83 years (IQR 77 to 88, Range 19 to 105 years) was significantly higher than that for males (80 years (IQR 70 to 86, Range 17 to 105 years) (p<0.001). While they differed, the age distributions of both male and female patients did not significantly change with time (comparison across all years: female p=0.70, male p=0.11). During the period of study there was a steady and significant increase in the proportion of male admissions from 174 of 740 (24%) in 2000 to 249 of 810 (31%) in 2012 (p<0.001) (Table 2).

Co-morbidities

Of the co-morbidities recorded there was a significant increase in the proportion of patients presenting with cardiovascular disease (CVD), diabetes mellitus (DM), renal disease and polypharmacy (patients on greater than 4 prescribed medications) with time (Figure 2). In 2000, the percentage of patients with CVD was 20% (145 of 740 admissions), which increased by a factor of 3.1 to 61% in 2012 (497 of 810 admissions) (p<0.001). Similarly the percentage of patients with DM increased by a factor of 1.8 from 9% (64 of 740 admissions) in 2000 to 15% (125 of 810 admissions) in 2012 (p<0.001). The presence of renal disease increased from 2% (15 of 740 admissions) in 2000 to 9% (69 of 840 admissions) in 2012, a greater than fourfold increase (p<0.001). The proportion of patients with polypharmacy also increased by a factor of two between 2000 (20%, 142 of 740 admissions) and 2012 (40%, 322 of 810 admissions)(p<0.001). For all other recorded co-morbidities the proportions of admissions with a positive diagnosis remained similar throughout the period of observation.

The median abbreviated mental test score for patients was 9 (IQR 3 to 10, Range 0 to 10) and did not change significantly year to year (p=0.51). The number of patients prescribed either Clopidogrel or Warfarin demonstrated significant variation from year to year and followed a steadily increasing trend between 2000 and 2012 (both p<0.001) (Figure 3).

Social demographics

Baseline social demographic data is presented in table 1.

Between 2000 and 2012 ~~(n=10044) 6742 (67.1%) patients were admitted from their own home, 1952 (19.4%) from warden aided / residential care and 1101 (11.0%) from nursing care and 249 from 'other' accommodation types. During this period~~ there was a gradual increase in the number of admissions from patient living in their own home ~~(2000 = 463 of 740 admissions (62.6%); 2012 = 587 of 810 admissions (72.5%))~~ (p<0.001). Over the same time period there was a reciprocal decrease in admissions from warden aided / residential care ~~(2000 = 171 of 740 admissions (23.1%); 2012 = 149 of 710 admissions (18.4%))~~ and nursing care ~~(2000 = 98 of 740 admissions (13.2%); 2012 = 66 of 810 admissions (8.2%))~~ (p<0.001) (Figure 3). Of the 6742 patients living in their own home 3278 (~~48.6~~49%) lived alone. The proportion of patients living alone in their own home remained similar over the period of observation~~s~~ (~~Figure~~ Table 24).

At the time of admission 5027 of the 10,044 (50.~~1~~%) admissions mobilised independently outdoors (Table 1)., ~~2443 (24.3%) mobilised independently indoors, 1302 (13.0%) were accompanied~~

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~~outdoors, 561 (5.6%) were accompanied indoors, 261 (2.6%) were immobile or could only transfer and for 450 (4.5%) mobility status was not known (Figure 5).~~ Of the~~se~~ 5027 patients ~~who were independent outdoors,~~ 3119 (62~~.0~~%) did not use any mobility aids, 1520 (30~~.2~~%) used one aid and 388 (8~~7.7~~%) used two aids / frame / walker. The reliance on walking aids increased as the level of mobility decreased (p<0.001). The proportions of patients mobilising independently outdoors at the time of admission increased significantly between 2000 and 2012. During the same period there was a reciprocal decrease in the proportion of patients mobilising independently indoors (p<0.001) (Table 2).

~~The proportions of patients mobilising independently outdoors at the time of admission increased between 2000 (343 of 740 admissions (46.4%)) and 2012 (429 of 810 admissions (53.0%)) (p<0.001). However, there was a more dramatic change in the proportions of patients mobilising independently indoors (2000 = 301 of 740 admissions (40.7%); 2012 = 129 of 810 admissions (15.9%)) and mobilising accompanied outdoors (2000 = 33 of 740 admissions (4.5%); 2012 = 120 of 810 admissions (14.8%)) during the same period (p<0.001) (Figure 5).~~

The proportions of patients who were completely independent for all activities of daily living (ADLs) were similar across the study period (~~Figure 6~~Table 2). Overall 4011 of 10,044 (~~39.9~~40%) patients were completely independent for all ADLs. For the 6033 patients that were not independent for their ADLs, 2586 (~~42.9~~43%) required assistance with some form of basic care (Washing, dressing, feeding, toileting) (Figure ~~7~~4). The proportion of patients requiring this level of care increased from 161 of 455 patients requiring assistance with ADLs (~~35.4~~36%) in 2000 to 220 of 460 patients requiring assistance with ADLs (~~47.8~~48%) in 2012 (p<0.001).

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~~**Co-morbidities**~~

~~Of the co-morbidities recorded there was a significant increase in the proportion of patients presenting with cardiovascular disease (CVD), diabetes mellitus (DM), renal disease and polypharmacy (patients on greater than 4 prescribed medications) (Figure 8). Of the total 10044 patients, 4851 (48.3%) had a diagnosis of CVD, 1242 (12.4%) had a diagnosis of DM, 614 (6.1%) had a diagnosis of renal disease and 3906 (38.9%) were prescribed greater than four medications.~~

~~In 2000, the percentage of patients with CVD was 19.6% (145 of 740 admissions), which increased by a factor of 3.1 to 61.4% in 2012 (497 of 810 admissions) (p<0.001). Similarly the percentage of patients with DM increased by a factor of 1.8 from 8.7% (64 of 740 admissions) in 2000 to 15.4% (125 of 810 admissions) in 2012 (p<0.001). The presence of renal disease increased from 2% (15 of 740 admissions) in 2000 to 8.5% (69 of 840 admissions) in 2012, a greater than fourfold increase (p<0.001). The proportion of patients with polypharmacy also increased by a factor of two between 2000 (20.2%, 142 of 740 admissions) and 2012 (39.8%, 322 of 810 admissions), n=142 (20.2%) increased to 2012 n=322 (39.8%) (p<0.001).~~

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~~For all other recorded co-morbidities the proportions of admissions with a positive diagnosis remained similar throughout the period of observation (respiratory disease: n=1726 (17.2%), previous stroke n=1442 (14.4%), malignancy n=1183 (11.8%), rheumatoid arthritis n=350 (3.5%), Parkinson's disease n=325 (3.2%), Paget's disease n=34 (0.3%)).~~

~~The median abbreviated mental test score for patients was 9 (IQR 3 to 10, Range 0 to 10) and did not change significantly year to year (p=0.51). The number of patients prescribed either Clopidogrel or Warfarin demonstrated significant variation from year to year and followed a steadily increasing trend between 2000 and 2012 (both p<0.001) (Figure 9).~~

Fracture demographics

The distributions of the type of fractures presenting to the unit by year are shown in figure 5 and given in table 1. The distribution of intracapsular and extracapsular (intertrochanteric / subtrochanteric / Other proximal femoral fractures) remained consistent over the period of study with approximately 60% of hip fractures / year being intracapsular.

~~The distributions of the type of fractures presenting to the unit by year are shown in figure 10. Of the total 10044 patients, 6012 (59.9%) presented with an intracapsular fracture of which 815 (8.1%) were undisplaced subcapital fractures, 4783 (47.6%) were displaced subcapital fractures and 414 (4.1%) were basicervical neck fractures. The remaining 4032 (40.1%) were extracapsular fractures of which 3202 (31.9%) were trochanteric (2 to 4 part), 711 (7.1%) were subtrochanteric or reverse oblique fractures, and 119 (1.1%) were other types / fracture pattern not recorded.~~

Discussion

Principle findings and comparison with other studies

The last decade has seen an increase in the number of hip fractures admitted to our institution. The number of admissions is expected to increase further over the next 20 years with a forecasted 15% rise in admissions by 2030. However, while the number of admissions is increasing, the quadratic time series curve produced suggested that, while the number of admissions is increasing, the size of the annual increase is reducing year on year. Using our data we have produced a simplified forecasting model which was +/- 1% accurate when compared to the predicted results from the time series curve. This equation can be used by centres wanting to calculate their expected short to mid-term hip fracture service requirements.

The predicted rise in the number of hip fractures mirrors the trends predicted for England [5] and Scotland [6]. However, the size of the increase is smaller than the 45 to 75% rise in numbers predicted by the Scottish group 6 and significantly lower than the 'pessimistic' estimate of a doubling in the number of hip fractures by 2033 reported for England by White et al [5]. Hip fracture admissions are expected to continue to rise despite a global decrease in the age related incidence of these fractures during the last decade [5,7]. This is because the population continues to age due to the success of public health strategies and the advent of medical interventions that prolong the average life expectancy during the second half of the 20th century [4,13]. In 2011 approximately 1 in 5 (22.6%) of the population of England and Wales was aged over 60 and the total number of residents aged over 90 was 430,000, up from 340,000 in 2001 [14]. Between 2001 and 2011 the population of Nottinghamshire increased by 37,500 (5%) from 748,300 (2001) to 785,800 (2011) with an associated 3% increase in the proportion of the population aged over 60 (21.1% in 2001, 24.1% in 2011) [15,16]. This may explain the observed 10% increase in the number of hip fracture admissions to our unit over the same time period and the relatively conservative estimate for the number of future admissions. Geographical areas with greater increases in the proportion of their population over 60 are likely to experience greater increases in hip fracture admissions in future years. Our equation for predicting future clinical need must therefore be interpreted in the context of each individual centres geographic population and will be most accurate for centres that service patient populations similar to our own.

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The median age of our cohort did not change with time, however, the proportion of male admissions increased. This contrasts with the review by Haleem et al,[13] which found a trend towards an increasing mean age and a static female: male ratio in the 36 publications they reviewed pertaining to hip fractures between 1959 and 1998. Similarly the 2013 National Hip Fracture Database report demonstrates an increase in the proportion of hip fractures in the very elderly (>90 years) with a static female: male ratio between 2009 and 2013 11. Census data for Nottingham suggests that between 2001 and 2011 there was a large increase in the number of male patients aged 75-89 years living within the hospitals catchment area,[15,16], helping to explain these differing findings and the increasing number of male admissions observed within our cohort.

Between 2000 and 2012 we observed a number of significant changes in the hip fracture population. At the end of the period a greater number of patients were living alone in their own homes, requiring assistance with basic activities of daily living, and presenting with significant medical co-morbidities. This increase in the levels of physical and social dependence has implications for the delivery of the hip fracture service. As a result of these changes we can expect to see increases in the rates of post-operative mortality, morbidity and length of hospital stay,[5,6]. White et al predicted that, as the population ages, 30 day mortality rates will rise from 8.3% in 2008 to 9.3% by 2033, resulting in 7000 additional deaths each year[5]. This effect is likely to be compounded by the increasing frailty observed in this study, and if these trends continue this estimate may need to be revised upward. These changes also suggest that we are supporting a population of patients who are increasingly frail and have significant social care needs within their own homes. This has implications for acute nursing care, post-operative rehabilitation and eventual discharge planning. Patients are less likely to achieve the requisite level of physical functioning to permit discharge home if they have poor functional reserve to begin with. They are also less likely to get home if they are socially isolated and require increased levels of social care. There are also implications for benchmarking and audit systems, such as the National Hip fracture Database and the Nottingham Hip Fracture Score that use living at home versus living in an institution as a surrogate for frailty[17,18]. Our data suggest that this distinction may be becoming less clear cut. Such scores may therefore need re-calibration in future years.

Changes in the prevalence of specific co-morbidities may be a direct manifestation of an increasingly frail elderly population within declining health. Some of this effect may be attributable

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to greater data accuracy as the hip fracture database matured and administrators became more familiar with the datasets. However, this is unlikely to account for the magnitude of the observed changes in each of the co-morbidities. The changing prevalence may also have been influenced by the introduction of national guidelines and health policies that aim to promote evidence based practice and incentivise the treatment of a range of chronic conditions in primary care during the period of study. Initiatives such as the Quality and Outcome Frameworks (QOF)[19] have been introduced to reward primary care practices if they deliver high quality on a range of services[20]. Areas of clinical care linked to rewards include the implementation of clinical interventions known to benefit patients with chronic conditions such as cardiovascular disease, diabetes, and chronic renal disease[21,22]. The initiation of such strategies in 2003/04 may, in part, account for the sudden jump in proportion of patients we observed with these co-morbidities. In addition, during the study period, the National Institute for Clinical Excellence[23,24,25,26,27,28] and the National Service Framework[29] have published a range of guidance which may have increased diagnostic awareness for these conditions.

~~This analysis of 13 consecutive years of hip fracture admissions demonstrates an increasing trend in the number of admissions between 2000 and 2012, which was largely due to an increase in the number of male admissions. Based on the observed data for this period we have produced a simplified equation that allows individual centres to calculate their own expected increases in hip fracture admissions over the next 20 years. We also observed significant increases in the number of patients admitted from their own home, the proportion of patients requiring assistance with basic activities of daily living (washing, dressing, feeding, toileting) and the incidence of cardiovascular disease, diabetes, renal disease, polypharmacy and rates of anticoagulation in our hip fracture population. Patient age, cognitive capacity and the type of hip fractures being treated were similar throughout the study period.~~

~~The 2011 National Census reported that approximately 1 in 5 (22.6%) of the population of England and Wales was aged over 60 and the total number of residents aged over 90 was 430,000, up from 340,000 in 2001[11]. Between 2001 and 2011 the population of Nottinghamshire increased by 37,500 (5%) from 748,300 (2001) to 785,800 (2011) with an associated 3% increase in the proportion of the population aged over 60 (21.1% in 2001, 24.1% in 2011)[12,13]. This may well explain the observed 10% increase in the number of hip fracture admissions to our unit over the same time period (2001: 704 admissions, 2011: 774 admissions). The Nottingham Census also found that between 2001 and 2011 there was a large increase in population numbers in residents aged 75-89~~

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years, and that this increase was greater for males than for females [12,13]. This suggests a greater relative improvement in survival rates for elderly male patients and helps to explain the increasing number of male admissions observed during the study period.

The observed increases in hip fracture admissions were best modelled using a quadratic time series curve which suggested that, while the number of admissions is increasing, the size of the annual increase is reducing year on year. This model forecasts our unit will admit 871 hip fracture patients in 2020 and 925 in 2030 representing an 8% and 14% increase from the observed number of admissions in 2012 (810) respectively. Based on this model we have produced a simplified equation for calculating the expected number of hip fracture admissions in any unit in England and Wales using the observed number of admissions in that unit in 2012. Using our own data this simplified model is +/- 1% accurate when compared to the forecasted results from the time series curve for predictions up to 2030. This supports its use as a simplified method of calculating the expected number of admissions in the short to medium term.

Between 2000 and 2012 there was an increase in the number of patients admitted from their own home (62.6% versus 72.5%), although the proportion of patients living alone in their own home remained similar. The national figure for proportion of patients admitted from their home in 2012 was 74.7%, suggesting that Nottingham may be fairly representative of the English population [9].

This analysis also found that the proportion of patients with dependency increased with more requiring assistance to mobilise and with basic activities of daily living. In addition, the number of patients with identified, concurrent co-morbidities significantly increased between 2000 and 2012. Hence, we are supporting a population of patients who are increasingly frail and have significant social care needs within their own homes. This has implications for nursing care within hospital, rehabilitation and eventual discharge from hospital following fracture treatment. Patients may be less likely to achieve the requisite level of physical functioning to permit discharge home if they have poor functional reserve to begin with.

Between 2000 and 2012 there was a two- to four- fold increase in the proportions of patients presenting with cardiovascular disease, diabetes, renal disease and polypharmacy. There was a similar increase in the number of patients prescribed either Clopidogrel or Warfarin. Over the

last 10 years, Quality and Outcome Frameworks (QOF) [14] have been introduced to incentivise the treatment of a range of conditions in primary care. These frameworks function as voluntary annual reward systems to primary care practices if they deliver high quality on a range of services [15]. Areas of clinical care linked to rewards include the implementation of evidence based clinical interventions known to benefit patients with chronic conditions such as diabetes, asthma, chronic renal disease, and cardiovascular disease treatment [16,17]. The initiation of such strategies in 2003/04 may, in part, account for the sudden jump in proportion of patients we observed with diagnosed cardiovascular disease, diabetes and renal disease and the associated increase in polypharmacy.

An increase in the volume of clinical evidence and national guidance may also have contributed to the increase in diagnosis of these co-morbidities. Since 2000 NICE has published a range of guidance including specific guidelines relating to the management of Chronic heart failure (2003) [18], Type 1 diabetes (2004) [19], Hypertension (2004) [20], Vascular disease (2005) [21], Cardiovascular disease (Statins) (2006) [22] and Atrial Fibrillation (2006) [23]. National Service Framework guidance on the management of cardiovascular disease (2000) [24] may also have influenced the observed increase in this diagnosis.

The use of warfarin and clopidogrel varied from year to year but overall demonstrated a progressive increased trend over the study period. Warfarin use was not observed in the elderly population who suffer hip fractures until 2007 but has steadily risen since. Reasons for this may include the publication of NICE guidance for atrial fibrillation [23] and the results of the BAFTA trial, which supported the use of warfarin for stroke prevention in patients aged over 75 [25,26]. Similarly the trends in Clopidogrel use may reflect the publication of results from the CAPRIE and MATCH trials [27,28] and subsequent NICE guidance on the use of clopidogrel and dipyridamole in vascular disease [21].

In 2011 NICE released specific guidance on the management of hip fractures (2011)[1]. Within this was a cost analysis detailing the projected financial impact of managing the hip fracture population. It identified a number of resources that were likely to incur significant costs to the NHS in the future as the number of hip fractures increases. These included the provision of dedicated trauma lists to ensure surgery is performed within 36 hours, implant costs, adequate physiotherapy and occupational therapy to allow early mobilization and rehabilitation, and ongoing orthogeriatric assessment and support. Our study confirms that the numbers of hip fracture admissions is increasing but the population is also changing with more men, more patients admitted from their

~~own homes, and more patients requiring assistance with mobility and activities of daily living. In addition, more patients have complex medical co-morbidities and so it is likely that the cost of treating these patients will climb at a faster rate than projections based upon changes in the age demographics alone. These changes will put pressure on orthopaedic trauma services and drive an increased requirement for nursing, physiotherapy, occupational therapy and orthogeriatric input to address the increasingly complex rehabilitation, social, and medical needs of this patient population.~~

Strengths and limitations

This study benefits from the size of the cohort available for analysis, the consecutive period of follow up, consistent data collection and the range of data collected. The hospital serves a well defined urban / rural population with no alternative hip fracture service within this geographical area. During the study period the trauma service at Nottingham was awarded major trauma centre status. This is, however, unlikely to have had a significant impact upon the number of hip fracture admissions and our future hip fracture projections as referral to a major trauma centre is triggered primarily based upon mechanism of injury. As the majority of hip fractures occur after low energy injuries such as fall from standing height they should not trigger the major trauma pathway and should be taken to their nearest orthopaedic unit as previously. While the unit's current data completeness rate of 93% is good and much better than Hospital Episode Statistics, it could be better. The introduction of the NICE guidance and best practice tariff may have raised awareness in reporting of facets of patient care giving more accurate and complete data in the later years. Inaccuracies in coding and recorder intervariability are potential sources of error which may account for some of the year on year differences observed. Any projections to a national population of hip fractures from a single centre, single population study may be liable to regional discrepancies and may not be applicable to other hospital populations where incidence of, for example, other co-morbidities may be significantly different. In addition our projections for future admissions are based upon static hip fracture incidence whereas current hip fracture incidence is declining at approximately 0.6%/year[5]. While we accept this may result in the number of hip fracture admissions being over estimated it was done to simplify the analysis, and the ability of other centres to use the proposed equations. In addition it is unclear whether this decrease in prevalence will continue at the same rate over the next 20 years, will decrease further or increase at some undefined point so that the prevalence starts to rise. However, despite these concerns we feel that the overall trends reported here are likely to be generalisable to national practice. While the National Hip Fracture Database (NHFD) publishes yearly reports on management of the hip fracture population it has only

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been reporting national results since 2009[11]. Despite comprising over 250,000 records its report contains~~; NHFD only has~~ limited ~~data~~ information on dependency and does not ~~collect~~present data on co-morbidities [3,9~~11~~]. The information presented here therefore adds significantly to the results available from this database. Further useful information is likely to come from the recently undertaken hip fracture Anaesthesia Sprint Audit Project (ASAP)[30]. This audit of 11,000 hip fracture cases will complement the information presented here by allowing us to better understand the absolute numbers and the variation in prevalence of a range of co-morbidities, and the differing ways in which these co-morbidities are treated.~~This report therefore adds significantly to the results available from this database.~~

Conclusion

The cost of treating hip fractures is rising[1,5]. Currently the annual cost of treating these injuries is approximately £2 billion/year which helps to deliver a high quality service based on NICE's recommendations of surgery performed on dedicated trauma lists within 36 hours of admission, adequate physiotherapy and occupational therapy provision allowing early mobilisation and rehabilitation, and ongoing orthogeriatric assessment and support. However, the projected increase in the number of hip fractures, combined with a more frail, elderly and socially dependent patients who are likely to experience greater rates of mortality, post-operative morbidity and longer inpatient stays will drive this figure up over the next 20 years. Cost estimates for hip fracture treatment predict a 243% increase in costs to £5.6 billion by 2033[5]. Worryingly we have shown that more and more patients have complex medical co-morbidities and social needs and so it is likely that the cost of treating these patients is likely to climb at a faster rate than these projections based upon changes in the age demographics alone. This must be appreciated to so that appropriate health care strategies and service planning can be implemented to prevent the hip fracture service enduring a financial shortfall, particularly at a time when there is an ever increasing drive to meet best practice targets.

~~The management of hip fractures represents a major financial, clinical and logistical burden for the NHS and social services. The increasing numbers of patients admitted with hip fractures mirrors the changes in population demographics reported by national census data. Over the last decade this group of patients have demonstrated increasing medical, social and rehabilitation care needs. This problem needs to be recognised so that appropriate health care~~

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~~strategies and service planning can be implemented. This paper provides data to allow projections of future service need, both in terms of patient numbers and dependency.~~

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Legend page

Tables:

Table 1: Baseline data for the study cohort

Table 2: Changes in patient and social demographics between 2000 and 2012 (results for 2000, 2004, 2008 and 2012 shown for clarity)

Figures:

Figure 1: Number of hip fracture admissions 2000 to 2012 with 'best fit' time series model (Red line: Admissions = 715.59 + (8.72 × number of years after 1999) - (0.06 × (number of years after 1999)^2), i.e. year 2000 = 1). Green line represents the forecasted number of admissions based on this model beyond 2030. Hip fracture admissions can be approximated in any hospital using a simplified equation based on this model: Predicted admissions in year X = Admissions in specified unit in 2012 + (0.01 × Admissions in specified unit in 2012 × (X – 2012)) – (0.0001 × Admissions in specified unit in 2012 × (X – 2012)^2).

Figure 2: Trends in the proportion of patients admitted with cardiovascular disease (CVD), diabetes mellitus (DM), renal disease (Renal) and polypharmacy (4+ meds) between 2000 and 2012.~~Proportion of Male and Female patients admitted with a hip fracture by year (2000 to 2012).~~

Figure 3: Number of admissions that were prescribed either Clopidogrel (C) or Warfarin (W). Percentages represent the proportion of admissions that were taking either of these agents in each year. ~~Place of residence prior to admission by year (2000 to 2012).~~

Figure 4: Patients requiring assistance with basic care (washing, dressing, feeding, toileting) as a proportion of all patients requiring assistance with their activities of daily living (ADLs) (n=6033).~~Proportion of patients admitted from their own homes that were living alone (2000 to 2012). Dotted line represents the overall proportion for the entire study period (48.6% living alone).~~

Figure 5: Distribution in the pattern of presenting fracture by year (2000 to 2012). ~~Trends in mobility status 2000 to 2012.~~

~~Figure 6: Proportion of patients who were independent for all activities of daily living (ADLs) at the time of admission (2000 to 2012).~~

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~~Figure 10: Distribution in the pattern of presenting fracture by year (2000 to 2012).~~

Tables and Figures

Patient Demographics	Study Cohort (n=10,044)
Median Age (years) (IQR) (Range)	82 years (IQR 76 to 88) (Range 17 to 105)
Gender (%)	
Male : Female	2626 (26%) : 7418 (74%)
Comorbidities (Yes (%))	
Cardiovascular disease	4851 (48%)
Cerebrovascular disease	1442 (14%)
Chronic Obstructive Airways Disease	1426 (17%)
Renal disease	614 (6%)
Diabetes Mellitus	1242 (12%)
Rheumatoid arthritis	350 (3%)
Parkinson's disease	325 (3%)
Malignancy	1183 (12%)
Median Abbreviated Mental Test Score (IQR)	9 (IQR 2 to 10)
Residence (Yes (%))	
Own Home	6742 (67%)
Warden aided / Residential home	1952 (19%)
Nursing home	1101 (11%)
Hospital inpatient	127 (1%)
Rehabilitation facility	26 (0%)
Other	77 (1%)
Unknown	19 (0%)
Walking ability (Yes (%))	
Independent outdoors	5027 (50%)
Independent indoors	2443 (24%)
Accompanied outdoors	1302 (13%)
Accompanied indoors	561 (6%)
Unable to mobilise / transfers only	261 (3%)
Unknown	450 (5%)
Walking aids (Yes (%))	
No aids	4434 (44%)
One or more aids	3086 (31%)
Frame / Walker	2009 (20%)
Wheelchair / Bedbound	293 (3%)
Unknown	222 (2%)
Fracture type (Yes (%))	
Intracapsular	6012 (60%)
Intertrochanteric	3202 (32%)
Subtrochanteric	522 (5%)
Other (e.g. Reverse Oblique)	305 (3%)
Unknown	3 (0%)

Table 1: Baseline data for the study cohort

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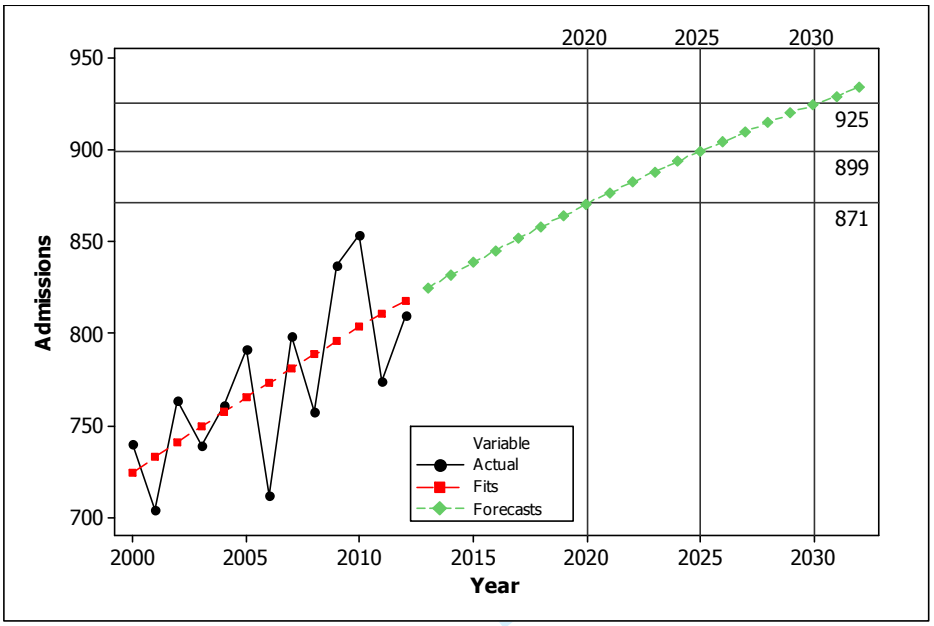
Patient Demographics	Year				p value*
	2000	2004	2008	2012	
n	740	761	758	810	
Median Age (years) (IQR)	81 (75 to 87)	81 (74 to 87)	82 (75 to 87)	82 (75 to 87)	0.06
Gender (%) Male : Female	174(24%):566(76%)	173(23%):588(77%)	206(27%):552(73%)	249(31%):261(69%)	<0.001
Median Abbreviated Mental Test Score (IQR)	8 (2 to 10)	8 (2 to 10)	8 (2 to 10)	7 (2 to 10)	0.51
Residence (Yes (%)) Own Home Warden aided / Residential home Nursing home Other / Unknown	 463 (63%) 171 (23%) 98 (13%) 8 (1%)	 505 (66%) 161 (21%) 74 (10%) 13 (2%)	 537 (71%) 127 (17%) 75 (10%) 19 (3%)	 587 (73%) 149 (18%) 66 (8%) 8 (1%)	<0.001
Living alone in own home	234 of 463 (51%)	263 of 505 (52%)	261 of 537 (49%)	301 of 587 (51%)	0.49
Walking ability (Yes (%)) Independent outdoors Independent indoors Accompanied outdoors Accompanied indoors Unable to mobilise / transfers only Unknown	 343 (46%) 301 (41%) 33 (4%) 46 (6%) 14 (2%) 3 (0%)	 385 (51%) 201 (26%) 101 (13%) 39 (5%) 26 (3%) 9 (1%)	 400 (53%) 126 (17%) 128 (17%) 35 (5%) 20 (3%) 49 (6%)	 429 (53%) 129 (16%) 120 (15%) 42 (5%) 33 (4%) 57 (7%)	<0.001
Independent for all ADLs (%)	455 (61%)	488 (64%)	441 (58%)	460 (57%)	=0.02
Requires assistance with basic care (%) (washing, dressing, feeding, toileting)	162 (22%)	240 (32%)	181 (24%)	220 (27%)	<0.001

Table 2: Changes in patient and social demographics between 2000 and 2012 (results for 2000, 2004, 2008 and 2012 shown for clarity), *comparison of variationin factors for all years with the analysis.



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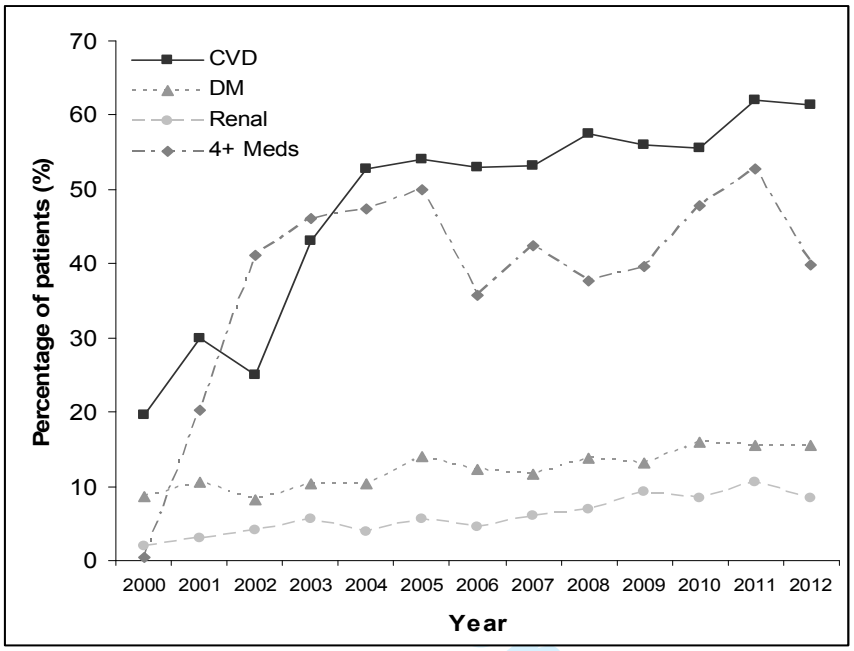

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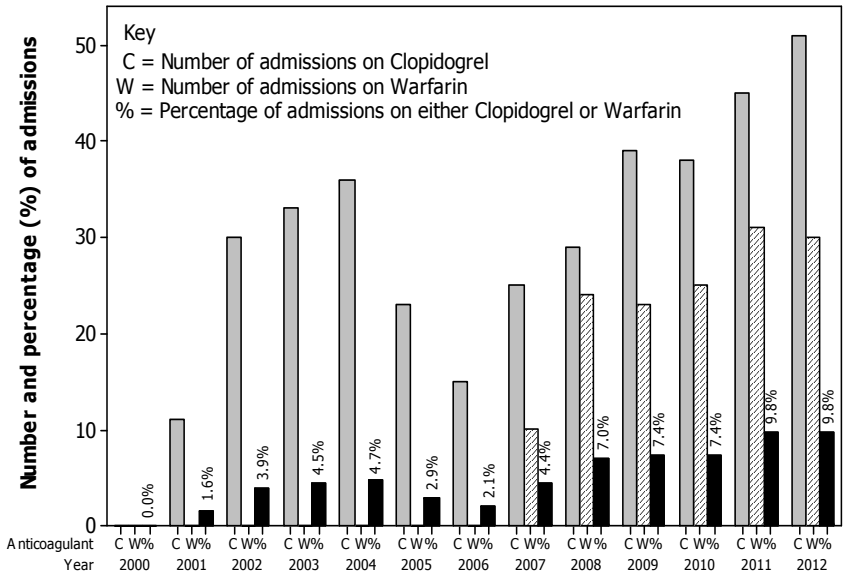
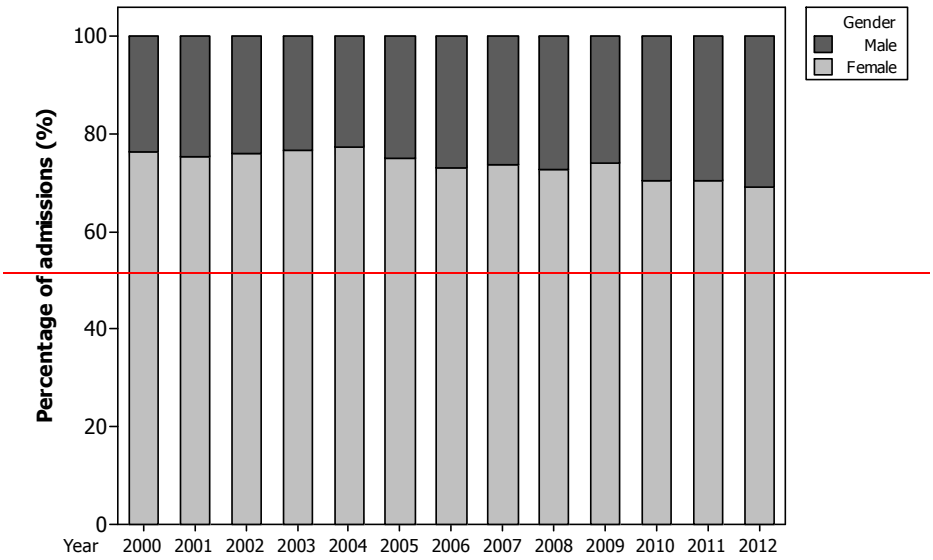


Figure 3: Number of admissions that were prescribed either Clopidogrel (C) or Warfarin (W). Percentages represent the proportion of admissions that were taking either of these agents in each year.



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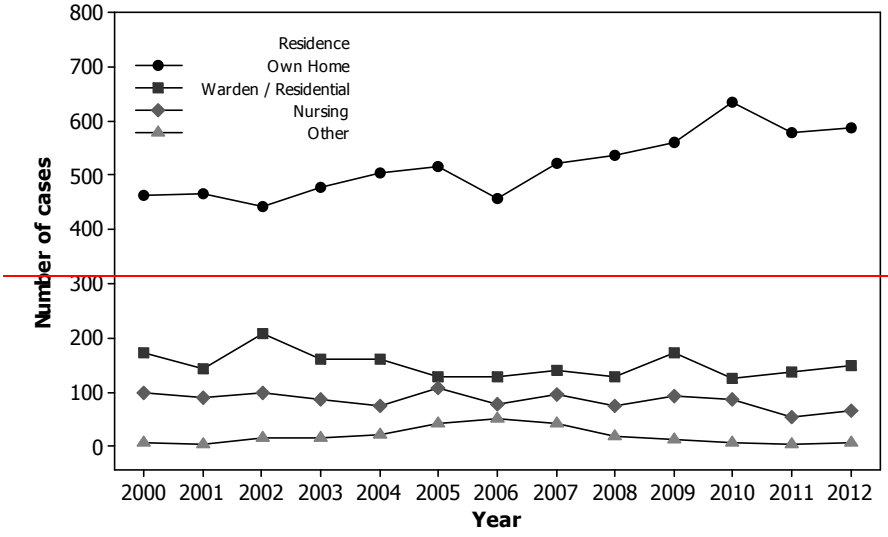

~~Figure 3: Place of residence prior to admission by year (2000 to 2012).~~

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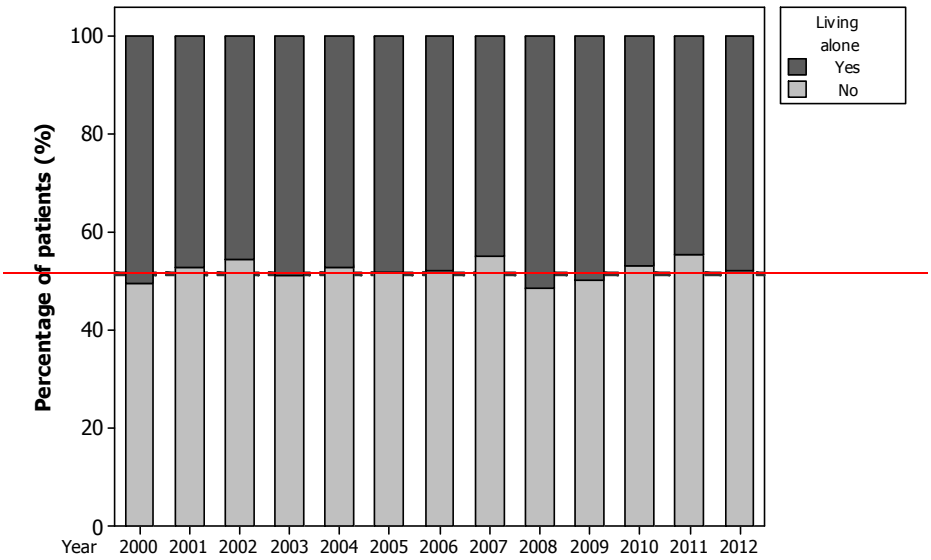

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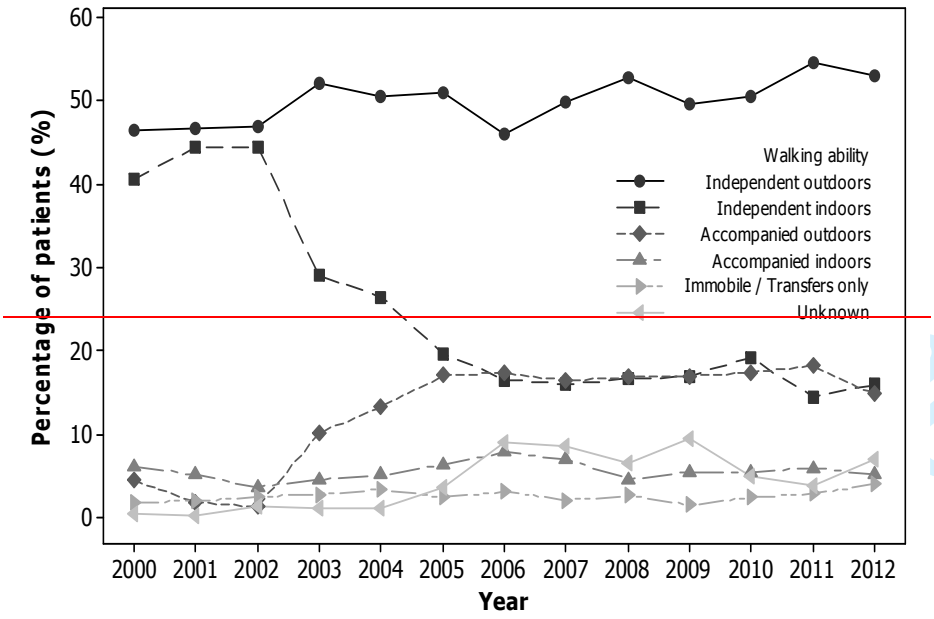
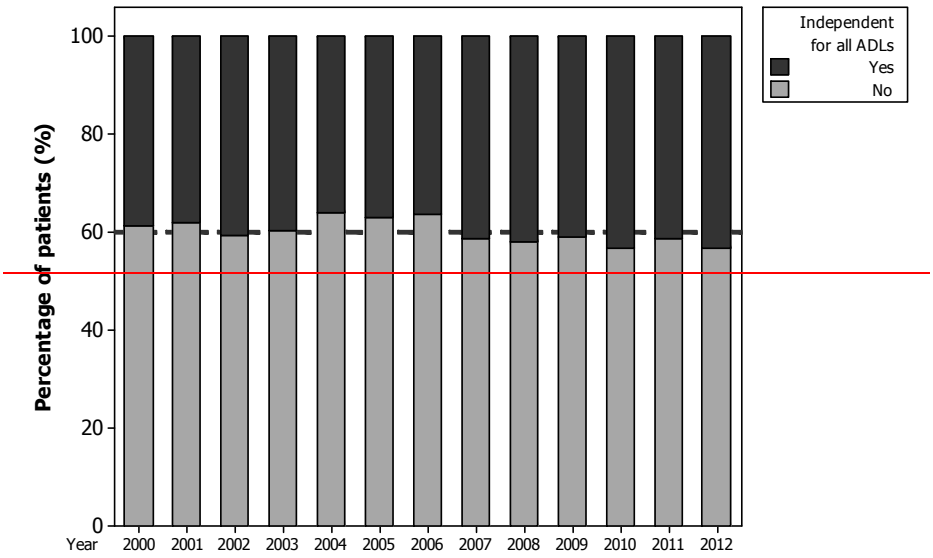


Figure 5: Trends in mobility status 2000 to 2012.



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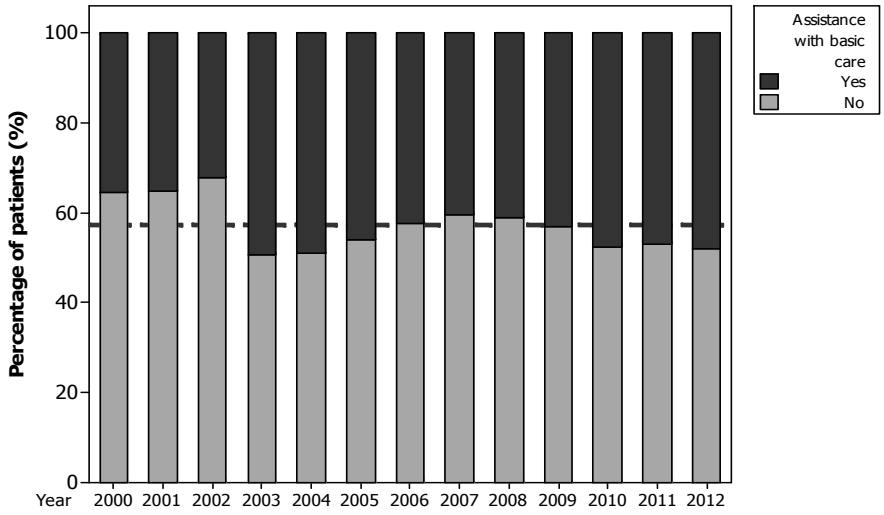

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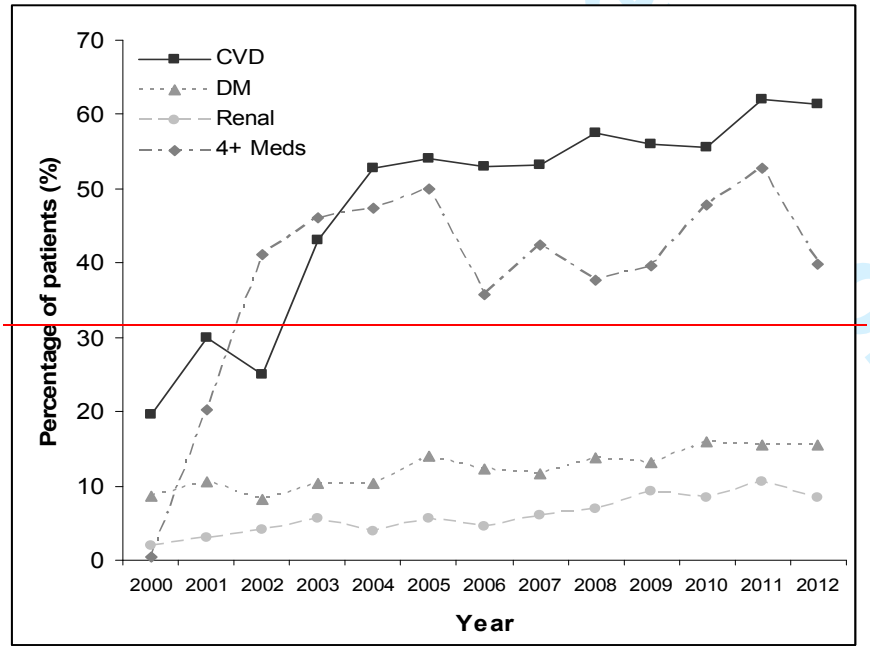

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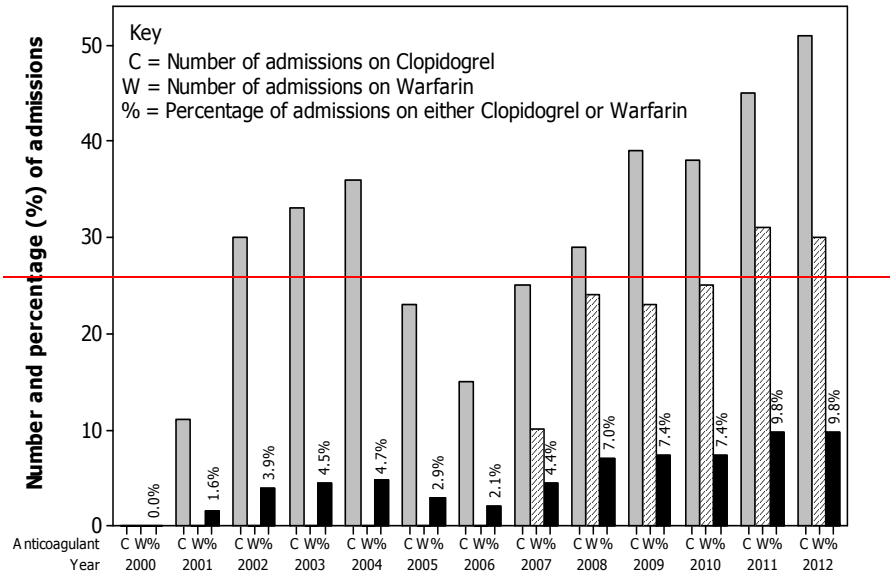

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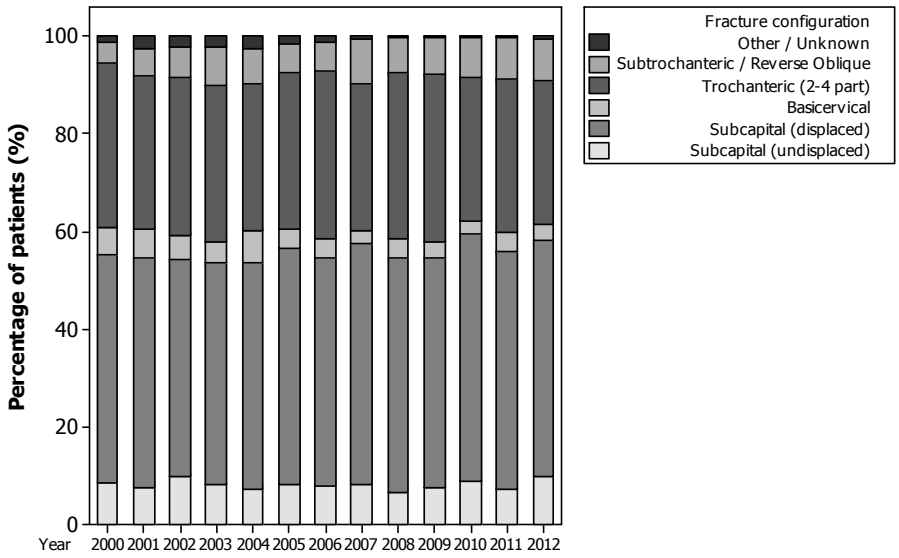

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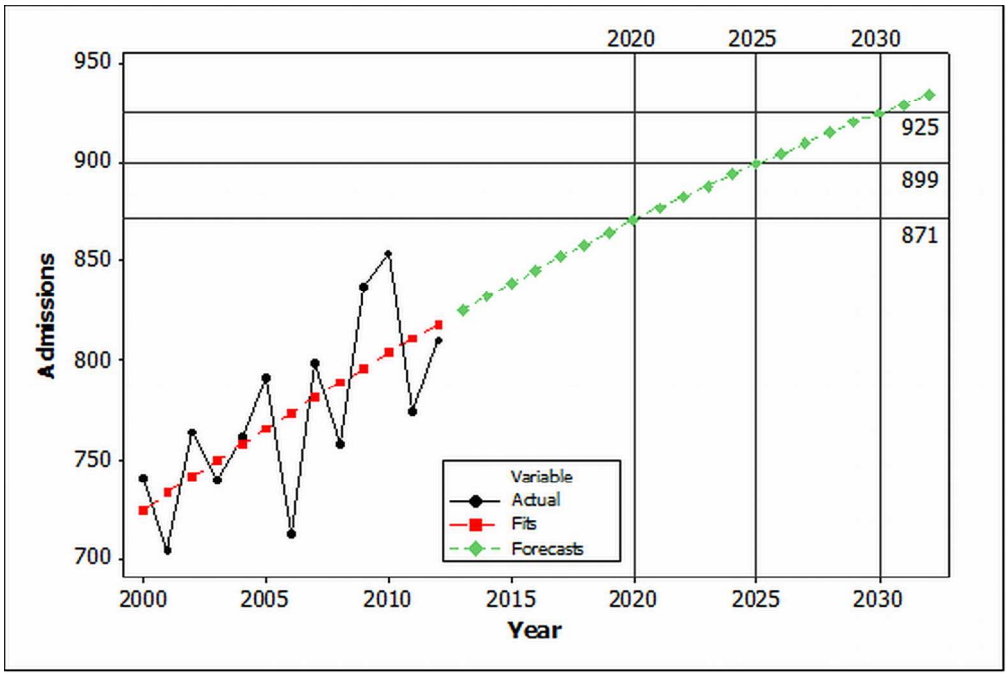

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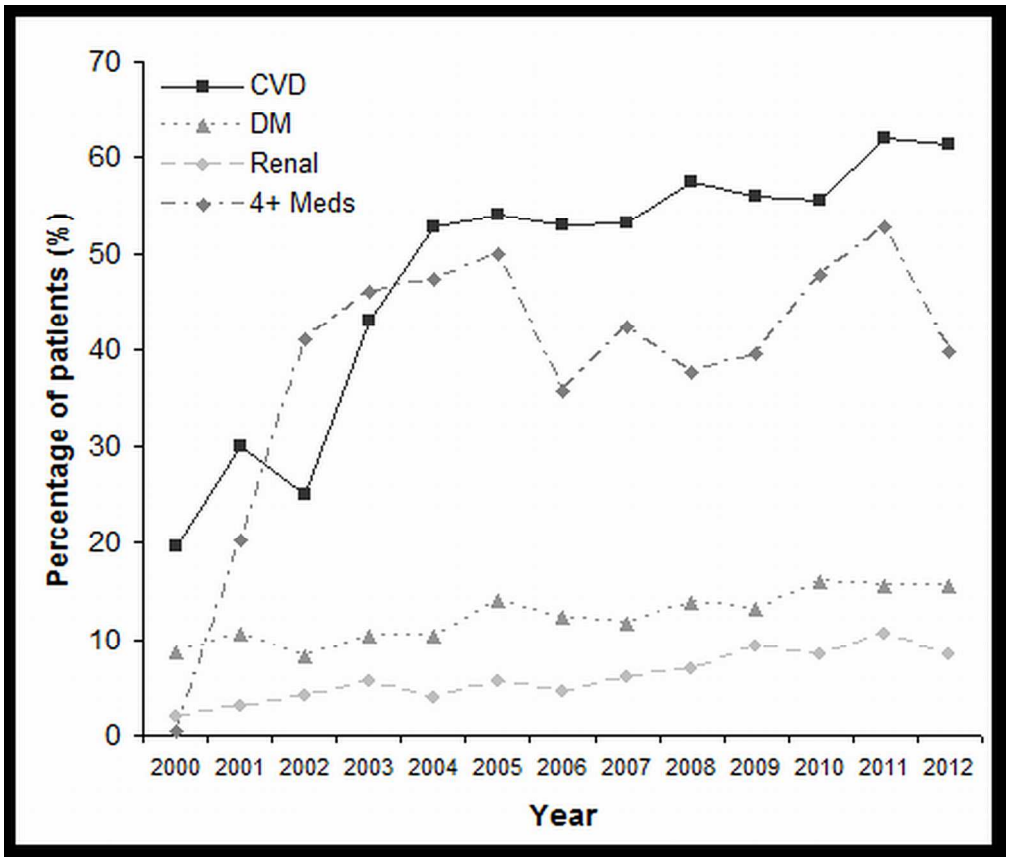

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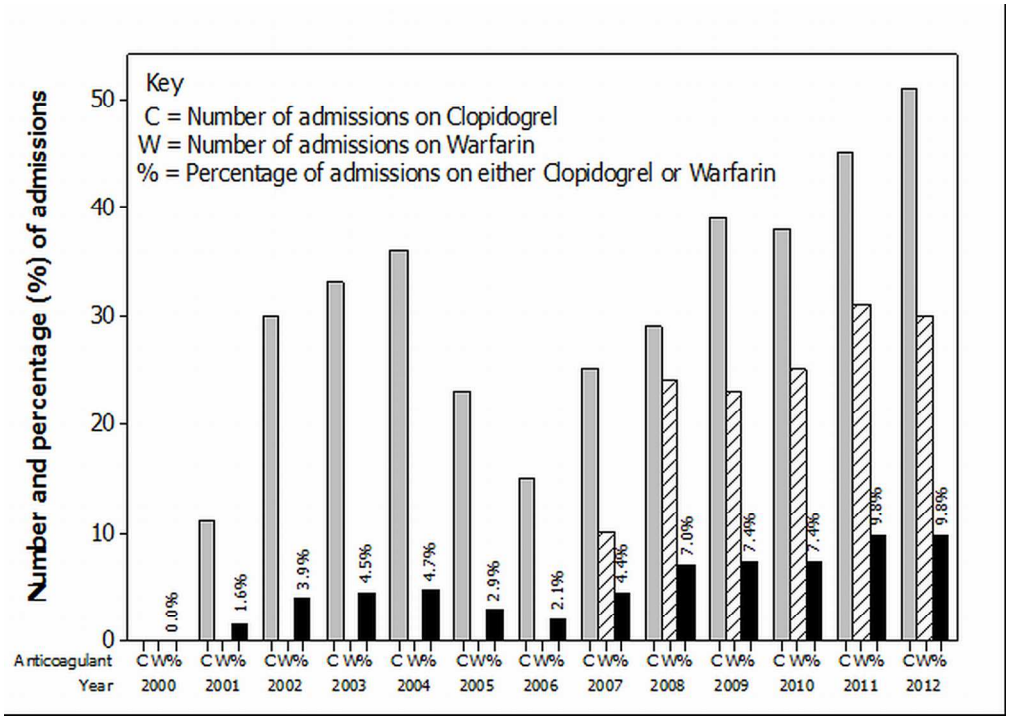

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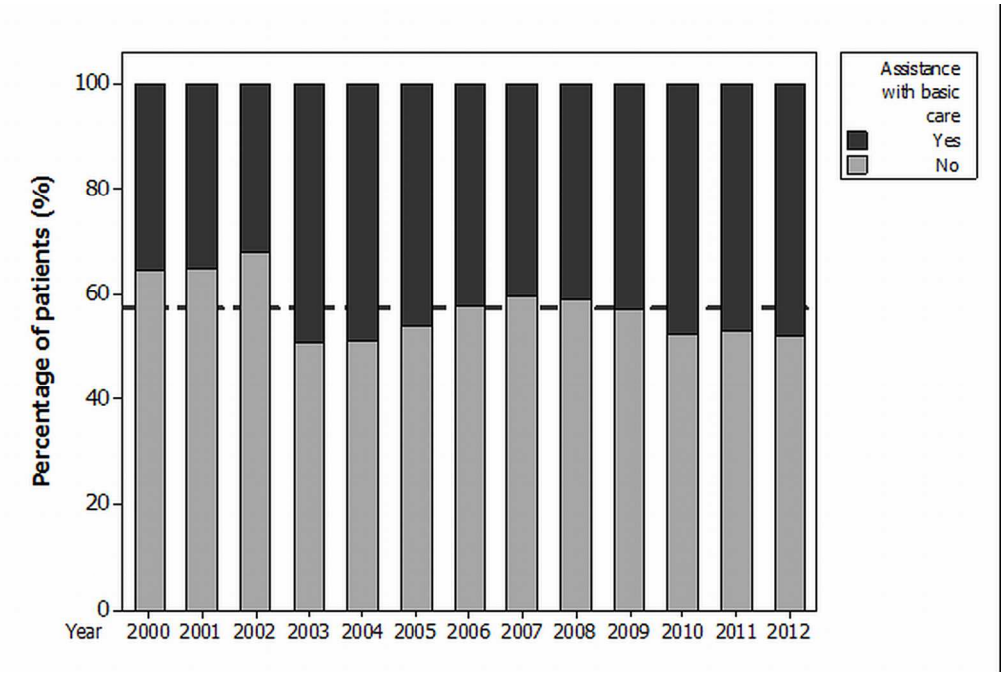

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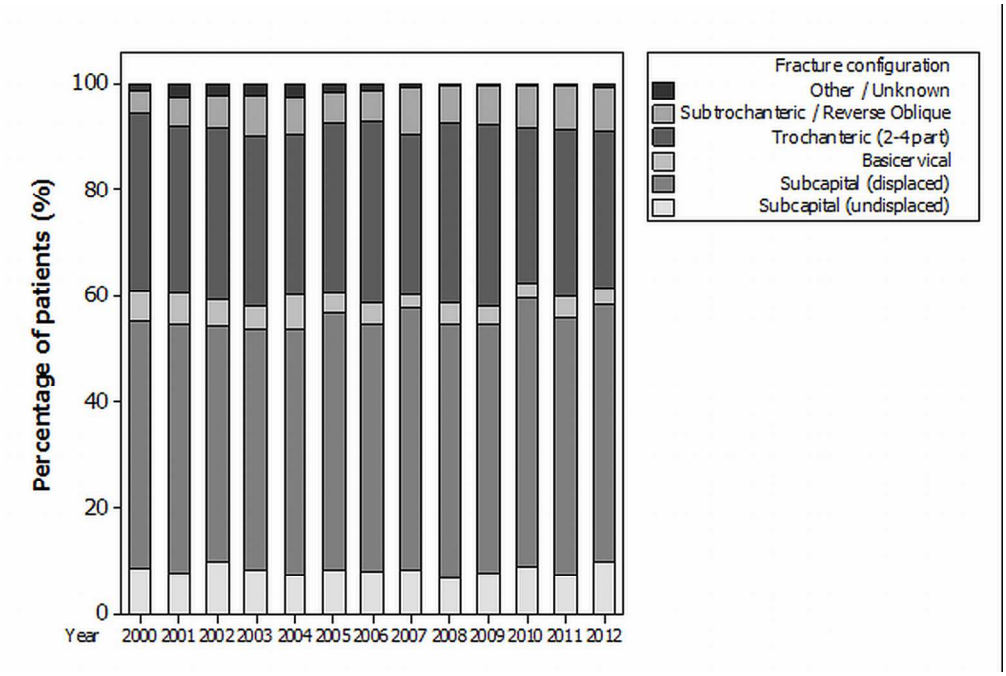

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract **Title: Page 1**
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found **Abstract: Page 4**
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported **Intro paragraph 1&2 (Page 5)**
Objectives	3	State specific objectives, including any prespecified hypotheses **Intro paragraph 3 (Page 5),**
Methods		
Study design	4	Present key elements of study design early in the paper **Methods: Study design and dataset section (Page 6)**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection **Methods: Study design and dataset section (Page 6)**
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up **Methods: Study design and dataset section (Page 6)** *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls **NA** *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants **NA**
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed **NA** *Case-control study*—For matched studies, give matching criteria and the number of controls per case **NA**
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable **Methods: Outcome variables section page 6/7**
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 **Methods: Outcome variables section page 6/7**
Bias	9	Describe any efforts to address potential sources of bias **Not described**
Study size	10	Explain how the study size was arrived at **Methods: Study design and dataset section (Page 6)**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why **Methods: Statistical analysis section (page 7/8)**

Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding **Methods: Statistical analysis section (page 7/8)**
		(*b*) Describe any methods used to examine subgroups and interactions **Methods: Statistical analysis section (page 7/8)**
		(*c*) Explain how missing data were addressed **NA**
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed **NA** *Case-control study*—If applicable, explain how matching of cases and controls was addressed **NA** *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy **NA**
		(*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 **Methods: Study design and dataset section (Page 6)**
		(b) Give reasons for non-participation at each stage **NA**
		(c) Consider use of a flow diagram **NA**
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders **Results (pages 8 to 10)**
		(b) Indicate number of participants with missing data for each variable of interest **NA**
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount) **NA**
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time **Results incl Table 1**
		Case-control study—Report numbers in each exposure category, or summary measures of exposure **NA**
		Cross-sectional study—Report numbers of outcome events or summary measures **NA**
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 **Results (Pages 8 to 10)**
		(*b*) Report category boundaries when continuous variables were categorized **NA**
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period **NA**
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses **Results (Pages 9 to 11) plus relevant tables**
Discussion		
Key results	18	Summarise key results with reference to study objectives **Discussion: principle findings and comparison with other studies section (page**

		12/13/14)
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 **Discussion: Strengths and limitations section (page 14)**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **Discussion (Page 12/13/14/15)**
Generalisability	21	Discuss the generalisability (external validity) of the study results **Discussion: principle findings and comparison with other studies section (page 12/13/14)**
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based **NA**

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

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