High health gain patients with asthma

Citation for published version:
Mukherjee, M, Nwaru, BI, Soyiri, I, Grant, I & Sheikh, A 2018, 'High health gain patients with asthma: a cross-sectional study analysing national Scottish data sets' npj Primary Care Respiratory Medicine, vol. 28, no. 1, pp. 27. DOI: 10.1038/s41533-018-0094-6

Digital Object Identifier (DOI):
10.1038/s41533-018-0094-6

Link:
Link to publication record in Edinburgh Research Explorer

Document Version:
Publisher's PDF, also known as Version of record

Published in:
npj Primary Care Respiratory Medicine

General rights
Copyright for the publications made accessible via the Edinburgh Research Explorer is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy
The University of Edinburgh has made every reasonable effort to ensure that Edinburgh Research Explorer content complies with UK legislation. If you believe that the public display of this file breaches copyright please contact openaccess@ed.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.
High health gain patients with asthma: a cross-sectional study analysing national Scottish data sets

Mome Mukherjee, Bright I. Nwaru, Ireneous Soyiri, Ian Grant and Aziz Sheikh

Studies have shown that a small proportion of patients have particularly high needs and are responsible for disproportionately high disease burden. Estimates suggest that 2–5% of patients are high users of healthcare for their health gain. Such patients in Scotland are referred to as high health gain (HHG) patients. We wanted to investigate if there were HHG individuals with asthma in Scotland. We analysed data from the Scottish Health Survey (2010–11), and primary and National Health Survey (NHS) secondary healthcare and administrative data sets (2011–12). In all, 1,379,690 (26.0%) and 836,135 (15.8%) people reported to have ever had and currently have symptoms suggestive of asthma, respectively; 369,868 (7.0%) people reported current symptomatic clinician-diagnosed asthma. 310,050 (5.6%) people had clinician-reported-diagnosed asthma; there were 289,120 nurse consultations, 215,610 GP consultations, 9235 accident and emergency visits (0.2% people), 8263 ambulance conveyances (0.2% people), 7744 inpatient episodes (0.1% people), 3600 disability allowance claims (0.1% people), 187 intensive care unit (ICU) episodes and 94 deaths from asthma. From our study a maximum of about 9.4% of asthma patients (n = 29,145), which is 0.5% of the Scottish population, and from the National Review of Asthma Deaths’ estimate (10% hospitalised), a minimum of nine people had severe asthma attacks that needed acute hospital attendance/admission. We found that although a high proportion of the Scottish population had symptoms suggestive of asthma and clinician diagnosed asthma, only a small proportion of asthma patients experienced exacerbations that were severe enough to warrant hospital attendance/admission in any given year. Developing risk prediction models to identify these HHG patients has the potential to both improve health outcomes while substantially reducing healthcare expenditure.

npj Primary Care Respiratory Medicine (2018) 28:27; doi:10.1038/s41533-018-0094-6

INTRODUCTION

Asthma is now one of the most common long-term conditions in economically-developed countries, with the prevalence being particularly high in English-speaking nations.1 There is also a growing body of work showing that asthma is responsible for considerable morbidity and, in some cases, mortality.2

While there are a number of investigations on the epidemiology and healthcare utilisation of asthma in specialist clinical settings and some using more population-based approaches,3−9 there have been relatively few attempts to provide a national overview of asthma and its impact.2 Such analyses are potentially important to support health policy and planning, as well as inform deliberations on whether there are subsets of the asthma population that are particularly at high risk of poor outcomes and thus need focussed care. This subset of the population is also sometimes known as ‘high need, high-cost’ (HNHC) patients and in Scotland as ‘high risk individuals’ (HRI) or ‘high health gain’ (HHG) individuals.10−16

Building on our recent work studying asthma in the UK,2 we sought to undertake a more detailed analysis of asthma in Scotland, taking advantage of the considerable data assets available, in order to provide the first detailed national profile of asthma in Europe. This work will enable us to ascertain if there is a HHG group of individuals with asthma.

RESULTS

Prevalence

In 2010–11, an estimated 26.0% (95% CI 21.7–30.4; equivalent to 1,379,690 people, 95% CI 1,148,779–1,610,601) of the Scottish population reported to ever had experienced symptoms of asthma in their lifetime; 15.8% (95% CI: 12.4–19.2; equivalent to 836,135 people, 95% CI 655,872–1,016,398) reported to have experienced symptoms of asthma in the last 12 months preceding the survey; 13.6% (95% CI 10.5–16.7; equivalent to 746,542 people, 95% CI 554,883–934,201) reported to have had clinician-diagnosed asthma in their lifetime; 9.9% (95% CI: 7.3–12.5; equivalent to 524,883 people, 95% CI 385,831–663,935) reported to have had clinician-diagnosed symptomatic asthma in the last 12 months; and 7.0% (95% CI 4.8–9.2; equivalent to 369,868 people, 95% CI 251,933–487,802) reported to have had clinician-diagnosed and-treated asthma in the last 12 months. In 2011–12, an estimated 5.6% (95% CI 5.5–5.7; equivalent to 310,050 people, 95% CI 305,182–314,918) had clinician-diagnosed asthma and 6.0% (95% CI 6.0–6.0; equivalent to 319,091 people, 95% CI 319,091–319,091) had clinician-diagnosed and-treated asthma.

1Asthma UK Centre for Applied Research, Centre for Medical Informatics, Usher Institute of Population Health Sciences and Informatics, The University of Edinburgh, Edinburgh, UK; 2Krefting Research Centre, Institute of Medicine, University of Gothenburg, Gothenburg, Sweden; 3Wallenberg Centre for Molecular and Translational Medicine, Institute of Medicine, University of Gothenburg, Gothenburg, Sweden and 4ScotPHO Collaboration, Information Services Division (ISD), NHS National Services Scotland, Edinburgh, UK

Correspondence: Mome Mukherjee (mome.mukherjee@ed.ac.uk)

Received: 26 January 2018 Revised: 29 May 2018 Accepted: 4 June 2018
Published online: 19 July 2018
Healthcare and societal care utilisation

In 2011–12, there were 289,120 nurse consultations (95% CI 284,422–293,818); 215,610 GP consultations (95% CI 211,563–219,657); 9235 A&E attendances (95% CI 8358–10,113); 8263 ambulance conveyances; 7744 inpatient episodes; 4575 out of hour calls; 3600 claimed DLA; there were 187 ICU episodes and 94 deaths.

Since this was a cross-sectional study, we could not ascertain what proportion of asthma patients contributed to the healthcare use. However, with the conservative assumption of one event or service use to one person only, and using the lowest denominator (i.e., 310,050 as the number of people with clinician-diagnosed asthma reported by GPs), then we can estimate that 93.2% (95% CI 91.7–94.8) had nurse consultations; 69.5% had GP (95% CI 68.2–70.8); 1.5% called out-of-hours service (95% CI 1.4–1.5); 3.0% attended A&E (95% CI 2.7–3.3); 2.7% used an ambulance service (95% CI 2.6–2.7); 2.5% had a hospital admission (95% CI 2.4–2.6); 1.2% claimed DLA (95% CI 1.1–1.2); 0.1% were admitted in an ICU (95% CI 0.1–0.1); and 0.03% died with asthma as an underlying reason (95% CI 0.02–0.04). This implies that in Scotland there was a maximum of about 9.4% of asthma patients (sum of 3% A&E attendances, 2.7% ambulance conveyances, 2.5% hospital admission, 1.2% DLA claims, 0.1% ICU, 0.03% deaths), equivalent to 29,145 people, which is 0.5% of the population, who had severe asthma, which required resource intensive ambulance services, acute hospital services (i.e., A&E/hospitalisation/ICU admission), costly DLA benefits or led to death.

The asthma population profile, describing asthma prevalence, healthcare utilisation and outcomes, including mortality, is illustrated using a pyramid graph below (Fig. 1). The stack of the pyramid is depicting the severity of the disease at population level. The bottom of the pyramid is showing the number of people who had ever experienced symptoms of asthma in their lifetime (n = 1,379,690), whereas the tip is showing the number of people who eventually died due to asthma as the underlying reason (n = 94).

DISCUSSION

Statement of principal findings

This national level profile of asthma epidemiology and health and social care utilisation in Scotland has found that even though the annual prevalence of symptoms suggestive of asthma (15.8% of the Scottish population) or of clinician-diagnosed asthma itself (5.6% of the Scottish population) is high in Scotland, only a small minority of patients (0.5% of the Scottish population) experience events severe enough to lead to emergency hospital attendance/admission, with far fewer still who experience ICU admission or have a fatal episode in any given year. This suggests that there may be potential to risk-stratify at a population level and develop cost-effective interventions in this high risk group.

Strengths

This study provides the first detailed national picture of asthma in Scotland using population representative survey data and routine data from a national health system and administrative data, with coverage from cradle-to-grave. The estimates produced in this exercise are slightly higher than our previous exercise. Are these estimates better? Our previous exercise was to compare nations across the UK. Hence, we had used European Standard Population (ESP) 2013 as the reference population when we age standardised. But when we are focussing on Scotland and not comparing to elsewhere, using the population estimate of Scotland (SMYEP) as the reference is a logical choice. If we compare ESP and SMYEP, we will find that: (a) population distribution by gender in ESP is identical, whereas in SMYEP it varies (online Appendix 2); and (b) SMYEP had less young population and higher older population compared to ESP. Thus, by using SMYEP split by 5-year age-groups and gender as the reference population, the estimates are not only different, but also higher. The reference population used to produce the estimates is appropriate for this particular study, hence these estimates are more appropriate for this purpose.

Limitations

We did not have cohort data to investigate if there is a small group of asthma patients who have high-need and thus use healthcare services more. In the absence of cohort data, the layout of this cross-sectional study amply suggests that there is a tiny group of asthma patients who have severe asthma and use resource intensive or costly services. Since this was not a cohort study, one step of the pyramid did not necessarily contribute to the next. Our estimates are based on conservative assumptions. Thus, we presume that the proportion of asthma patients who had severity or fatality are even smaller than we estimated here (9.4%). Nevertheless, this study lends us a hypothesis of the proportion of HNHC/HRI/HHG asthma patients, i.e., a maximum of 9.4% of asthma patients could be HNHC/HRI/HHG. Some data gaps we found were unavailability of out-of-hours GP services data, lack of diagnosis data in outpatient clinics, people who got Xolair (drug used to treat severe asthma), people who used private medical services for their asthma. Although we had good coverage of data, there were two NHS health boards, which did not contribute data to A&E2 and thus were excluded in this analysis.

Interpretation in the light of the previous literature

Of the 16 outcome measures reported here, nine outcomes had the same values as in our previous exercise, since either they

![Fig. 1 Asthma population profile in Scotland in 2011–12 (patient reported 2010–2011): asthma prevalence, healthcare utilisation and outcomes](image-url)
were real absolute numbers and cannot/should not be adjusted to population level, example number of calls to NHS 24, number of ambulance trips, number of day-case/inpatient episodes, number of deaths, or they were already adjusted to the respective database population, example GP consultations, nurse consultations and annual prevalence of clinician-reported-and-diagnosed asthma, all from Practice Team Information (PTI) primary care database, or the data did not have age-sex distribution and hence could not be adjusted, example annual prevalence of clinician-reported-diagnosed-and-treated asthma from Quality and Outcomes Framework (QOF), Disability living allowance (DLA). The other seven estimates generated from using SMYEP are more appropriate when looking into Scotland alone. These seven new estimates were for five prevalence estimates from Scottish Health Survey, A&E and ICU. For the five prevalence estimates from Scottish Health Survey, the number of respondents who had said yes to the question (n), number of respondents (N), ASR (95% CI), were provided for Scotland in the previous exercise. The age and gender adjusted rates were different when SMYEP was used, and thus the estimated number reported in this manuscript. A&E estimates for the two HBs, which did not submit patient level data were generated adjusting to the respective HBs estimated population and were estimated for Scotland using SMYEP. We did not have the number of children under 15 in adult ICUs (from ICNARC) for England, Wales and Northern Ireland. But we had small number of children who were 15 and older in paediatric ICUs in PICANet and children under 15 in adult ICUs in SICSAG for Scotland. These small numbers had to be excluded in our earlier exercise to follow the same principle of inclusion across the four nations. Since this manuscript is about Scotland specific estimate, we could use these small numbers by combining data from PICANet and SICSAG.

We found that while 310,050 people who were diagnosed for asthma by clinicians (5.6% people (95% CI: 5.5–5.7)), 319,091 people (6.0% people (95% CI: 6.0–6.0)) had clinician-diagnosed and treated asthma as per the financial incentive based QOF register. Perhaps there was an issue of possible over-diagnosis or over-labelling, as was found in studies on children and adults in the Netherlands and in Canada, respectively. There is likely to be scope for diagnostic clarification in the population with asthma symptoms.

This work shows that only a small proportion (0.5%) of the Scottish population end up with serious asthma attacks or deaths. We know from our previous exercise that of the approximately £92.2 million public expenditure in Scotland for asthma, about £54.5 m (59.1%) was spent on community prescriptions, £14.8 m (16%) on DLA, £8.6 m (9.3%) on GP consultations, £6.3 m (6.9%) on inpatient episodes, £4.0 m (4.4%) on nurse consultations, £2.4 m (2.6%) on ambulance conveyance, £0.9 m (1.0%) on A&E, £0.5 m (0.5%) on ICU and £0.1 m (0.1%) on out-of-hour calls. Due to data constraints in that exercise we could not calculate cost per patient for use of each of those healthcare services, which would have helped us understand resource use of a healthcare service in monetary units at a person level. However, using our conservative assumption above, we can estimate that 1.2% people with clinician-diagnosed asthma who claimed DLA, cost the economy £14.8 m; 2.5% who had a hospital admission for asthma cost the economy at least £6.3 m; and 0.1% who were admitted in an ICU had cost the economy at least £0.5 m.

In the UK-wide review of asthma deaths, NRAD had found that of the 195 deaths for asthma, 21% had been to A&E and 10% were hospitalised for their asthma in the 12 months prior to their deaths. These UK-wide percentages are much higher than our conservative estimates for Scotland. Yet, if we apply the NRAD percentages to the Scottish asthma deaths, we reckon of the 94 people who died due to asthma, 20 might had been to A&E and 9 were hospitalised in the year before their death.

Our conservative assumption is too simplistic; in reality there are re-admissions to hospital, thus the counts of cases do not necessarily equal counts of patients. Therefore, the proportion of people using healthcare and social care services is expected to be lower than the estimates we have computed here. The implication of this is that there is only a small number of asthma patients who have high care needs and for whom public expenditure is very steep. There is thus the potential for risk stratification, using prognostic factor research, and case management, to reduce the risk of hospitalisations, ICU admissions, near death situations and deaths. Recent work has found that about 2% of patients contribute to about 50% of healthcare costs in Scotland. Although our work alludes towards this fact, given the limitations in the data we could not ascertain this in the asthma patient population. Making such inference will require a cohort study design, which will permit investigating whether there is a HNHCH/HR/HHG asthma patient group in Scotland, and if there is, estimates of proportions of HHG and HC asthma patients.

Implications for policy, practice and research

This study, through the pyramid structure of the disease portrayal, very clearly demonstrates that Scotland has both a pressing need and the data assets needed to address the issue of identifying HNHCH/HR/HHG patients. Although asthma should in the vast majority of cases be manageable in primary care contexts, our study found that in Scotland—despite the NHS spending around £100 m/year—there are nearly 8000 hospitalisations and 100 deaths from asthma/year. Much of this expenditure and poor outcomes is down to a small percentage of people who are not always easy to identify and manage. Having studied the overall patterns of care and costs of asthma in Scotland, we now need to build on this and develop a new tool that allows healthcare professionals to find patients at risk of poor asthma outcomes. We plan to do this by analysing Scotland’s unique national data sets, through linkage, to create a cohort of asthma patients to help understand and identify patients who could gain from better case management earlier on, than letting them become severely sick and costly. Once we have found this patient group, we need to find new ways to give them more tailored care, so they do better. Similar work is also needed in other UK and European nations, to understand the asthma population profiles in each of their respective nations, for better care and resource allocation.

CONCLUSIONS

Although asthma is common in Scotland, only a relatively small proportion of those with asthma experience attacks requiring acute hospital attendance/admission in any given year. It is important to characterise the relatively small subset of patients who are experiencing poor asthma outcomes and see if it is possible to develop and validate prognostic algorithms for identifying those with severe asthma attacks in Scotland, and then armed with this information proactively intervene to reduce the risk of severe, potentially life-threatening asthma attacks.

METHODS

We undertook a national cross-sectional study in Scotland. The STROBE and RECORD statements were used to guide the reporting of this manuscript (online Appendix 1). We undertook secondary analyses of Scottish Health Survey (SHeS) and National Health Service (NHS) data sets on primary and secondary care and administrative data. SHeS is a series of stratified, cluster-sampled, cross-sectional surveys designed to measure the health of a representative sample of the Scottish population living in private households. The NHS

Published in partnership with Primary Care Respiratory Society UK

npj Primary Care Respiratory Medicine (2018) 27
Table 1. Outcome measures by data sets used for asthma population profile in Scotland—name of data set, population coverage in the data set and criteria used to select study population from that data set

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Data sets used for Scotland</th>
<th>Name of data set</th>
<th>Population coverage</th>
<th>Selection criteria for study population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prevalence</td>
<td></td>
<td>Practice Team Information (PTI)</td>
<td>Sixty GP practices in National Health Service (NHS) Scotland (6% of all GP practices)</td>
<td>Read codes, version 2, for asthma diagnosis^b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quality and Outcomes Framework (QOF)</td>
<td>All GP practices in NHS Scotland (about 1000 number changes slightly with time)</td>
<td>Read codes, version 2, for asthma diagnosis^b</td>
</tr>
<tr>
<td></td>
<td>Lifetime prevalence of patient-reported symptoms suggestive of asthma^a</td>
<td>Scottish Health Survey (SHeS)</td>
<td>National population survey of randomly sampled private household</td>
<td>Answer to survey questions^c–^g</td>
</tr>
<tr>
<td></td>
<td>Annual prevalence of patient-reported symptoms suggestive of asthma^a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Life-time prevalence of patient-reported asthma</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual prevalence of patient-reported asthma</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual prevalence of patient-reported asthma</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary care—healthcare utilisation</td>
<td>Practice Team Information (PTI)</td>
<td>Sixty Scottish GP practices (6% of all GP practices)</td>
<td>Read codes, version 2, for asthma diagnosis^a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NHS 24</td>
<td>All telephone calls to NHS 24 in NHS Scotland</td>
<td>Calls triaged using NHS 24’s asthma-specific algorithm</td>
<td></td>
</tr>
<tr>
<td>Secondary care—healthcare utilisation</td>
<td>Scottish Ambulance Service (SAS)</td>
<td>All ambulance conveyances in Scotland</td>
<td>ICD-10 codes for asthma,^h including ‘R062’ (family history of asthma) or if the ‘presenting complaint text’ or ‘diagnosis text’ referred to any of the terms asthma, wheezing, low saturation, chest tightness or shortness of breath</td>
<td></td>
</tr>
<tr>
<td>Accident and emergency (A&amp;E) visits</td>
<td>Accident and Emergency datamart</td>
<td>All hospitals with A&amp;E in NHS Scotland</td>
<td>ICD-10 codes for asthma as primary reason for admission^h</td>
<td></td>
</tr>
<tr>
<td>Inpatient and day-case episodes (non-psychiatric)</td>
<td>Scottish Morbidity Records (SMR01)</td>
<td>All hospitals in NHS Scotland</td>
<td>ICD-10 codes for asthma as primary reason for admission^h</td>
<td></td>
</tr>
<tr>
<td>Paediatric ICU episodes</td>
<td>Paediatric Intensive Care Audit Network (PICANet)</td>
<td>All paediatric intensive care units in NHS Scotland</td>
<td>Read codes, version 3, as primary reason for admission^1</td>
<td></td>
</tr>
<tr>
<td>Adult ICU episodes</td>
<td>Scottish Intensive Care Society Audit Group (SICSAG)</td>
<td>All adult intensive care units in NHS Scotland</td>
<td>APACHE III diagnoses for asthma as primary reason for admission</td>
<td></td>
</tr>
<tr>
<td>Societal</td>
<td>Department for Work and Pensions (DWP)</td>
<td>All individuals claiming benefit in Scotland</td>
<td>ICD-10 codes for asthma as primary reason for admission^h</td>
<td></td>
</tr>
<tr>
<td>Disability living allowance</td>
<td>National Records of Scotland (NRS)</td>
<td>All individuals who died in Scotland</td>
<td>ICD-10 codes for asthma as underlying cause of death^h</td>
<td></td>
</tr>
</tbody>
</table>

^aThe total population of PTI GP practices Scottish population with regards to age, gender and deprivation, and small imbalances due to these demographic and socio-economic factors are addressed during data analysis through a process of direct standardisation
^cHave you ever had wheezing/wheezing in the chest at any time, either now/in the past?
^dHave you had wheezing or whistling in the chest in the last 12 months?
^eDid a doctor ever tell you that you had asthma?
^fHave you had wheezing or whistling in the chest in the last 12 months? and ‘Did a doctor ever tell you that you had asthma?’
^gWere you treated in the past 12 months for wheezing by GP/nurse at surgery/community/school/district nurse/hospital, consultant/specialist elsewhere, homeopath/acupuncturist/other alternative medicine professional?
^hICD-10 codes ‘J45’ (asthma), ‘J46’ (status asthmaticus)

The administrative data sets used were Quality and Outcomes Framework (QOF), Practice Team Information (PTI), NHS 24, Accident and Emergency (A&E) datamart, Scottish Ambulance Service (SAS), Scottish Morbidity Records (SMR) for outpatients (SMR01) and inpatients (SMR1), Paediatric Intensive Care Audit Network (PICANet) and Scottish Intensive Care Society Audit Group (SICSAG). The administrative data sets used were disability living allowance (DLA) from Department of Work and Pensions (DWP) and death registrations from National Records Scotland (NRS). All GP practices in Scotland report to QOF, whereby they get financial incentive for providing quality care to their patients, according to the UK General Medical Services (GMS) contract. PTI is a general practitioner (GP) database comprising a sample of 60 practices representing about 6% of Scottish GP practices and about 6% of the Scottish patient population. NHS 24 is a national telephone triage and advice service across Scotland during out-of-hour GP service. NHS 24 calls are triaged by call-handling nurses using disease-specific algorithm to support decision-making. A&E...
outcome measures

Table 1 below describes the outcome measures by data sets used for asthma population profile in Scotland, with the name of data set, population coverage in the data set and criteria used to select study population from that data set.

SHEs was used to describe the lifetime and annual prevalence of patient-reported symptoms suggestive of asthma, lifetime prevalence of patient-reported clinician-diagnosed asthma, annual prevalence of patient-reported clinician-diagnosed symptomatic asthma and annual prevalence of patient-reported clinician-diagnosed and-treated asthma. The relevant questions used to determine these prevalence outcome measures have been previously described. QOF was used for annual prevalence of clinician-reported-diagnosed and-treated asthma. PTI was used for annual prevalence of clinician-reported-diagnosed and treated asthma and GP and nurse consultations, by using Read codes version 2.23,26 Number of calls for asthma during GP out-of-hours services were obtained from NHS 24,27 Only ‘new’ and ‘unplanned return’ type of appointments at A&E were used, and not when patients had a scheduled visit to A&E clinics, classified as ‘recall’ or ‘planned return’. Furthermore, A&E visits were selected based on ICD-10 codes ‘J43’ (asthma) and ‘J46’ (status asthmaticus), along with ‘R062’ (family history of asthma) or if the ‘presenting complaint text’ or ‘diagnosis text’ referred to any of the terms or textual variations of asthma, wheezing, low saturation, chest tightness or shortness of breath.22,28 The NHS Health Boards of Orkney and Tayside did not submit patient level information to A&E2, and hence these two regions were excluded from the A&E analysis. The number of ambulance conveyances for asthma were obtained from SAC.23,34 SMR0 was not used since diagnoses in outpatient clinics are not recorded.23,35 Hospital discharge episodes for asthma were obtained from SMR01, which had ICD-10 codes ‘J43’ and ‘J46’ as the primary diagnosis.23,25 ICU discharges for Scottish residents with primary diagnosis of asthma were obtained from PICANet using Read codes version 3 and from SICSAG using Acute Physiology and Chronic Health Evaluation (APACHE) III diagnoses.36 Paediatric and adult ICU episodes have been added up to generate estimates of ICU episode numbers at population level. The number of people who received DLA for asthma as their main disabling condition were available from DWP, 24 using ICD-10 codes. The number of deaths with asthma as the underlying cause of death, using ICD-10 codes, were available from NRS.27 We had access to anonymised SHEs records at individual respondent level from the open data source from UK Data Services. QOF was obtained and is available aggregated, at individual GP level. All the other data, except QOF, were available aggregated by 5-year age-group and gender to ensure patient confidentiality by data custodians.

Acknowledgements

The grant holders were also Ceri J. Phillips, Swansea Centre for Health Economics (SCHE), College of Human and Health Science, Swansea University, Singleton Park, Swansea SA2 8PP, UK; David P. Strachan, Population Health Research Institute, St. George’s, University of London, Cranmer Terrace, London SW17 0RE, UK and Gwyneth A. Davies, Asthma & Allergy Group, Institute of Life Science, Swansea University Medical School, Swansea University, Singleton Park, Swansea SA2 8PP, UK. B.J. N. acknowledges the support of Knut and Alice Wallenberg Foundation and the Wallenberg Centre for Molecular and Translational Medicine, University of Gothenburg.

Authors’ contributions

A.S. conceived the study and was the PI. M.M. analysed the data and wrote the drafts. All authors reviewed the drafts. This study was funded by Asthma UK (reference: AUK- PG-2012-178), and the Farr Institute. The funders had no influence of the analytical methods employed, interpretation of results or the decision to publish. The Farr Institute is supported by a 10-funder consortium: Arthritis Research UK, the British Heart Foundation, Cancer Research UK, the Economic and Social Research Council, the Engineering and Physical Sciences Research Council, the Medical Research Council, the National Institute of Health Research, the National Institute for Social Care and Health Research (Welsh Assembly Government), the Chief Scientist Office (Scottish Government Health Directorates), the Wellcome Trust (MRC Grant No: MR/ K006525/1).

Additional information

Supplementary information accompanies the paper on the npj Primary Care Respiratory Medicine website (https://doi.org/10.1038/s41533-018-0094-6).

Competing interests: The authors declare no competing interests.

Publisher’s note: Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

References

31. Scottish Intensive Care Society Audit Group (SICSAg) http://www.sicsag.scot.nhs.uk/.