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Uptake of pneumococcal polysaccharide vaccine in at-risk populations in England and Wales 1999–2005

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SUMMARY

The UK has had a pneumococcal polysaccharide vaccination (PPV) programme for groups at higher risk of invasive disease since 1992. This paper presents data from a sample of primary-care practices (Q-RESEARCH) of PPV uptake in patients according to their risk status. Of 2·9 million registered patients in 2005, 2·1% were vaccinated with PPV in the preceding 12 months and 6·5% in the preceding 5 years. Twenty-nine per cent of the registered population fell into one or more risk groups. The proportion of each risk group vaccinated in the previous 5 years ranged from 69% (cochlear implants), 53·4% (splenic dysfunction), 36·5% (chronic heart disease), 34·7% (diabetes), 22·9% (immunosuppressed), 28·7% (chronic renal disease), 15·9% (sickle cell disease) to 12·6% (chronic respiratory disease). Uptake was lower in areas where the non-white proportion of population was >10%. In conclusion, there remain large gaps in the uptake of PPV in several high-risk populations in the United Kingdom. Effective strategies need to be developed to address these deficiencies.

INTRODUCTION

Streptococcus pneumoniae is the commonest cause of community-acquired pneumonia and a frequent cause of bacteraemia and meningitis in the United Kingdom. Pneumococcal pneumonia is estimated to affect 0·1% of the population each year and has an overall case fatality ratio of 10–20%, with a wider range if stratified by age group [1, 2].

S. pneumoniae may be carried in the nasopharynx without causing symptoms; however, it can also cause disease. Clinical presentation ranges from more common non-invasive manifestations such as sinusitis or otitis media, to infection of the lungs causing pneumonia or less common invasive infections including bacteraemic pneumonia, septicaemia and meningitis [2]. Pneumococcal antibiotic resistance is emerging as an increasing problem in some parts of the world – including Europe [2].

All age groups can be affected by invasive *S. pneumoniae*, but it predominately affects the elderly; infants and young children; those with an absent or non-functioning spleen; those with solid organ dysfunction and those with other causes of impaired immunity. Individuals with a non-functioning spleen are at much increased risk of serious invasive bacterial infection, a condition known as overwhelming post-splenectomy infection (OPSI), of which pneumococcal

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disease is the leading agent. Recurrent pneumococcal infections may also occur in those who have a cochlear implant, those with skull defects, fractures of the skull or cerebrospinal fluid (CSF) shunts [2].

Two pneumococcal vaccines are currently licensed in the United Kingdom. Since 1992 a 23-valent pneumococcal polysaccharide vaccination (PPV) has been recommended by the Department of Health as part of the national immunization programme for individuals falling into a defined at-risk group. Since 2004 a 7-valent pneumococcal conjugate vaccine (PCV) has been recommended for use in children falling into a risk group aged <5 years. Since September 2006, PCV has been recommended in the national immunization programme routinely for all infants and young children. In 2003, PPV was recommended for all people aged $\geqslant 65$ years and has been phased in with the nationally funded programme over 3 years in England and Wales [3].

Several studies have been published outside of the United Kingdom on uptake of PPV mainly from North America [4, 5] and Australia [6]. Some work on the uptake of pneumococcal vaccine in risk groups in the United Kingdom has been published; however, the studies have in general either been some time ago, small in size or focused on only specific risk groups. A recent UK-based study showed coverage in those aged >65 years was only 29% prior to the introduction of the general over 65 programme [7]. Coverage amongst high-risk groups has ranged from 4% in a single Family Health Services Authority (FHSA) in 1995 [8]; to 15% in 1999 [9]; and 13% in 2000/2001 in a primary-care setting [10]. A study undertaken in 1998 of high-risk patients discharged from a district general hospital found $\sim$50% had been vaccinated [11]. Studies of uptake in splenectomized individuals found coverage ranged from almost 50–88% [8]. In contrast an audit of diabetic patients attending secondary care found only 35% had received vaccine [12].

Q-RESEARCH is a newly developed general practice-derived database containing routine consultation data for a population of over three million patients registered with a nationally representative sample of over 500 practices. The information recorded on the database includes patient demographic details (year of birth, sex, socio-economic data derived from the UK 2001 census), characteristics (height, weight, smoking status), symptoms, clinical diagnoses, consultations, referrals, prescribed medication and results of investigations. The database has been extensively validated [13, 14]. As well as diagnostic information and prescribing/immunization data the database also contains postcode level information on deprivation scores, ethnicity and rurality. Analysis can be performed to Strategic Health Authority (SHA) level. This paper uses data derived from the Q-RESEARCH database to examine uptake of pneumococcal vaccination within the previous year and the last 5 years in patients in an at-risk group. In addition it compares uptake rates in patients from deprived and affluent areas, by ethnicity and in urban and rural areas.

METHODS

We used version 9 of the Q-RESEARCH database for this analysis. This contains data from 518 general practices throughout the United Kingdom. Our study period consisted of the six years between 1 April 1999 and 1 April 2005. Therefore we included only practices with complete data for the entire period from 1 April 1999 to 1 April 2005 in the analysis to ensure practices had complete data prior to the start of the study period. Our study population consisted of all patients registered on 1 April each year who had been registered for the whole of the previous 3 months. Double counting is not possible, as each person is uniquely identified. Although it is theoretically possible a person may leave one of the study practices and join one of the other 517, this would be unlikely as the practices are well dispersed throughout the United Kingdom. Patients who were not currently registered with a practice were excluded from the analysis. Temporary residents were excluded from both the numerator and the denominator.

We identified patients in each of the risk group categories defined by the Department of Health using the risk groups in the guidance issued in March 2005 (see Appendix). These patients were defined as those eligible for receiving pneumococcal vaccination. The risk categories were identified using the relevant computerized Read codes (list available from the authors). Both practising GPs and health protection epidemiologists selected Read codes, which conformed to the risk categories. Given the changes to the risk group categories over the study period of the project we used the risk group categories recommended for the 2003/2004 vaccination season and extended these back through the study period.

Our study outcome was the proportion of patients in each risk group who received pneumococcal

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Table 1. *Age-specific prevalence of risk groups per 1000 general population in 2005*

	Age group (years)									
Risk group	1–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79	⩾80	Overall
Chest	83·0	181·7	139·0	108·4	105·2	109·0	136·5	167·2	155·0	127·7
Chronic heart disease	0·7	0·6	0·9	1·9	8·9	36·2	99·9	195·3	263·9	42·9
Diabetes	n.a.	n.a.	4·8	9·6	22·8	47·5	89·3	128·2	104·9	34·6
Immunosuppressed	15·2	9·2	10·1	15·6	21·7	31·7	51·8	71·0	75·5	27·4
Renal	0·3	0·6	1·0	1·5	2·0	2·4	4·3	7·9	11·6	2·6
Liver	0·0	0·2	0·3	0·9	2·2	3·9	4·6	3·8	2·3	1·9
Coeliac/sickle	0·8	1·1	1·0	1·5	2·1	2·2	2·8	2·4	1·7	1·7
Invasive pneumococcal disease	0·0	0·2	0·5	0·9	1·4	1·8	1·9	1·7	1·6	1·0
Asplenia	0·0	0·2	0·5	0·9	1·4	1·8	1·9	1·7	1·6	1·0
CSF shunt	0·3	0·3	0·3	0·3	0·2	0·2	0·2	0·3	0·2	0·3
Cochlear implant	0·14	0·09	0·02	0·02	0·02	0·04	0·03	0·05	0·01	0·05

vaccination in the 12 and 60 months preceding the 1 April that year. Pneumococcal vaccination status was identified using a combination of computerized Read codes and prescription data. It was not possible in this study to distinguish between different types of pneumococcal vaccination.

The Q-RESEARCH database contains two measures of deprivation: the Townsend score and the Index of Multiple Deprivation score (IMDS). These are based on 2001 census data measured at output area (output areas consist of about 125 households and are nested within electoral wards). Whilst these measures are linked to postcodes, the data were linked within the patient's electronic health-care record on site and only the scores extracted (leaving the postcodes behind to guarantee patient confidentiality).

To ascertain ethnicity, the percentage white in each output area was determined using the 2001 census data and grouped into five groups (99–100% white, 97–98·9% white, 90–96·9% white, <90% white, missing). We also determined the uptake for patients in rural and urban areas according to a standard rurality index associated with their postcode.

Ethics approval was obtained from the Trent MREC and also the Q-RESEARCH Scientific Board.

RESULTS

Study population

There were 413 practices meeting our inclusion criteria with complete data between 1 April 1999 and 1 April 2005. There were 2·9 million registered patients on 1 April 2005 who had also been registered for the whole of the preceding 3 months. The overall crude and age-specific prevalence of risk groups in this population are shown in Table 1. The highest crude prevalence was observed for those with chest disease (128/1000 general population), coronary heart disease (43/1000), diabetes (35/1000) and immunosuppression (27/1000). The lowest prevalence for those with cochlear implants (5/100 000) and CSF shunts (30/100 000). With the exception of those with immunosuppression, CSF shunts and cochlear implants, there was a clear increase in age-specific prevalence with age.

In 2005, of these 2·9 million registered patients, only 62 214 patients (2·1%) had been vaccinated with pneumococcal vaccine in the preceding 12 months and 191 187 patients (6·5%) in the preceding 5 years. The corresponding figures in 2001 were 1·3% and 4·9%.

Total at-risk population vaccinated

On 1 April 2001, 812 870 persons (29% of all those registered) fell into one or more risk group (including being >65 years of age). This proportion remained 29% in 2005. In 2001, 4·2% of these 'at-risk' patients of all ages had been vaccinated with pneumococcal vaccine in the preceding 12 months and 15·8% in the preceding 5 years. This proportion had risen to 7% and 21·1% respectively by 2005.

Patients with chronic heart disease

Of the 116 093 patients with chronic heart disease in 2001, 7·3% had been vaccinated in the preceding 12 months and 31·8% in the preceding 5 years. This had risen to 10·2% and 36·5% respectively by 2005

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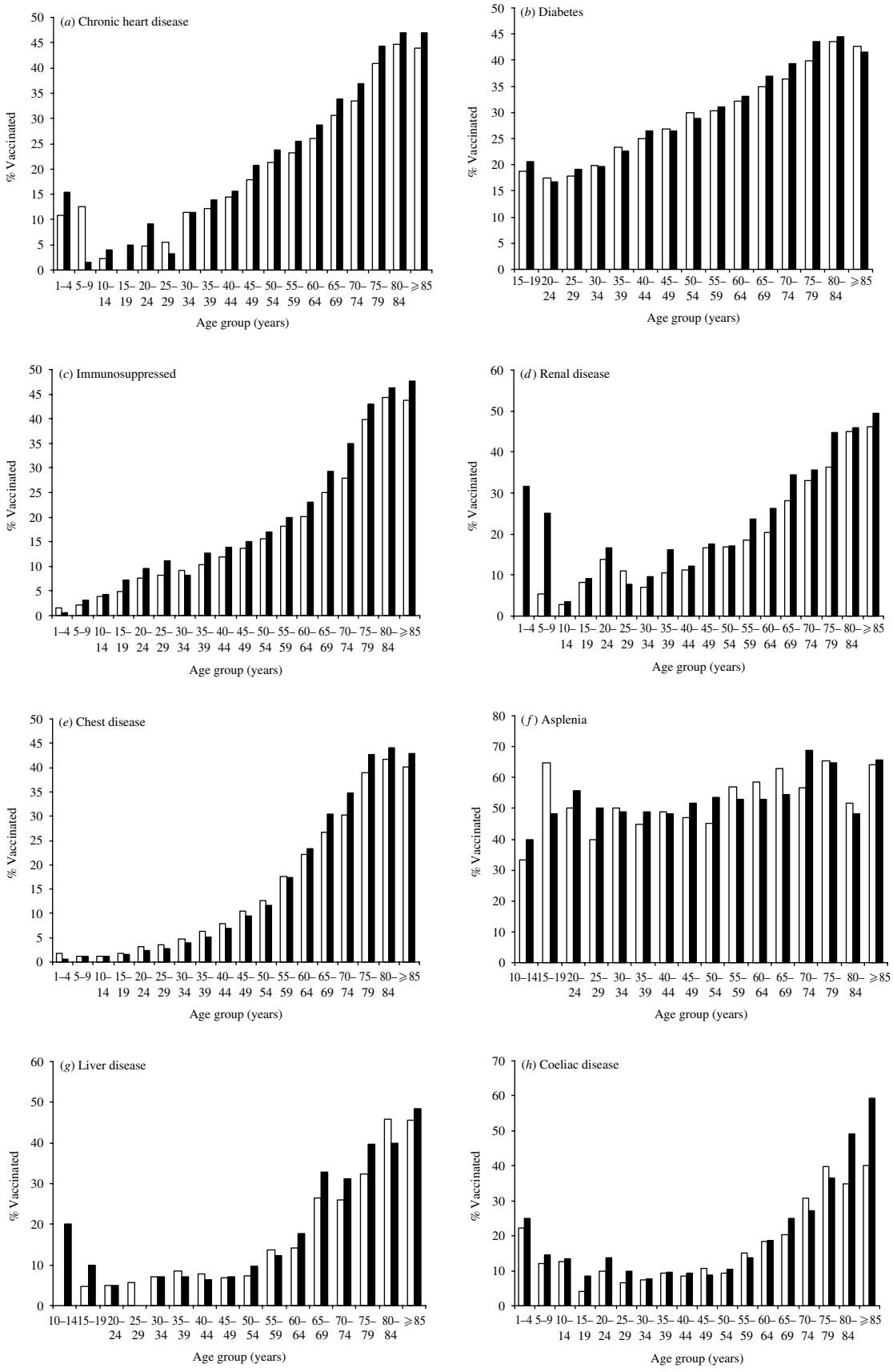

Fig. 1. For legend see next page.

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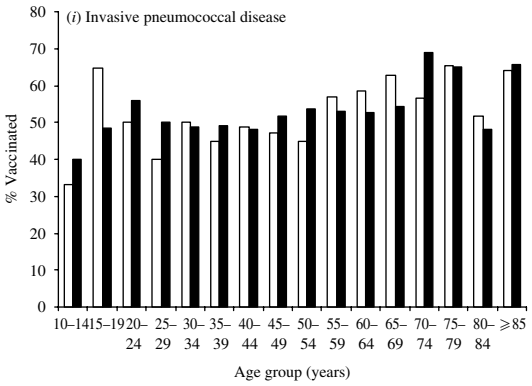

Fig. 1. Proportion of persons vaccinated in past 5 years by age and sex, 2005. (*a*) Chronic heart disease, (*b*) diabetics, (*c*) immunosuppressed, (*d*) renal disease, (*e*) chest disease, (*f*) asplenia, (*g*) liver disease, (*h*) coeliac disease, (*i*) invasive pneumococcal disease. □, Female; ■, male.

(Fig. 2). The proportion of persons vaccinated in the past 5 years by age and sex in 2005 is given in Figure 1*a*. There is an increase from around 5–10% of persons aged <30 years to >40% in those aged >75 years.

Patients with diabetes

Of the 108 938 patients with diabetes in 2001, 6·7% had been vaccinated in the preceding 12 months and 27·7% in the preceding 5 years. This rose to 10·2% and 34·7% respectively by 2005 (Fig. 2). The proportion of persons vaccinated in 2005 in the past 5 years by age and sex is given in Figure 1*b*. The proportion vaccinated increases from ~20% in those <30 years to over 40% in those aged >75 years.

Patients who were immunosuppressed

Of the 67 840 patients who were immunosuppressed in 2001, 5·2% had been vaccinated in the preceding 12 months and 22·2% in the preceding 5 years. This proportion had risen to 6·9% and to 22·9% respectively by 2005 (Fig. 2). The proportion of persons vaccinated in 2005 in the past 5 years by age and sex is given in Figure 1*c*. Fewer than 5% of those aged <15 years had received vaccination compared to more than 40% of those aged >75 years.

Patients with chronic renal disease

Of the 5688 patients with chronic renal disease in 2001, 6·0% had been vaccinated in the preceding 12 months and 25·9% in the preceding 5 years. This had risen to 8·4% and 28·7% respectively by 2005 (Fig. 2). The proportion of persons vaccinated in 2005 in the past 5 years by age and sex is given in Figure 1*d*. The proportion vaccinated is >20% in males aged <9 years, drops in teenagers and increases to levels above 40% in those aged >75 years.

Patients with chronic respiratory disease

Of the 320 379 patients diagnosed with chronic respiratory disease in 2001, 3·0% had been vaccinated in the preceding 12 months and 13·3% in the preceding 5 years. This proportion rose to 3·7% and fell to 12·6% respectively by 2005 (Fig. 2). The proportion of persons vaccinated in 2005 in the past 5 years by age and sex is given in Figure 1*e*. Fewer than 5% of those aged <35 years of age with chronic respiratory disease had received PPV in the previous 5 years compared with over 40% of those aged >75 years.

Patients with asplenia

Of the 2770 patients with asplenia in 2001, 10·9% had been vaccinated in the preceding 12 months and 45·8% in the preceding 5 years. This rose to 13·2% and 53·4% respectively by 2005 (Fig. 2). The proportion of persons vaccinated in the past 5 years by age and sex is given in Figure 1*f*. In almost all age groups, 50% or more have received PPV in the previous 5 years.

Patients with a CSF shunt

Of the 533 patients with a CSF shunt in 2001, 0·9% had been vaccinated in the preceding 12 months and 6·4% in the preceding 5 years. This rose to 4·3% and 10·9% by 1 April 2005 of the 762 patients with a CSF shunt (Fig. 2).

Patients with liver disease

Of the 3816 patients with chronic liver disease in 2001, 4·1% had been vaccinated in the preceding 12 months and 16·8% in the preceding 5 years. This rose to 4·8% and 17·7% respectively by 2005 (Fig. 2). The proportion of persons vaccinated in the past 5 years by age and sex is given in Figure 1*g*. Fewer than 10% of those with liver disease aged <50 years have received

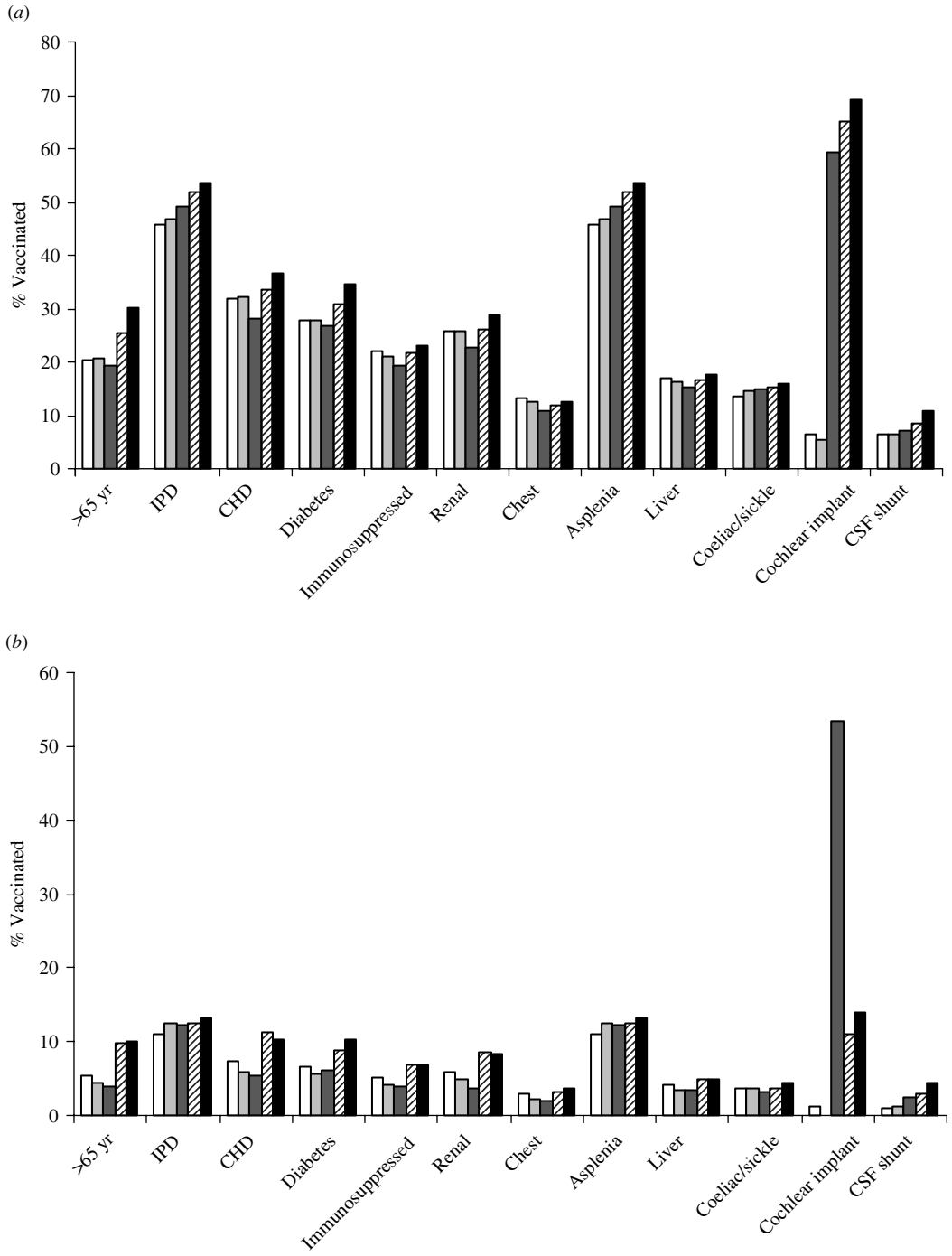

Fig. 2. Proportion vaccinated with pneumococcal vaccine in (*a*) the previous 5 years and (*b*) the previous 1 year by risk group, 2001–2005. □, 2001; ▒, 2002; ■, 2003; ▨, 2004; ■, 2005.

a dose of PPV in the previous 5 years compared to over 40% of those aged 80 years.

Patients with sickle cell or coeliac disease

Of the 3584 patients with either sickle cell or coeliac disease in 2001, 3·7% had been vaccinated in the preceding 12 months and 13·5% in the preceding 5 years. This rose to 4·3% and 15·9% respectively by 2005 (Fig. 2). The proportion of persons vaccinated in the past 5 years by age and sex is given in Figure 1*h*. No age group (except 1–4 years) exceeded 20% vaccination coverage in the previous 5 years up to the age of 65 years in 2005.

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Table 2. *Proportion vaccinated in the previous 5 years by rurality, ethnicity and deprivation score, 2001–2005*

	2001	2002	2003	2004	2005
Rurality					
Urban	4·7	4·7	4·4	5·2	5·9
Rural	5·4	5·5	5·0	6·3	7·6
Missing	3·6	3·9	4·3	5·8	6·7
Ethnicity					
99–100% white	5·8	5·8	5·4	6·6	7·8
97–98·9% white	5·1	5·0	4·7	5·8	6·8
90–96·9% white	4·7	4·5	4·2	5·0	5·9
<90% white	3·5	3·6	3·2	3·7	4·2
IMDS					
1 (most affluent)	4·4	4·3	4·0	5·2	6·5
2	4·9	5·0	4·6	6·0	7·2
3	5·3	5·4	4·9	5·9	7·0
4	5·1	5·2	4·7	5·8	6·6
5 (most deprived)	4·9	5·0	4·5	5·0	5·3
6 (missing)	4·7	4·8	4·8	5·7	6·5
Townsend score					
1 (most affluent)	4·8	4·9	4·7	5·8	7·0
2	5·0	4·9	4·6	5·6	6·8
3	5·1	5·0	4·6	5·6	6·7
4	5·1	5·0	4·6	5·6	6·3
5 (most deprived)	5·0	5·1	4·7	5·3	5·6
6 (missing)	2·5	3·3	4·0	6·4	7·2

IMDS, Index of Multiple Deprivation score.

Patients with a cochlear implant

Of the 78 patients with a cochlear implant in 2001, 1·3% had been vaccinated in the preceding 12 months and 6·4% in the preceding 5 years. This rose to 14% and 69% by 2005 (Fig. 2).

Patients with invasive pneumococcal disease

Of the 2770 patients with a history of invasive pneumococcal disease in 2001, 10·9% had been vaccinated in the preceding 12 months and 45·8% in the preceding 5 years. This rose to 13·2% and 53·4% by 2005 (Fig. 2). The proportion of persons vaccinated in the past 5 years by age and sex is given in Figure 1*i*. In almost all age groups, ⩾50% had received PPV in the previous 5 years.

Vaccination uptake by level of deprivation

The crude pneumococcal vaccination uptake in the previous 5 years was 5% in patients from the most deprived areas compared to 4·8% from the most affluent areas in 2001 compared to 5·6% and 7% respectively in April 2005 according to the Townsend score. According to the IMDS score, the proportion of patients in a risk group that have been vaccinated was 4·4% in the most affluent areas compared to 4·9% in the most deprived areas in 2001. By 2005, this had risen to 6·5% and 5·3% respectively.

Vaccination uptake in rural *vs.* urban patients

For every year, the crude uptake of pneumococcal vaccination was higher in patients from rural compared to urban areas. For example by 2005, 5·4% of all patients from rural areas had been vaccinated in the preceding 12 months compared to 4·7% of patients from urban areas.

Vaccination uptake by 'ethnicity'

Vaccination uptake in patients by ethnicity of their area of residence is shown in Table 2. Uptake rates for the total population are substantially higher in areas where 99–100% of the population are white. In 2005 uptake was 7·8% in the previous 5 years in areas where 99–100% of the population is white compared to 4·2% in areas where <90% of the population is white.

DISCUSSION

This study has provided detailed information on pneumococcal vaccine uptake by specific risk group at a national level for the first time. Our key finding is that despite being part of the national immunization programme, uptake of PPV in certain recommended risk groups in the United Kingdom remains low. There is evidence of an increase in coverage over the past 5 years, which is partially explained by the recent over-65-year-old PPV campaign started in 2003.

There are several potential weaknesses to the study. Variation in vaccine uptake can be explained by a number of factors. Our study focused on the role of socio-economic and ethnic variation, but did not look at other explanations such as smoking, which is both an independent risk factor for invasive pneumococcal disease [15] and may influence vaccine uptake [16]. This should be an area for future research. Another potential weakness with use of routine datasets relate to sampling and data validity. Much validation

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work has been undertaken on the Q-RESEARCH database. Double counting is not possible as each person is uniquely identified. Data extraction from Q-RESEARCH has been subject to extensive checks to ensure what is held exactly matches GP contract queries. Rates for GP contract queries are compared with external data sources on an on-going basis. The prevalence estimates for the risks groups demonstrated by this study are equivalent to those found in the Quality Management and Analysis System (QMAS) at least for coronary heart disease and diabetes (Comparison of key practice characteristics between general practices in England and Wales and general practices in the Q-RESEARCH database). However, recording of some chronic diseases (such as heart disease and respiratory disease) are likely to have high levels of completeness, whereas recording of other diseases (such as asplenia or CSF shunt) may be less complete and the numbers of patients at risk may have been underestimated.

Our study provides an updated national perspective to previous studies that have examined pneumococcal vaccine uptake in populations at higher risk of invasive disease in a UK setting [7]. We found that the highest coverage was observed in patients diagnosed with cochlear implants from 2002 onwards, following a Medical Devices alert that individuals with a cochlear implant are at increased risk of pneumococcal meningitis. The Department of Health introduced guidance that all those undergoing or with pre-existing implants should receive pneumococcal vaccination [3]. We also demonstrated that almost half of those with asplenia or a previous history of invasive pneumococcal disease have not been vaccinated with PPV in the previous 5 years. This compared to about 70–80% of those diagnosed with chronic respiratory, heart, liver and renal disease, diabetes, immunosuppression, CSF shunts, and sickle cell disease. Overall coverage in risk groups (21%) is now higher than has been observed during the late 1990s (4–15%). This observation is congruent with published studies [8–12] from over 5 years ago, which show similar levels of coverage for groups such as diabetics and asplenics. Our study provides an extremely useful baseline for policy-makers and clinicians.

We provide mixed evidence for health inequalities being associated with vaccine uptake. Our study found little evidence to suggest lower vaccine uptake in more deprived geographical areas. This observation contradicts published literature – both for childhood vaccination such as MMR [17] and for influenza uptake in the elderly. In both instances, there was evidence of lower vaccine uptake in more deprived, inner-city areas [18]. However, it is important to state that our analysis is an ecological approach and the lack of a clear difference in uptake using socio-economic indicators could be as a consequence of confounding: the 'ecological fallacy' [19]. PPV uptake was lower in areas where the proportion of the population that is non-white is very high and in patients from urban compared to rural areas. This is congruent with other studies particularly from the United States suggesting that there are in inequalities in vaccine uptake related to ethnicity [20]. This requires further investigation, but has potentially important implications in terms of access to preventive health care.

Our study, undertaken in primary care, has demonstrated large gaps in PPV uptake in a number of risk populations. These coverage levels are very much lower than those observed for influenza vaccination. What are the possible explanations for these differences? It probably reflects both health service and patient factors. Out-of pocket expenses should not be barriers to uptake in the United Kingdom, as both the cost of the vaccine and its delivery are met by the health service. However, there is variation in the way different vaccination programmes are remunerated in general practice in the United Kingdom: with a financial incentive for GPs to give influenza vaccination, but not PPV. In addition, patient knowledge of pneumococcal vaccine in high-risk groups has been shown to be low [21, 22].

As the vast majority of patients receive pneumococcal vaccination in primary care in the United Kingdom, rather than through the hospital [10], what strategies might be undertaken to address these gaps? Besides the introduction of GP targets and incentives, several other strategies have been shown to be effective at increasing immunization uptake, such as focused campaigns in general practice settings with clinical guidelines and educational outreach visits [22, 23]. Computerized reminder and recall systems have also been shown to increase uptake [24] in the United Kingdom. Finally, there is evidence that organizational changes such as immunization clinics and use of routine visits to deliver vaccination can be very effective interventions [25]. A careful consideration of the most appropriate strategy to implement in the United Kingdom to address these gaps needs to be undertaken.

Clinical risk category	Examples
Asplenia or severe dysfunction of the spleen	Including homozygous sickle cell disease and coeliac syndrome
Chronic renal disease	Including nephritic syndrome, chronic renal failure, renal transplantation
Immunosuppression	Immunosuppression due to disease or treatment, including asplenia or splenic dysfunction, and also including those on or likely to be on systemic steroids for more than 1 month at a dose equivalent to prednisolone at $\geqslant$20 mg per day (any age) or for children under 20 kg a dose of $\geqslant$1 mg/kg per day. HIV infection at all stages. Patients undergoing chemotherapy
Chronic heart disease	Includes those requiring regular medication/or follow-up for ischaemic heart disease, congenital heart disease, hypertensive heart disease and chronic heart failure
Chronic respiratory disease, including asthma	This includes COPD, chronic bronchitis and emphysema, bronchiectasis, cystic fibrosis, interstitial lung fibrosis, pneumoconiosis, bronchopulmonary dysplasia (BPD); asthma requiring continuous or repeated use of inhaled or systemic steroids or with previous exacerbations requiring hospital admission. Children with respiratory conditions caused by aspiration, or a neuromuscular disease (e.g. cerebral palsy) with a risk of aspiration
Chronic liver disease	Including cirrhosis
Diabetes mellitus	Requiring insulin or oral hypoglycaemic drugs
Cochlear implants	
Individuals with CSF shunts	And other conditions where leakage of CSF can occur
Children aged <5 years who have previously had invasive pneumococcal disease	Children who have previously had pneumococcal meningitis or pneumococcal bacteraemia

Source: Department of Health. The pneumococcal immunization programme for older people and risk groups, 31 March 2005 [18].

APPENDIX

Identification of risk groups: CMO's recommendations (31 March 2005)

Pneumococcal vaccine is recommended for the following:

- All patients aged $\geqslant$65 years.
- All patients aged >2 months in the following clinical risk groups:
  Children aged 2 months to <5 years of age should receive 7-valent pneumococcal conjugate vaccine followed by a single dose of 23-valent PPV after the age of 2 years. Children aged $\geqslant$5 years and adults should receive a single dose of polysaccharide vaccine.

2003/2004

From 20 August 2003 a new pneumococcal immunization programme for older people was introduced. In the first year all patients aged $\geqslant$80 years who had not previously received the vaccine were offered the vaccine.

2004/2005

From 1 April 2004 all patients aged $\geqslant$75 years could be offered the vaccine.

2005/2006

From 1 April 2005 all patients aged $\geqslant$65 years were offered the vaccine.

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DECLARATION OF INTEREST

None.

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